Chapter

16 Digestion and Absorption

Nutrition refers to all activity included in obtaining the food and its utilization in the body. Food which on taken and digested in the body provides energy for life activities, materials for growth, repair, and reproduction, resistance from disease or regulation of body processes.

Our body functions best when essential nutrients are present in correct proportions. A diet that satisfies this is called a ***balanced diet.***

The Six Essential Nutrients are: Carbohydrates, Fats (lipids), Proteins, Minerals, Vitamins, and Water.

Food can be classified into three categories based on their functions.

(i) **Energy providing foods**: These are rich in carbohydrates and fats and provide energy on oxidation in the body. **Examples:** cereals, sugar, fats, oils, jaggery etc.

(ii) **Body building foods:** These are rich in proteins and help in the formation of new tissues etc. **Examples:** legumes, milk, egg, meat, fish, pulses, nuts and oilseeds.

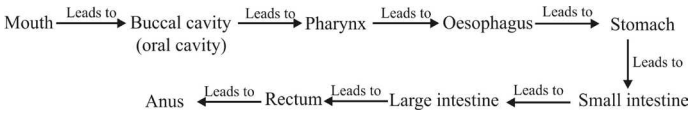
(iii) **Protective/regulatory foods:** These are rich in minerals, vitamins, roughage and water. They help in regulation of internal metabolism in the body. **Examples:** Green leafy vegetables, fruits, amla, guava, citrus, oranges etc.

HUMAN ALIMENTARY CANAL AND DIGESTIVE GLANDS

The human digestive system includes **Alimentary canal and associated (Digestive) glands.**

I. Alimentary canal (gut)

- Alimentary canal is a long continuous tube extending from mouth to anus. It is about 6-9 meters long in humans.
- Alimentary canal is also known as digestive tract or gut.
- Arranged sequentially, it includes the following parts:



Mouth

Food is taken into the body through the mouth. The main function of mouth is to receive the food.

Buccal cavity (oral or mouth cavity)

It is the mouth cavity by which food is taken into alimentary canal and chewed.

It consists of palate, teeth and muscular tongue.

(a) Palate

(i) The roof of the buccal cavity is called palate.

(ii) Palate (roof) has anterior hard palate and posterior soft palate.

(iii) The hinder free part of the soft palate freely hangs down as a small flap called the uvula.

(b) Teeth: The mouth or the buccal cavity has teeth, which mechanically break down the food into smaller pieces. Teeth are rooted in separate sockets in the gums.

➢ The nature and mode of arrangement of teeth is called **dentition**.

➢ **Human dentition** is

(a) Heterodont (different kinds of teeth). They are ***incisors (I)*** for cutting, ***canines (C)*** for tearing, ***premolars (PM)*** and ***molars (M)*** for mastication. Premolars and molars are collectively called as ***cheek teeth*** which have **cusps**.

(i) The codont: The codont are the teeth embedded in the sockets of the jaw bone. *E.g.,* in mammals.

(ii) Diphyodont: The teeth formed twice in life time are called diphyodont. *E.g.,* in mammals. They are ***milk (decidual) teeth*** and ***permanent teeth***. Milk teeth are erupted at **6-7 months** of birth and are **20** in number. They are replaced by permanent teeth at the age of **6-7**. Permanent teeth are **32** in number. The last 4 molars ***(wisdom teeth)*** appear only at the age of 18.

➢ **Dental formula:** The dental formula expresses the arrangement of teeth in each half of the upper jaw and the lower jaw.

➢ The dental formula for milk teeth in humans is: $\frac{2102}{2102} \times 2 = 20$

Each half of the upper jaw and the lower jaw has 2 incisors, 1 canine and 2 molar. Premolars are absent in milk teeth.

- The dental formula for permanent teeth in humans is: $\frac{2123}{2123} \times 2 = 32$

Each half of the upper jaw and the lower jaw has 2 incisors, 1 canine, 2 premolars, and 3 molars. An adult human has 32 permanent teeth.

- **Tongue:** Tongue is a muscular organ which is attached at the back to the floor of the buccal cavity by a fold called the lingual frenulum.

The upper surface of the tongue has four types of little projections called papillae:

(i) **Circumvallate papillae or vallate papillae:** It is the largest of the four types.

(ii) **Filiform papillae:** These are the smallest and most numerous of the four.

(iii) **Fungiform papillae:** They are most numerous near the tip of the tongue.

(iv) **Foliate papillae:** These are not developed in human tongue.

- Tongue contains taste buds, which can detect four basic **flavors**- sweet, salty, sour and bitter tastes.

The taste buds for each of these flavors are located in different parts of the tongue.

➢ Sweet is detected at the tip of our tongue.
➢ Salt is detected at the front side of our tongue.
➢ Sour is detected along the rear side of our tongue.
➢ Bitter is detected across the back of our tongue.

- **Functions of the Tongue**
  ➢ It mashes the food and helps in mixing saliva with food. Chewing is essential for the digestion of food.
  ➢ It also helps in rolling and pushing (deglutition or swallowing) of partially digested food into the oesophagus.

3. Pharynx (Throat):

- It is the common passage for digestive and respiratory systems.
- It is divided into three parts:
  ➢ Nasopharynx (Nasal part of the pharynx)
  ➢ Oropharynx (Oral part of the pharynx)
  ➢ Laryngopharynx (Laryngeal part of the pharynx)
- When food materials pass through the pharynx, the ***epiglottis*** closes the ***glottis*** (opening of larynx) and prevents the entry of food into trachea.
- Sometimes, when we eat too fast or laugh while eating, then a little air pipe remains open due to which food particles may enter the larynx. When food particles enter the larynx, we may get choking sensation, commonly known as hiccups.

4. Oesophagus (Food pipe/Gullet)

- It is a muscular tube with 30 cm long, which conducts slightly digested food from the mouth into stomach.
- When food enters oesophagus, the muscles in the walls of oesophagus start alternate contractions and relaxations producing wave like movement called peristals is, which pushes the food downwards towards the stomach.
- At the posterior region of oesophagus, ***oesophageal sphincter*** (a circular muscle) is present. It controls the opening of oesophagus into stomach.

5. Stomach

- The stomach is a muscular, J-shaped, sac like organ, present on the left side of the abdomen.
- Stomach helps in storage and digestion of food.
- It is divided into three parts: upper (anterior) fundus, middle cardiac stomach and lower (posterior) pyloric stomach (antrum).
- The gastric glands present in its walls secrete gastric juices, which help in the digestion of food. These juices contain hydrochloric acid (HCl), mucus and enzymes like pepsin.
- Pyloric stomach leads to small intestine by an opening called **Pylorus**, guarded by ***pyloric sphincter muscle***. This sphincter allows only one teaspoon of food at a time to enter the duodenum.
- The mucosal wall of the stomach bears irregular folds known as rugae. These help increase the surface area to volume ratio of the expanding stomach.
- The product of digestion in the stomach is called as **chyme**.
- The stomach basically acts like a mixer, breaking food into smaller pieces and adding digestive juices to allow for easier absorption. It can store approximately 2 litres of food.

6. Small intestine

- It is the longest part of gut (7m long and 2.5cm diameter).
- The chyme (partially digested food) from stomach enters into small intestine where complete digestion and absorption of food takes place.
- It consists of three parts, namely **duodenum** (C shaped first part), **Jejunum** (middle part) and **Ileum** (terminal part).
- Both jejunum and ileum are greatly coiled.
- The mucosal wall of the small intestine contains numerous finger like projections called villi (singular: villus). These villi increase the surface area for absorption of digested food. Each villus has a brush-bordered columnar epithelial layer provided with ***microvilli***.
- Villus contains a lymph capillary called lacteal in the center. Lacteal in turn is surrounded by a network of thin and small blood vessels called blood capillaries close to its surface. As the food moves slowly between, over and around the villi, the surface of villi absorbs the digested food materials into blood flowing through them. Blood, in turn, carries the absorbed food materials to all the parts of the body. In the cells food is used for energy, repair and growth. The process is known as assimilation.

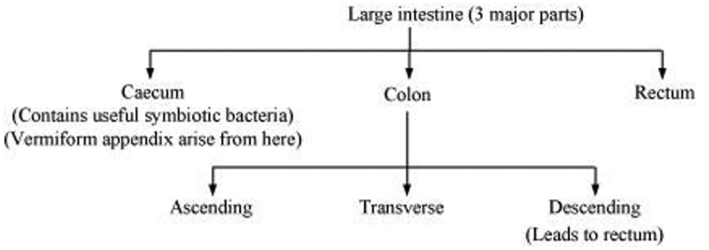
Nutrients

Nutrients are absorbed through the small intestine where the blood carries them to all the cells of the body. The three basic types of nutrients are amino acids, simple sugars, and fatty acid.

- **Carbohydrates** are broken down into simple sugars (glucose) which is used by the cells for energy.
- **Proteins** are broken down into amino acids (the building blocks of cells) which are used to repair old cells and build new cells (skin, blood, muscle, bone and nerve).
- **Fats** are broken down into fatty acids and glycerol which are stored for future use.

7. Large intestine

- The food that remains undigested and unabsorbed passes from small intestine into large intestine.
- It is much shorter than the small intestine although the diameter is much larger.
- It is made of three parts: **caecum, colon** and **rectum.**
- The colon consists of ***ascending colon, transverse colon, descending colon*** and ***pelvic colon***.



- Caecum is well-developed in herbivores but in man it is very small. Arising from the caecum is a finger-like vestigial organ, the ***vermiform appendix.***
- Pelvic colon leads to **rectum** that opens out by **anus**.
- The main function of large intestine is to absorb most the water from the indigested food material.
- In some herbivores, the large intestine consists of several cellulose digesting bacteria.
- Caecum and vermiform appendix are very large sized in herbivores like rabbit, ass and horse. They have large number of symbiotic bacteria, which help in fermentation and digestion of cellulose. The simplified cellulose in rabbit and pig are egested out with faeces. These eat their own faeces to absorb the simplified cellulose. This phenomenon is called coprophagy.

8. Rectum and Anus

- The remaining undigested food is stored in the last part of the large intestine called rectum for some time.
- Later, this undigested, semi-solid waste is forced to pass out form our body through anus in the form of faeces.

Histology of human gut

- The walls of the alimentary canal are made up of four layers. These are as follows:

a. **Serosa:** It is the outermost fibrous layer of the human alimentary canal. It is made up of a thin layer of secretory epithelial cells, with some connective tissues underneath.
b. **Muscularis externa:** It is a thin layer of smooth muscles arranged into an outer longitudinal layer and an inner circular layer.
c. **Sub-mucosa:** It is a layer of loose connective tissues, containing nerves, blood, and lymph vessels. It supports the mucosa.
d. **Mucosa:** It is the innermost lining of the lumen of the alimentary canal. It is mainly involved in absorption and secretion.

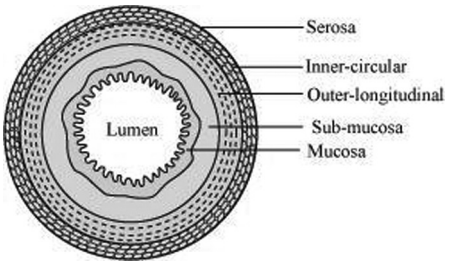


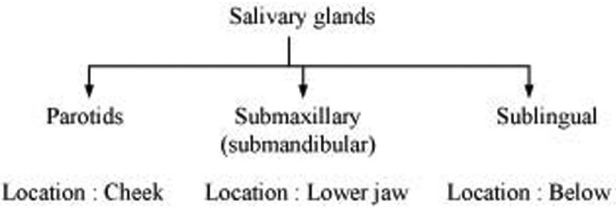
Fig. T.S. of Human gut

II. Digestive glands

- They secrete **digestive juices**. It includes salivary glands, gastric glands, intestinal glands, pancreas and liver.

1. Salivary glands (found in mouth)

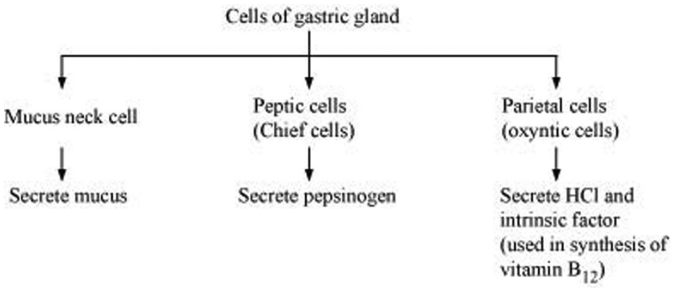
- The salivary glands secrete watery liquid called saliva.
- *Functions of saliva:*
  - ➢ Saliva contains an enzyme called salivary amylase that helps to digest the starch (carbohydrate) present in the food partially.
  - ➢ Saliva also helps in lubricating the food and makes it easier for swallowing.
- Three pairs of salivary glands open into the mouth. They are parotid (largest salivary gland), sub-maxillary *(sub mandibular)* and sub-lingual.



2. Gastric glands

- They are tubular glands found on the inner wall.
- They consists of
  - ➢ **Mucous neck cells (Goblet cells):** They secrete **mucous.** Mucous and bicarbonates protect the inner lining of stomach wall (mucosal epithelium) from its own secretion HCl and prevents auto digestion.
  - ➢ **Chief (zymogen or peptic) cells:** They secrete inactive enzymes like *pepsinogen, prorennin* and *lipase*.

➢ **Oxyntic (parietal) cells:** They secrete HCl and *Castle's gastric factor*. Gastric glands secrete acidic (pH 1.8-2.0) gastric juice (99.5% water and 0.5% residual substances).



- **Functions of Hydrochloric acid:**
  - ➢ It kills the bacteria in food.
  - ➢ It stops the action of salivary enzyme found in slightly digested food.
  - ➢ It makes the medium acidic. Acidic medium is required for activation of protein digesting enzyme called pepsin.
  - ➢ It helps in softening of food.

3. Liver

- Liver is the largest gland (1.5 kg) of the human body.
- It is bilobed having large right lobe and small left lobe. Each lobe is formed of many ***hepatic lobules*** (functional units).

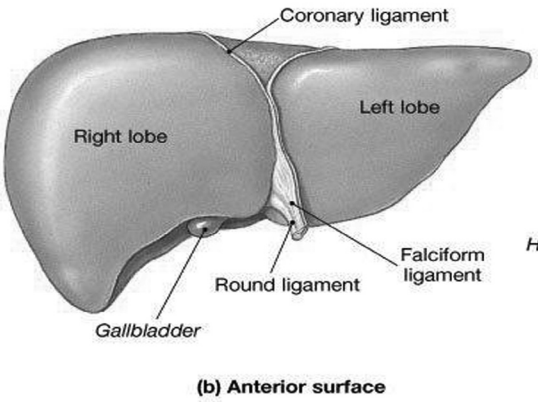


Fig. Liver

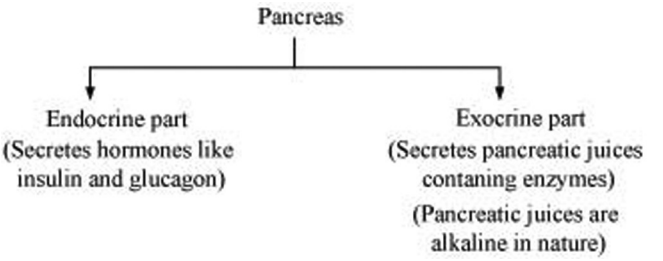
- A lobule has many **hepatic cells** arranged as radiating plates around a **central vein**. They secrete alkaline **bile juice**.
- Bile is stored temporarily in gall bladder until it is needed by the small intestine to emulsify fats. Bile does not contain any digestive enzymes but contains bile pigments (bilirubin and biliverdin), bile salts, cholesterol and phospholipids.
- *Functions of Bile:*
  - (i) It makes the acidic food coming from stomach to alkaline so that pancreatic enzymes can act on it.
  - (ii) Bile contains bile salts that help in proper digestion of fats by breaking down large fat globules into smaller ones, so that enzyme can easily act on it and digest them. This process is known as emulsification of fats
- Each liver lobule is surrounded by a connective tissue sheath called *Glisson's capsule*.
- Between the plates are blood filled *hepatic sinusoids.*
- The **Kupffer's cells** present in the sinusoids engulf and remove bacteria, damaged cells etc from blood.
- On the lower surface of right liver lobe, there is a thin walled, pear shaped sac, called gall bladder. It stores bile secreted by liver.
- Bile is drained from the liver by a bile duct (ductus choledochus) which is formed by the joining of a cystic duct from the gall bladder and a common hepatic duct from different liver lobes.
- **Usual flow of bile from the liver is:**

Bile → Hepatic duct → Gall bladder → Cystic duct → Bile duct → Common hepato-pancreatic duct → Duodenum

- Just near the duodenum, the bile and pancreatic ducts join to form hepatopancreatic duct. The opening of hepato-pancreatic duct in the duodenum is guarded by sphincter of Oddi.
- *Functions of liver:*
  - ➢ Liver plays an important role in carbohydrate metabolism where hepatic cells conduct glycogenesis (converting glucose into glycogen), and glycogenolysis (breaking glycogen down to glucose).
  - ➢ It is also critical in lipid metabolism where hepatic cells produce bile (for fat emulsification), oxidize fatty acids, synthesize various forms of lipids, and convert glucose to fatty acids by the process known as lipogenesis.
  - ➢ Liver also helps in storage of glycogen, iron, and vitamins A, D, B_{12}.
  - ➢ It contains phagocytes to destroy damaged erythrocytes and foreign substances, using phagocytosis.
  - ➢ It detoxifies harmful substances in the blood.
  - ➢ It serves as a blood reservoir (contains 7% of blood volume).

4. Pancreas

- It is the second largest gland present near duodenal loop.
- It is a cream-coloured heterocrine gland, i.e. it has both exocrine and endocrine (islets of Langerhans) parts.



(a) Exocrine Part

- ➢ The exocrine part has a pancreatic duct that opens into duodenum along with bile duct (hepato-pancreatic duct).
- ➢ It secretes alkaline pancreatic juice, which contains inactive enzymes (trypsinogen, chymotrypsinogen and procarboxypeptidases), amylases, lipases and nucleases.

➢ Pancreatic juice breaks down fats completely into fatty acids and glycerol. It also breaks down carbohydrate and protein into simpler forms.

(b) Endocrine part:

➢ It consists of group of islets of Langerhans. Each islets of Langerhans consists of three types of cells, which secrete hormones into the circulating blood.

♦ **Alpha cells:** They produce glucagon hormone, which convert glycogen into glucose in the liver.

♦ **Beta cells:** They produce insulin hormone which converts glucose into glycogen in the liver and the muscles.

♦ **Delta cells:** They secrete somatostatin hormone which inhibits the secretion of glucagon by alpha cells and secretion of insulin nutrients from the gastrointestinal tract.

Note: Deficiency of insulin causes Diabetes mellitus.

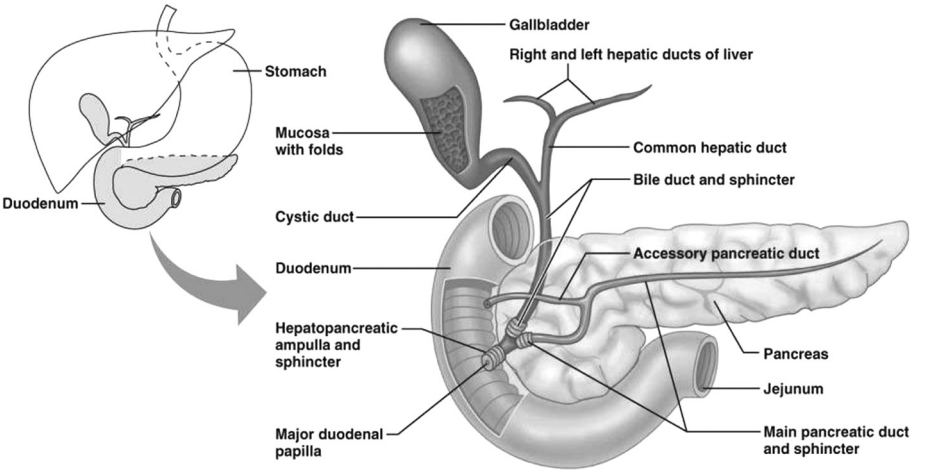


Fig. Structure of duodenum

5. Intestinal glands

- It is simple tubular glands found in the walls of small intestine. It is of two types:
  (a) **Crypts of Lieberkuhn:** It consists of mucous-secreting Goblet cells and enzyme-secreting Paneth cells.
  Goblet cells are the cells of intestinal mucosal epithelium which secrete mucus.
  (b) **Brunner's (duodenal) glands:** It is confined to sub mucosa of duodenum and secrete **mucous** only.
- The secretions of both types of glands are collectively called intestinal juices or succus entericus. It contains enzymes such as maltase, lactase, sucrase, dipeptidase, lipases, nucleotidases, nucleosidases etc. The bicarbonate and mucous provide alkaline medium and protect intestinal mucosa.

DIGESTION, ABSORPTION AND ASSIMILATION OF PROTEINS, CARBOHYDRATES AND FATS

I. Digestion

- Digestion is the process in alimentary canal by which the complex food is converted mechanically and biochemically into simple substances suitable for absorption and assimilation.
- It includes mechanical processes such as ***mastication*** (chewing), ***deglutition*** (swallowing) and ***peristalsis*** (wave-like movement of food bolus through the gut by muscular contraction).
- There are two basic types of digestion.
  ➢ **Mechanical Digestion:** It is the initial stage of physically breaking down food into smaller pieces. It occurs mainly in the mouth where teeth chew food and tongue manipulates the food.
  ➢ **Chemical Digestion:** It is the separation of food into molecular components by chemical means. The process begins in the mouth with the secretion of saliva, which contains the digestive enzyme, ***amylase***. The chemical breaking down of food continues through the through the stomach and is completed in the small intestine.

Physiology of Digestion

1. Digestion of carbohydrate

- The digestion of carbohydrates takes place in the mouth (buccal cavity) and the small intestine region of the alimentary canal.
- There are two types of carbohydrates in the human food

that need to be digested in the alimentary canal of man. These are:

- ➢ Polysaccharides like starch, glycogen and cellulose
- ➢ Disaccharides like maltose, sucrose, and lactose.

In the Mouth (Buccal cavity)

- Two basic functions are performed by buccal cavity − mastication of food and facilitation of swallowing.
- As food enters the mouth, it gets mixed with saliva.
- Saliva contains enzymes salivary amylase (Ptyalin), lysozyme, and electrolytes.
- Mucus in saliva lubricates and adhere food particles into *Bolus*.
- Deglutition or swallowing conveys the bolus to pharynx and then to oesophagus.
- Peristalsis conveys the bolus from oesophagus to stomach.
- Saliva – secreted by the salivary glands – contains a digestive enzyme called salivary amylase. This enzyme breaks down starch into sugar at pH 6.8. About 30% of starch is digested by amylase.

$$\text{Starch} \xrightarrow[\text{pH 6.8}]{\text{Salivary amylase}} \text{Maltose + Isomaltose + Limit dextrins}$$

- Lysozyme present in saliva acts as an antibacterial agent.
- Salivary amylase continues to act in the oesophagus, but its action stops in the stomach as the contents become acidic. Hence, carbohydrate-digestion stops in the stomach.

In the small intestine

- Carbohydrate-digestion is resumed in the small intestine.
- Here, the food gets mixed with the bile, pancreatic juice and the intestinal juice. Bile has no enzymes so has no chemical action on carbohydrates.

Action of pancreatic juice

- Pancreatic juice contains the pancreatic amylase (Amylopsin) that hydrolyses the polysaccharides into disaccharides. The pancreatic enzyme operates in alkaline pH of 8.8, which is provided by bicarbonates mainly present in bile juice though also present in pancreatic juices.

$$\text{Starch} \xrightarrow{\text{Amylopsin}} \text{Maltose + isomaltose + limit dextrins}$$

Action of intestinal juice

- The intestinal juice (pH 8.3) contains a variety of enzymes, which hydrolyse the specific oligosaccharides into their monosaccharides. For e.g.
  - ➢ **Maltase** digests maltose into glucose.
  - ➢ **Sucrase** digests sucrose into glucose and fructose.
  - ➢ **Lactase** digests lactose into glucose and galactose.
- These disaccharidases help in the digestion of disaccharides.

$$\text{Maltose} \xrightarrow{\text{Maltose}} 2\text{Glucose}$$

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

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

- The digestion of carbohydrates is completed in the small intestine.

2. Digestion of Protein

- The digestion of proteins begins in the stomach and is completed in the small intestine. The enzymes that act on proteins are known as proteases or peptidases.

In the stomach

- The semi-digested food rests in stomach for about 4-5 hours, then gets mixed with acidic gastric juices by churning movement of muscular wall and is called **chyme** at this stage.
- Chyme is the semifluid mass into which food is converted by gastric secretion and which passes from the stomach into the small intestine.
- Gastric juice contains HCl, pepsinogen, rennin, and lipase.
- Hydrochloric acid dissolves the bits of food and creates an acidic medium so that pepsinogen is converted into pepsin.
- Pepsin is a protein- digesting enzyme. It is secreted in its inactive form called pepsinogen, which then gets activated by hydrochloric acid. HCl provides optimum pH of 1.2 to 1.8 for pepsin.

$$\underset{\text{(Inactive)}}{\text{Pepsinogen}} \xrightarrow{\text{HCl}} \underset{\text{(Active)}}{\text{Pepsin + Inactive peptide}}$$

- The activated pepsin then converts proteins into proteases and peptides.

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Proteases + Peptides}$$

- Rennin is a proteolytic enzyme, released in an inactive form called prorennin. Prorennin is activated by HCl in acidic medium to rennin. Rennin plays an important role in the coagulation of milk.

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

$$\downarrow$$

$$\text{Milk casein} \longrightarrow \text{Paracasein}$$

- The food in the stomach is thick, acidic and semi-digested and is called chyme.

In the small intestine

- The food from the stomach (chyme) is acted upon by three enzymes present in the small intestine – pancreatic juice (pH 8.8), intestinal juice (known as succus entericus- pH 8.3), and bile juice (pH 8.0).
- Pancreatic juice and bile reach the duodenum through hepato-pancreatic duct.

Action of pancreatic juice

- Pancreatic juice contains a variety of inactive enzymes such as trypsinogen, chymotrypsinogen, and carboxypeptidases. These enzymes play an important role in the digestion of proteins.

- Trypsinogen is present in an inactive form in the pancreatic juice. The enzyme ***Enterokinin (enteropeptidase)*** secreted by the intestinal mucosa – activates trypsinogen into trypsin.

$$\text{Trypsinogen} \xrightarrow{\text{Enterokinase}} \text{Trypsin} + \text{Inactive peptide}$$

- The activated trypsin then further hydrolyses the remaining trypsinogen and activates other pancreatic enzymes such as chymotrypsinogen and carboxypeptidase.

$$\underset{\text{(Inactive)}}{\text{Chymotrypsinogen}} \xrightarrow{\text{Trypsin}} \underset{\text{(Active)}}{\text{Chymotrypsin}}$$

- The activated chymotrypsin plays an important role in the further breakdown of the partially-hydrolysed proteins.

$$\text{Proteins} \xrightarrow{\text{Chymotrypsin}} \text{Peptides}$$

- Trypsin also helps in breaking down proteins into peptides.

$$\text{Proteins} \xrightarrow{\text{Chymotrypsin}} \text{Peptides}$$

- Carboxypeptidases act on the carboxyl end of the peptide chain and help in releasing the last amino acids.

$$\text{Peptides} \xrightarrow{\text{Carboxypeptidase}} \text{Small peptide chain} + \text{Amino acids}$$

- Thus, in short, we can say that the partially-hydrolysed proteins present in the chyme are acted upon by various proteolytic enzymes of the pancreatic juice for their complete digestion.

$$\text{Proteins, peptones} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/Chymotrypsin}} \text{Dipeptides and proteases}$$

Action of intestinal juice

- Intestinal juice (also known as Succus entericus) contains enterokinase (enteropeptidase), aminopeptidases and dipeptidases.
- Enterokinase converts trypsinogen of pancreatic juice into trypsin.
- Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin + Inactive peptide
- The proteases (Aminopeptidase and dipeptidases) hydrolyse peptides into dipeptides and finally into amino acids.

$$\text{Large peptides} \xrightarrow{\text{Aminopeptidase}} \text{Dipeptides} + \text{Amino acids}$$

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

3. Digestion of fats

Fat digestion is started in the stomach and is nearly completed in the small intestine. The enzymes involved in fat digestion are known as lipases.

In the stomach

- The gastric juice contains a small amount of gastric lipase which converts some fats into monoglycerides and fatty acid.

In the small intestine

Action of bile

- Bile juice has bile salts such as bilirubin and biliverdin. These break down large fat globules into smaller globules so that the 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.

Action of pancreatic enzymes

- The pancreatic lipase present in the pancreatic juice and the intestinal lipase present in the intestinal juice hydrolyse the fat molecules into triglycerides, diglycerides, monoglycerides, and ultimately into glycerol.

$$\text{Fats} \xrightarrow[\text{lipase}]{\text{Pancreatic}} \text{Triglycerides} + \text{Diglycerides}$$

$$\text{Diglycerides and monoglycerides} \xrightarrow{\text{Lipases}} \text{Fatty acids} + \text{Glycerol}$$

- Pancreatic lipase is the principal enzyme for the digestion of fat.

Action of intestinal lipase

Intestinal lipase converts remaining fats into monoglycerides and fatty acids.

4. Digestion of Nucleic acids

Nucleic acids are digested in the small intestine. The enzymes that digest nucleic acids are called nucleases. The nucleases break down nucleic acids into nucleotides and nucleosides.

Action of pancreatic juice

- Pancreatic juice contains two nucleases: Deoxyribonucleases (DNase) and Ribonucleases (RNase).
- *Deoxyribonucleases (DNase)* break down DNA into Deoxyribonucleotides.

  DNA $\rightarrow$ (*DNase*) Deoxyribonucleotides
- *Ribonucleases (RNase)* break down RNA into Ribonucleotides.

  RNA $\rightarrow$ (*RNase*) Ribonucleotides

Action of intestinal juice

- Intestinal juice contains two enzymes called *nucleotidases* and *nucleosidases.*
- *Nucleotidase* acts on nucleotides and breaks them down into nucleosides and inorganic phosphate.

  Nucleotides $\rightarrow$ (*Nucleotidase*) Nucleosides + Inorganic phosphate
- *Nucleosidase* breaks down nucleosides into nitrogenous bases and pentose sugar.

  Nucleosides $\rightarrow$ (*Nucleosidase*) Nitrogenous bases + Pentose sugar

  Fully digested semi fluid and alkaline food is called ***chyle.***

Summary of Main Digestive Enzymes and their Action

Enzyme	Secretion	Site of Action	Substrate → Products (Reaction)
Salivary glands in saliva of mouth			
Salivary amylase	Saliva	Mouth	Starch $\xrightarrow[\text{pH 6.8}]{\text{Salivary amylase}}$ Maltose
Gastric gland secretes gastric juice in Stomach.			
Pepsin	Gastric juice	Stomach	Proteins $\xrightarrow{\text{Pepsin}}$ Proteases + Peptides
Rennin			Prorennin $\xrightarrow{\text{HCl}}$ Rennin
Gastric lipase			Fats $\xrightarrow[\text{lipase}]{\text{Pancreatic}}$ Triglycerides + Diglycerides
Pancreas secreted Pancreatic juice in small intestine			
Pancreatic α-amylase	Pancreatic juice	Small intestine	Starch $\xrightarrow{\text{Amylase}}$ Disaccharides
Trypsin			Proteins $\xrightarrow{\text{Trypsin}}$ Peptides
Chymotrypsin			Proteins $\xrightarrow{\text{Chymotrypsin}}$ Peptides
Carboxypeptidase			Peptides $\xrightarrow{\text{Carboxypeptidase}}$ Small peptide chain + Amino acids
Pancreatic lipase			Fats $\xrightarrow[\text{lipase}]{\text{Pancreatic}}$ Triglycerides + Diglycerides
Deoxyribonucleases			DNA $\xrightarrow{\text{DNase}}$ Deoxyribonucleotides
Ribonuclease			RNA $\xrightarrow{\text{RNase}}$ Ribonucleotides
Small intestine secretes Intestinal juice			
Enterokinase	Intestinal juice	Small intestine	Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin + Inactive peptide
Dipeptidase			Dipeptides $\xrightarrow{\text{Dipeptidases}}$ Amino acids
Disaccharidases			Maltose $\xrightarrow{\text{Maltose}}$ 2Glucose Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose
Intestinal lipase			Diglycerides and monoglycerides $\xrightarrow{\text{Lipases}}$ Fatty acids + Glycerol
Nucleotidase			Nucleotides $\xrightarrow{\text{Nucleotidase}}$ Nucleosides + Inorganic phosphate
Nucleosidase			Nucleosides $\xrightarrow{\text{Nucleosidase}}$ Nitrogenous bases + Pentose sugar

II. Absorption of Digested Products

- **Absorption** is the transfer of end products of digestion from the intestine to the circulatory fluids (blood and lymph).
- *It is of two types-passive and active.*

(a) Passive absorption (Passive transport): It is the absorption of nutrients from higher concentrated region to lower concentrated region without the expenditure of energy.

It includes **osmosis** (absorption of water) and **diffusion** (absorption of solute molecules).

Diffusion is of two types:

(i) **Simple diffusion:** In this, molecules alone can be diffused. E.g. absorption of vitamins, chloride ions etc.

(ii) **Facilitated diffusion:** Diffusion with the help of carrier ions like Na^+. E.g. Absorption of Fructose, mannose etc.

(b) Active absorption (Active transport): It is the **a**bsorption of nutrients from lower concentrated region to higher concentrated region (i.e. against concentration gradient). It needs energy. E.g. absorption of Amino acids, monosaccharides like glucose, electrolytes like Na+ etc.

Absorption in Different Parts of Alimentary Canal

- ➢ **Mouth:** Certain drugs.
- ➢ **Stomach:** Water, simple sugars, some drugs and alcohol.
- ➢ **Small intestine:** Almost all nutrients including minerals, vitamins etc.
- ➢ Ileum is the chief area of absorption due to its great length and coiled nature and the presence of villi (which increases the surface area of absorption).
- ➢ **Large intestine:** Water, some minerals and some drugs.

- The absorbed materials are then incorporated into tissues for their activities. It is called assimilation.
- The undigested substances like plant fibres, dead bacteria etc form faeces. It enters into caecum through the ileocaecal valve, which prevents back flow of faeces.
- Faeces are temporarily stored in rectum and are eliminated through anus. It is called egestion (defaecation).

Absorption of carbohydrates

- Carbohydrates are absorbed as monosaccharides in stomach and jejunum.
- Glucose and Galactose are absorbed by active pump of cell membrane.
- Fructose is absorbed by facilitated transport.

Absorption of amino acids

- Amino acids are absorbed mainly in the duodenum and jejunum.
- Amino acids are absorbed by active transport while some are absorbed by facilitated transport.

Absorption of lipids

- Fat absorption is an active process. During fat digestion, fats are hydrolysed into fatty acids and glycerol. However, since these are water insoluble, they cannot be directly absorbed by the blood. Hence, they are first incorporated into small droplets called micelles and then transported into the villi of the intestinal mucosa.
- They are then reformed into small microscopic particles called chylomicrons, which are small, protein-coated fat globules.
- These chylomicrons are transported to the lymph vessels in the villi. From the lymph vessels, the absorbed food is finally released into the blood stream and from the blood stream, to each and every cell of the body.

Absorption of water

- About 90% of all water absorption takes place in the small intestine by osmosis.

III. Assimilation

Assimilation is anabolic process in which the absorbed food is taken in by body cells and used for energy, growth and repair.
For example,

Assimilation of monosaccharides:

(a) The excess of monosaccharides like glucose, fructose and galactose are usually stored in the liver and muscle cells in the form of glycogen. This process is known as glycogenesis. Whenever there is a deficiency of glucose in the blood, the glycogen is broken down into glucose by a process known as glycogenolysis.
(b) Some of the glucose from digested food is broken down into carbon dioxide and water along with the release of energy.
(c) A considerable amount of glucose is converted into fat and stored as such.

Assimilation of amino acids

(a) Amino acids are used to make proteins required by the cells.
(c) Excess amino acids can be converted into glucose and then to fat and are thus stored. This is an irreversible reaction.

Assimilation of fat

(a) Fat is stored in the body as subcutaneous layers. It is a readily available source of fuel for the cells.
(c) In the liver, fats are converted into amino acids and carbohydrates.

IV. Egestion or Defecation

- Egestion is the process of elimination of faeces (waste matter) from the alimentary canal.
- The remaining undigested food gradually passes from small intestine into the colon. The colon absorbs most of the water.
- A bacterium called *Escherichia coli* lives in the colon which feeds on undigested matter. This bacterium in turn produces vitamin B_{12}, Vitamin K, Vitamin B_1 and Vitamin B_2 which are absorbed by the wall of colon.
- Consequently, the chyme gets converted into semi-solid faeces.
- The semi-solid faeces are stored in the last part of the large intestine called rectum for some time.
- Later, when we go to toilet, this undigested, semi-solid waste is forced to pass out form our body through anus in the form of faeces. This process is known as **egestion.**
- The ***anus*** contains rings of muscular muscle called the anal ***sphincter (circular voluntary muscles)*** that allow the body to control timing of elimination to some extent.
- The faeces is formed of 75% water and 25% solid matter which is further formed of undigested roughage (30%), fats (20%), proteins (3%) and bacteria (3%).

- The yellow colour of faeces is due to bile pigments especially bilirubin.

CALORIFIC VALUE OF PROTEINS, CARBOHYDRATES AND FATS

- Calorie is defined as the energy required to raise the temperature of 1g of water by 1°C at normal atmospheric pressure. The unit to measure calorie is **kcal**.
- The caloric values of different food items are different.
- The amount of heat liberated from complete combustion of 1 g food in a bomb calorimeter is its calorific value.
- The gross calorific values of
  - ➢ Carbohydrates: 4.1 kcal/g
  - ➢ Protein: 5.65 kcal/g
  - ➢ Fat: 9.45 kcal/g
- The physiological calorific value of food is the actual amount of energy liberated in the human body due to combustion of 1 g of food.
- It is always less than gross calorific value calculated by bomb calorimeter.
- The physiological calorific value of
  - ➢ Carbohydrate: 4 kcal/g
  - ➢ Protein: 4 Kcal/g
  - ➢ Fat: 9 Kcal/g, which is about 2.25 times more than the energy provided by same amount of glucose.
- Although fats yield more energy per gram (9 kcal/g) and proteins (4 kcal/g) yield just as much, carbohydrates are preferred as regular sources of energy. This is because they contain more oxygen molecules and therefore require lesser number of oxygen molecules for oxidation to give energy. Almost 80% of our energy requirements are met by carbohydrates.

DISORDERS OF DIGESTIVE SYSTEM

(i) Jaundice: In jaundice, the skin and eye turns yellow due to the deposition of bile pigments. It indicates liver damage.

(ii) Vomiting: Vomiting is the ejection of stomach content through mouth. During vomiting, the food moves in the opposite direction *i.e.* from stomach to mouth, by a process known as anti-peristalsis in oesophagus. It is controlled by medulla oblongata.

(iii) Diarrhoea: Diarrhoea is a diseased condition in which a person passes out watery stools frequently. It reduces the absorption of food. It basically leads to loss of water from the body of a person through watery stools. The process is known as dehydration.

(iv) Constipation: Constipation is infrequent elimination of dry stool. It is due to decreased peristalsis in colon.

(v) Indigestion: Indigestion is the condition leading to feeling of fullness due to improper digestion. It is due to anxiety, inadequate enzyme secretion, food poisoning, spicy food etc.

(vi) Dysentery: Dysentery is a frequent watery stool often with blood and mucus and with pain, fever and causes dehydration.

Nutritional disorders due to deficiency of dietary component:

- The diseases which occur due to deficiency of one or more nutrients (proteins, carbohydrates, vitamins and minerals) in our diet are called **deficiency diseases**.
- **Malnutrition** is the condition caused by not getting enough food or right kind of food.
- The deficiency diseases are of three types:
  - ➢ Protein Energy Malnutrition (PEM)
  - ➢ Mineral deficiency diseases
  - ➢ Vitamin deficiency diseases

1. Protein energy malnutrition (PEM)

- The growing children suffer from protein-energy malnutrition as they require more proteins for their growth and development.
- It occurs due to two reasons:
  - ➢ Lack of proteins in the diet
  - ➢ More intake of carbohydrate than proteins
- Protein energy malnutrition results in two diseases: Kwashiorkor and Marasmus.

(a) Kwashiorkor: This disease develops in children whose diets are deficient of protein. It occurs in children between 6 months and 3 years of age.

Symptoms:

- ➢ under weight
- ➢ has protruding belly
- ➢ the skin is dark and scaly
- ➢ has enlarged liver
- ➢ has anaemia
- ➢ suffers from repeated diarrhoea
- ➢ stunted growth
- ➢ loss of appetite
- ➢ hair becomes reddish
- ➢ swelling of legs and feet due to retention of water by the cell (oedema)

Cure: The child suffering from kwashiorkor needs adequate amount of proteins.

(b) Marasmus: It is caused due to the deficiency of carbohydrates, fats and proteins. It usually affects infants below the age of one year.

Symptoms

- ➢ Shrivelled appearance of child as the stored fats and tissue proteins are catabolised for energy production.
- ➢ Folded skin.
- ➢ Sunken eyes, thin face, thinning of limbs and abdominal walls.
- ➢ Retarded physical and mental growth.
- ➢ Ribs become prominent (Pigeon chest), as fat layer beneath the skin disappears.
- ➢ Oedema and skin pigmentation are absent.

Cure: The child suffering from marasmus needs adequate amount of proteins, fats and carbohydrates.

2. Mineral deficiency diseases

(i) Deficiency of Iron: Causes Anaemia. Deficiency of iron results in reduction of red blood cells. This reduces the oxygen carrying capacity of blood.

Symptoms: A person becomes pale, tires easily, loses appetite and loses weight.

Cure: This disease can be cured by eating food stuff rich in iron and vitamin B_{12}, e.g. eggs, meat, liver, milk, green leafy vegetables, such as spinach and fruits like apple, banana, guava (Iron tablets and tonics can also supplement the food).

(ii) Deficiency of Calcium and Phosphorus: Causes Rickets in children and Osteomalacia in adults.

Symptoms of Rickets:

- bones become soft, get deformed or bend easily,
- bow legs (bent legs),
- pigeon chest,
- loss of teeth enamel (outer shiny layer in teeth), and
- tender (soft) bones that tend to fracture easily.

Symptoms of Osteomalacia:

- softening of bones
- pain in bones which tend to fracture easily.

Cure: Rickets and osteomalacia can be prevented by giving diet rich in calcium and phosphorus like milk, cod liver oil, egg yolk, green leafy vegetables, etc.

(iii) Deficiency of Iodine: Causes Goitre and Cretinism

Symptoms of goitre:

- Enlargement of thyroid gland
- protruding eyes,
- stunted growth,
- puffy appearance
- irregular heart beat
- low intelligence

Symptoms of cretinism:

- stunted growth,
- retarded mental growth,
- delayed puberty and
- Low metabolic rate.

Cure: Use of iodised table salt and eating sea food, fish

(iv) Deficiency of Sodium and Potassium: Cause High blood pressure, and Oedema

Symptoms:

- Severe malnutrition
- High blood pressure
- Fatigue
- Loss of appetite
- Vomiting

Cure: Taking more of common salt, and eating fish, fruits, cereals, eggs, spinach, pulses, yogurt etc.

3. Vitamin deficiency diseases

Vitamins are grouped into two classes:

(a) Water soluble vitamins: Vitamins B complex and C

(b) Fat soluble vitamins: Vitamins A, D, E and K

Water Soluble Vitamins

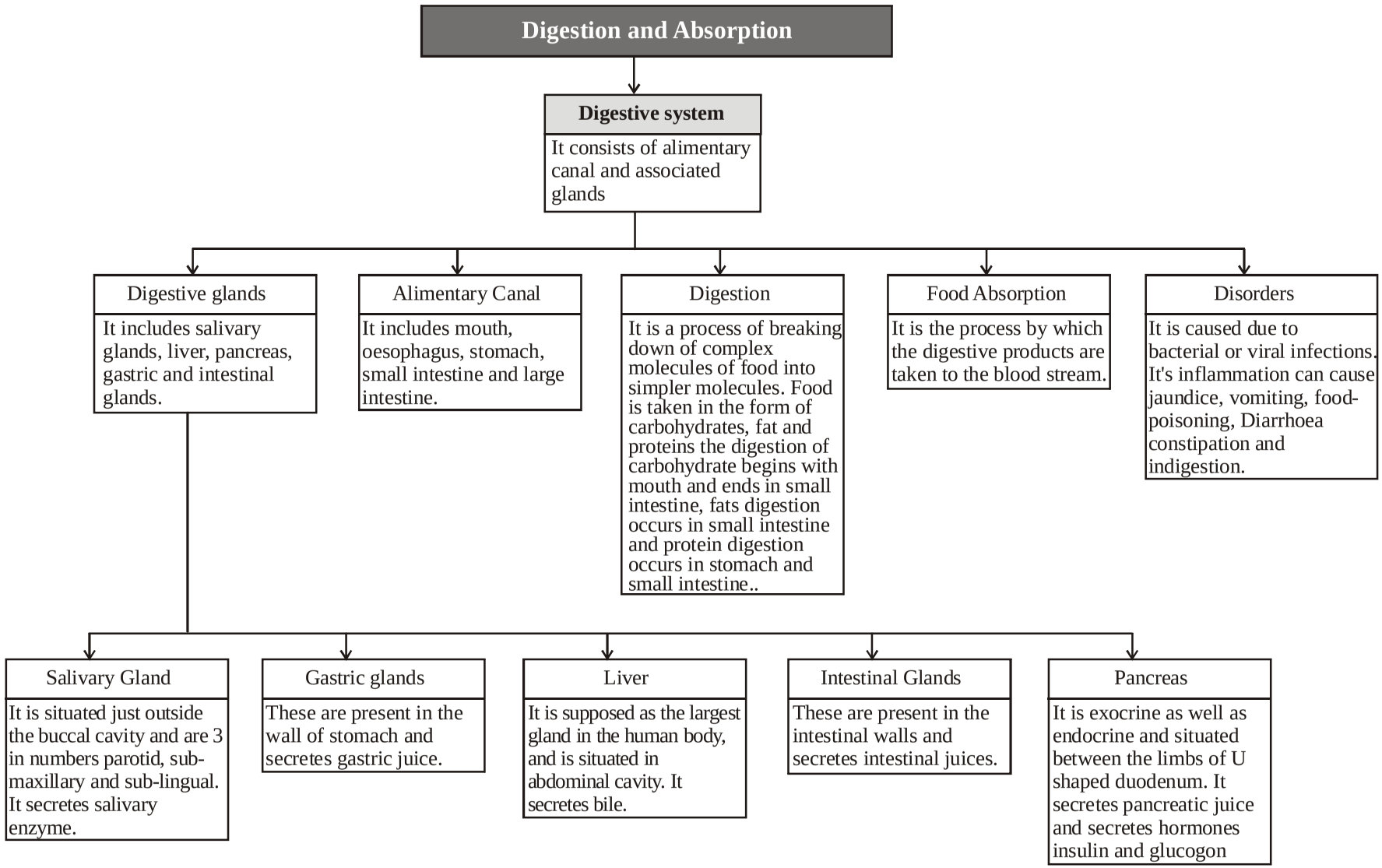
Vitamins	Function	Deficiency Disease	Symptoms	Sources
Vitamin B_1 (Thiamine)	Part of an enzyme, Needed for energy metabolism; Important to nerve function	Beri beri	Pain in hands and feet, Swelling of body, Paralysis of limbs, Oedema	Found in all nutritious foods in moderate amounts: pork, whole-grain or enriched breads and cereals, legumes, nuts and seeds
Vitamin B_2 (Riboflavin)	Part of an enzyme, Needed for energy, metabolism; Important for normal vision and skin health	Cheilosis	Retarded growth and mental disorder, Cracking of skin at corners of mouth, Lesions of eyes	Milk and milk products; leafy green vegetables; whole-grain, enriched breads and cereals
Vitamin B_3 (Niacin)	Coenzyme for fat, protein, and carbohydrate metabolism; Important for nervous system, digestive system, and skin health	Pellagra	Dermatitis, diarrhoea, Mental disorder	Meat, poultry, fish, whole-grain or enriched breads and cereals, vegetables (especially mushrooms, asparagus, and leafy green vegetables), peanut butter
Folic acid	Part of an enzyme, Needed for making DNA and new cells, especially red blood cells	Macrocytic anaemia (Megaloblastic anaemia)	Presence of large, immature or malformed RBCs in blood, stunted growth, Impairment of antibody synthesis	Leafy green vegetables and legumes, seeds, orange juice, and liver; now added to most refined grains
Vitamin B_{12} (Cyanocobalamin)	Part of an enzyme, Needed for making new cells; Important to nerve function	Pernicious anaemia	Paleness of skin, breathlessness, retarded growth	Meat, poultry, fish, seafood, eggs, milk and milk products; not found in plant foods
Vitamin C (Ascorbic acid)	Antioxidant; Part of an enzyme, Needed for protein metabolism; Important for immune system health; Aids in iron absorption	Scurvy	Bleeding gums, pain in joints, general weakness	Found only in fruits and vegetables, especially citrus fruits, vegetables in the cabbage family, cantaloupe, strawberries, peppers, tomatoes, potatoes, lettuce, papayas, mangoes, kiwi fruit

Fat soluble Vitamins

Nutrient	Functions	Deficiency disease	Symptoms	Sources
Vitamin A (Retinol)	Needed for vision, healthy skin and mucous membranes, bone and tooth growth, immune system health	Night blindness, Xerophthalmia	Cannot see in dimlight, Retarded keratinization of epithelia	Vitamin A from animal sources (retinol): fortified milk, cheese, cream, butter, fortified margarine, eggs, liver Beta-carotene (from plant sources): Leafy, dark green vegetables; dark orange fruits (apricots, cantaloupe) and vegetables (carrots, winter squash, sweet potatoes, pumpkin)
Vitamin D Needed for proper absorption of calcium; stored in bones		Rickets in children,	Failure of growing bones to calcify, bow legs, Pigeon chest Softening of bones	Egg yolks, liver, fatty fish, fortified milk, fortified margarine. When exposed to sunlight, the skin can make vitamin D.
		Osteomalacia in adults	Painful bones, Spontaneous fracture	
Vitamin E	Antioxidant; Protects cell walls	Reproductive failure in males and females	Sterility in males, miscarriage, or death of embryos during pregnancy in females	Polyunsaturated plant oils (soybean, corn, cottonseed, safflower); leafy green vegetables; wheat germ; whole-grain products; liver; egg yolks; nuts and seeds
Vitamin K	Needed for proper blood clotting	Faulty blood clotting, Haemorrhage	Delayed blood clotting	Leafy green vegetables and vegetables in the cabbage family; milk; also produced in intestinal tract by bacteria

Disorders caused due to over nutrition

Disorder	Excess Nutrient	Symptoms
Obesity	Excessive intake of food calories deficient of water	Excessive accumaltion of fats. High blood pressure. Increased chances of heart disorders and diabetes.
Hypercholesterolemia	Saturated fats like butter, ghee, hydrogenated vegetable oils and eggs	Increased level of cholesterol in blood. Arteriosclerosis and high blood pressure. Coronory thrombosis and heart attack.
Hypervitaminosis A	Vitamin A	Loss of hair. Drowsiness Painful swelling of long bones. Loss of appetite. Nausea and vomiting.
Hypervitaminosis D	Vitamin D	Deposition of calcium in soft tissues of body like kidneys. Drowsiness. Nausea Vomiting.
Fluorosis	Fluoride	Defective teeth with mottled enamel. Loss of shiny appearance White patches on teeth.


Digestion and Absorption
Digestive system
It consists of alimentary canal and associated glands
Digestive glands
It includes salivary glands, liver, pancreas, gastric and intestinal glands.
Alimentary Canal
It includes mouth, oesophagus, stomach, small intestine and large intestine.
Digestion
It is a process of breaking down of complex molecules of food into simpler molecules. Food is taken in the form of carbohydrates, fat and proteins the digestion of carbohydrate begins with mouth and ends in small intestine, fats digestion occurs in small intestine and protein digestion occurs in stomach and small intestine..
Food Absorption
It is the process by which the digestive products are taken to the blood stream.
Disorders
It is caused due to bacterial or viral infections. It's inflammation can cause jaundice, vomiting, food-poisoning, Diarrhoea constipation and indigestion.
Salivary Gland
It is situated just outside the buccal cavity and are 3 in numbers parotid, sub-maxillary and sub-lingual. It secretes salivary enzyme.
Gastric glands
These are present in the wall of stomach and secretes gastric juice.
Liver
It is supposed as the largest gland in the human body, and is situated in abdominal cavity. It secretes bile.
Intestinal Glands
These are present in the intestinal walls and secretes intestinal juices.
Pancreas
It is exocrine as well as endocrine and situated between the limbs of U shaped duodenum. It secretes pancreatic juice and secretes hormones insulin and glucogon

EXERCISE - 1
Conceptual Questions

1. The centre of hunger or centre which regulates the amount of food we eat or out appetite is located in –
(a) Medulla (b) Cerebrum
(c) Hypothalamus (d) Alimentary canal

2. The lymph vessels called lacteals are found in –
(a) Mammary glands (b) Pancreas
(c) Mucosa of intestine (d) Villi of ileum

3. Pylorus occurs between –
(a) Ileum and rectum
(b) Duodenum and ileum
(c) Stomach and deodenum
(d) Oesophagus and stomach

4. Parotid salivary glands are present –
(a) Below the tongue
(b) Below the ears
(c) In the angle between two jaws
(d) Below the eye orbits

5. Essentially the word 'digestion' means
(a) burning of food (b) oxidation of food
(c) hydrolysis of food (d) breakdown of bood

6. Which is the element that hardens the tooth enamel ?
(a) Calcium (b) Fluorine
(c) Iodine (d) Sodium

7. Caecum is large for digestion of cellulose with the help of symbiotic bacteria in
(a) Man (b) Rabbit
(c) Cat (d) Frog

8. Intestinal villi are more numerous and larger in posterior part of small intestine than in anterior part, because
(a) digestion is faster in posterior part
(b) blood supply is poorer is anterior part
(c) blood supply is poorer in posterior part
(d) there is more of digested food in posterior part

9. Protein coated small fat globules for absorption are called
(a) Chylomicrons (b) Micelles
(c) Lacteals (d) None of these

10. Ptyalin of saliva acts in
(a) slightly alkaline (7.8) medium
(b) slightly acidic (6.8) medium
(c) neutral (7.00) medium
(d) strongly acidic (3.2) medium

11. Oxyntic cells are located in
(a) Islets of Langerhans and secrete glucagon
(b) Gastric epithelium and secrete pepsin
(c) Gastric glands and secrete HCl
(d) Kidneys and secrete renin

12. The intestine in human body is about 29 feet long, because
(a) it provides more area for food storage
(b) bacteria contained in food may gradually be killed
(c) more length increases food digestion and absorption
(d) None of these

13. Crypts of lieberkuhn are present in
(a) intestine (b) stomach
(c) oesophagus (d) all of these

14. The structure which prevents entry of good into windpipe during swallowing in mammals is
(a) larynx (b) pharynx
(c) glottic (d) epiglottis

15. The hardest substance in vertebrate body is
(a) enamel (b) keratin
(c) dentine (d) chondrin

16. Epithelium that forms the inner lining of stomach wall
(a) cuboidal (b) ciliated
(c) squamous (d) columnar

17. Which of the following is not a proteolytic enzyme ?
(a) Chymotrypsin (b) Rennin
(c) Steapsin (d) All of these

18. Jaundice is a disorder of
(a) Excretory system (b) Skin and eyes
(c) Digestive system (d) Circulatory system

19. When gall bladder of a man is removed
(a) fat digestion is not possible
(b) acidity continues in duodenum
(c) effect of pancreatic juice upon food is impaired
(d) All of these

20. Which set of organ and histological structures present in it is correct ?
(a) Stomach–goblet cells, Brunner's glands, zymogen cells
(b) Intestine–goblet cells, crypts of Leiberkuhn, submucosa
(c) Lung–vocal sacs, bronchioles, bronchus
(d) Kidney–glomerulus, alveoli, loops of Henle

21. Functional units of absorption of digested food are
(a) Payer's patches (b) villi
(c) crypts of Leiberkuhn (d) Brunner's gland

22. The sphincter of Oddi is present between
(a) Oesophagus and cardiac stomach
(b) Pyloric stomach and duodenum
(c) Hepatic duct and cystic duct
(d) Hepatopancreatic duct and duodenum

23. The tongue is attached to the floor of oral cavity by
(a) Papillae (b) Frenulum
(c) Uvula (d) Gullet

24. Which is correct pairing of site of action and substrate of rennin ?
(a) Stomach – fat (b) Small intestine – protein
(c) Stomach – casein (d) Mouth – starch

25. Digestion of proteins, fats and carbohydrate is completed in
(a) Stomach (b) Duodenum
(c) Ileum (d) None of these

26. The swallowing of food from buccal cavity into oesophagus is a reflex action controlled by –
(a) Brain (b) Medulla oblongata
(c) Hormones (d) Peripheral nerves

27. Glucose, some amino acids and sodium are absorbed in to blood by
(a) Simple diffusion
(b) Active transport
(c) Facilitated transport
(d) The statement is incorrect since they are absorbed in lymph and not in blood

28. Gastric juice does not contain
(a) Lipase (b) Rennin
(c) Protease (d) Amylase

29. The products of protein digestion the amino acids are absorbed in the ileum through –
(a) Lacteals of villi
(b) Blood capillaries of villi
(c) Both (a) and (b)
(d) Muscularis mucosa of villi

30. Gastric juice contains which of the following enzymes?
(a) Pepsin and renin
(b) Amylase, pepsin and lipase
(c) Amylase and pepsin
(d) Insulin and glucagon

31. Function of galbladder is
(a) storage of bile (b) formation of enzymes
(c) synthesis of bile (d) formation of bile salts

32. After absorption of digested lipids by lymphatics of small intestine, these become milky, then these lipoprotein droplets are called as –
(a) Chyme (b) Chyle
(c) Chylomicron (d) Micelles

33. Hydrolysis of phospholipids yields –
(a) Glycerol, phosphoric acid and fatty acids
(b) Glycerol, phosphoric acid and nitrogen base
(c) Glycerol & fatty acids
(d) Acetyl coA

34. The food that gives more calories per unit mass of food is
(a) Protein (b) Carbohydrates
(c) Fat (d) Water

35. The utilization of absorbed food substances by tissues is called
(a) Deglutition (b) Assimilation
(c) Emulsification (d) Constipation

36. The hydrolytic action of the following enzyme produces pentose sugar
(a) Amylase (b) Sucrase
(c) Nucleotidase (d) None of these

37. Which of the following substance can be assimilated unchanged ?
(a) Vitamin (b) Starch
(c) Proteins (d) Lipids

38. Secretion of hormone cholecystokinin is for –
(a) Controlling blood pressure
(b) Absorbtion of iron
(c) Bile functions
(d) Release of insulin

39. Trypsinogen is produced by –
(a) Liver (b) Duodenum
(c) Stomach (d) Pancreas

40. Enterokinase is
(a) A hormone that prevents the secreton of gastric juice
(b) An enzyme that activates the enzymes of pancreatic juice
(c) An enzyme that activates the proteolytic enzymes of succus entericus
(d) A hormone that prevents the secretion of pancreatic juice

41. Hydrolysis by following enzyme produces only glucose
(a) Amylase (b) Sucrase
(c) Lactase (d) Maltase

42. Contraction of gall bladder is induced by
(a) Gastrin (b) Cholecystokinin
(c) Secretin (d) Enterogastrone

43. Fatty acid and glycerol are first taken up from alimentary canal by
(a) Villi (b) Blood capillaries
(c) Hepatic portal vein (d) Lymph vessels

44. Meals which are rich in fat are not digested in the intestine in absence of
(a) Pepsin (b) Enterokinase
(c) Insulin (d) Steapsin

45. Enzyme trypsin is secreted by
(a) Duodenum (b) Liver
(c) Pancreas (d) Stomach

46. Lysozyme, that is present in perspiration, saliva and tears, destroys.
(a) most virus-infected cells (b) certain fungi
(c) certain types of bacteria (d) all viruses

47. Mammals may drink water and also get it from
(a) Breakdown of glycogen into glucose
(b) Secretion of saliva
(c) Oxidation of glucose
(d) Conversion of oxyhaemoglobin into haemoglobin

48. When a piece of bread in chewed it tastes sweet because
(a) The sugar contents are drawn out
(b) Saliva converts starch into maltose
(c) It does not taste sweet
(d) The taste buds are stimulated by chewing

49. Herbivorous animals can digest cellulose because
(a) their molar and premolar teeth can crush and grind the food
(b) bacteria present in their caecum help in digestion of cellulose
(c) gastric juice has a digestive enzyme for cellulose digestion
(d) alimentary canal is very long.

50. Part of alimentary canal meant for reabsorption of the maximum H_2O is
(a) Small intestine (b) large intestine
(c) rectum (d) colon

51. Which are the end products of carbodydrate digestion ?
(a) Glucose, galactose, fructose
(b) Sucrose, galactose, maltose
(c) Galactose, glucose, maltose
(d) None of these

52. Pancreatic juice takes part in digestion of
(a) proteins and carbodydrates
(b) proteins, fats and carbohydrates
(c) proteins and fats
(d) proteins only

53. A carbohydrate splitting enzyme is secreted by
(a) liver
(b) zymogen cells of gastric glands
(c) salivary glands
(d) crypts of Leiberkuhn

54. The common bile duct in humam is formed by the joining of
(a) Pancreatic duct and bile duct
(b) Cystic duct and hepatic duct
(c) Cystic duct and pancreatic duct
(d) Hepatic duct and pancreatic duct

55. Stomach is the site of digestion of
(a) carbohydrates (b) fats
(c) proteins (d) All of these

56. Hormone involved in discharge of pancreatic juice and contraction of gall bladder in mammals is
(a) secretin
(b) secretin and cholecystokinin
(c) gastrin
(d) enterogastrone

57. Jaundice may be caused by retarded function of
(a) Lungs (b) Kidneys
(c) Heart (d) Liver

58. Succus entericus is secreted by —
(a) islets of Langerhans
(b) gastric glands
(c) uterine crypts
(d) crypts of Leiberkuhn and Brunner's glands

59. Chymotrypsin acts upon
(a) proteins in duodenum in alkaline medium
(b) starch in duodenum
(c) proteins in stomach
(d) proteins in duodenum in acidic medium

60. Emulsification of fat by bile occurs in
(a) liver (b) pancreas
(c) duodenum (d) stomach

61. Which one does not produce any digestive enzyme ?
(a) Acini of Pancreas (b) Liver
(c) Stomach (d) Duodenum

62. Digestion of fats, proteins and carbohydrates is completed in
(a) liver (b) large intestine
(c) stomach (d) small intestine

63. Pancreatic lipase acts upon
(a) glycogen (b) triglycerides
(c) disachharides (d) polypeptides

64. Stomach in vertebrates is the chief site of digestion of
(a) Proteins (b) Carbohydrates
(c) Fats (d) All

65. The substrate for amylase is
(a) Proteins (b) Fats
(c) Starch (d) Cane sugar

66. As HCl is to pepsinogen, so is enterokinase to
(a) renin (b) trypsinogen
(c) pectin (d) none of these

67. Which of the following processes is helped by bile salts?
(a) $\text{Nucleic acid} \xrightarrow[\text{Nuclease}]{} \text{Nucleotides} \xrightarrow[\text{Nucleotidase}]{} \text{Nucleosides} \xrightarrow[\text{Nucleosidase}]{} \text{Sugar} + \text{bases}$
(b) $\text{Sucrose} \xrightarrow[\text{Sucrase}]{} \text{Glucose} + \text{Fructose}$
(c) $\text{Fats} \xrightarrow[\text{Lipase}]{} \text{Diglycerides} \longrightarrow \text{Monoglycerides}$
(d) $\left.\begin{matrix}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{matrix}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/Chymotrypsin}} \text{Dipeptides}$

68. Which part of the alimentary canal does not secrete any enzyme?
(a) Mouth (b) Oesophagus
(c) Stomach (d) Duodenum

69. Rennin acts on milk protein and changes
(a) Caesinogen into caesin
(b) Caesin into paracaesin
(c) Caseinogen into paracaesin
(d) Paracaesin into caesinogen

70. A patient is generally advised to specially, consume more meat, lentils, milk and eggs in diet only when he suffers from
(a) Scurvy (b) Kwashiorkor
(c) Rickets (d) Anaemia

71. Which of the following enzyme/digest milk protein in alkaline medium ?
(a) Pepsin (b) Trypsin
(c) Rennin (d) Chymotrypsin

72. Which one of the following is a fat-soluble vitamin and its related deficiency disease?
(a) Retinol – Xerophthalmia
(b) Cobalamine – Beri-beri
(c) Calciferol – Pellagra
(d) Ascorbic acid – Scurvy

73. The absorption of water alcohol and simple sugars occurs in
(a) Oral mucosa (b) Gastric mucosa
(c) Mucosa of ileum only (d) Mucosa

74. Carbohydrases are missing from
(a) Intestinal juice (b) Pancreatic juice
(c) Gastric juice (d) Saliva

75. Which one of the following correctly represents the normal adult human dental formula ?
(a) $\frac{3}{3},\frac{1}{1},\frac{3}{2},\frac{1}{1}$ (b) $\frac{2}{2},\frac{1}{1},\frac{3}{2},\frac{3}{3}$
(c) $\frac{2}{2},\frac{1}{1},\frac{2}{2},\frac{3}{3}$ (d) $\frac{3}{3},\frac{1}{1},\frac{3}{3},\frac{3}{3}$

EXERCISE - 2
Applied Questions

1. Anxiety and eating spicy food together in an otherwise normal human, may lead to
(a) Indigestion (b) Jaundice
(c) Diarrhoea (d) Vomiting

2. Epithelial cells of the intestine involved in food absorption have on their surface
(a) pinocytic vesicles (b) microvilli
(c) zymogen granules (d) phagocytic vesicles

3. Secretin and cholecystokinin are digestive hormones. They are secreted in
(a) Pyloric stomach (b) Duodenum
(c) Ileum (d) Oesophagus

4. Angiotensinogen is a protein produced and secreted by
(a) endothelial cells (lining the blood vessels)
(b) liver cells
(c) juxtaglomerular (JG) cells
(d) macula densa cells

5. What will happen if the secretion of parietal cells of gastric glands is blocked with an inhibitor?
(a) Gastric juice will be deficient in chymosin.
(b) Gastric juice will be deficient in pepsinogen.
(c) In the absence of HCI secretion, inactive pepsinogen is not converted into the active pepsin enzyme.
(d) Enterokinase will not be released from the duodenal mucosa and so trypsinogen is not converted to trypsin.

6. Which one of the following is the correct matching of the site of action, substrate, and the end product?
(a) Duodenum : Triglycerides : Monogly-cerides
(b) Small inestine : Starch : Disaccharide (Maltose)
(c) Small intestine : Proteins : Amino acids
(d) Stomach : Fats : Micelles

7. When breast feeding is replaced by less nutritive food low in proteins and calories; the infants below the age of one year are likely to suffer from
(a) Rickets (b) Kwashiorkor
(c) Pellagra (d) Marasmus

8. A young infant may be feeding entirely on mothers milk which is white in colour but the stools which the infant passes out is quite yellowish. What is this yellow colour due to ?
(a) bile pigments passed through bile juice
(b) undigested milk protein casein
(c) pancreatic juice poured into duodenum
(d) intestinal juice

9. Which one of the following statements is true regarding digestion and absorption of food in humans?
(a) Fructose and amino acids are absorbed through intestinal mucosa with the help of carrier ions like Na^+.
(b) Chylomicrons are small lipoprotein particles that are transported from intestine into blood capillaries.
(c) About 60% of starch is hydrolysed by salivary amylase in our mouth
(d) Oxyntic cells in our stomach secrete the proenzyme pepsinogen.

10. If for some reason our goblet cells are non functional, this will adversely affect:
(a) production of somatostatin
(b) secretion of sebum from the sebaceous glands
(c) maturation of sperms
(d) smooth movement of food down to the intestine

11. Two friends are eating together on a dining table. One of them suddenly starts coughing while swallowing some food. This coughing would have been due to improper movement of

(a) epiglottis (b) diaphragm

(c) neck (d) tongue

12. Which one of the following enzymes carries out the initial step in the digestion of milk in humans?

(a) Pepsin (b) Rennin

(c) Lipase (d) Trypsin

13. Mark the incorrect statement in the followings

(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 of the circular layer of tunica muscularis

14. A patient of diabetes mellitus excretes glucose in urine even when he is kept on a carbohydrate free diet. The most likely reason for that is

(a) Amino acids are catabolised in the liver to form sugar

(b) Amino acids are discharged in the blood stream from the liver

(c) Fats are catabolised to form glucose

(d) None of these

15. A healthy person eats the following diet - 5 gm raw sugar, 4 gm albumin, 10 gm pure buffalo ghee adultrated with 2 gm vegetable ghee (hydrogenated vegetable oil) and 5 gm lignin. How many calories he is likely to get?

(a) 144 (b) 126

(c) 164 (d) 112

16. Which enzymes are likely to act on the baked potatoes eaten by a man, starting from the mouth and as it moves down the alimentary canal?

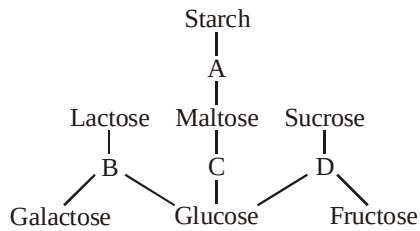
(a) Salivary maltase → carboxypeptidase → trypsinogen

(b) Pancreatic amylase → salivary amylase → lipases

(c) Disaccharidase like maltase → lipases → nucleases

(d) Salivary amylase → pancreatic amylase → disaccharidases

17. Identify enzymes A, B, C and D in digestion of carbohydrates



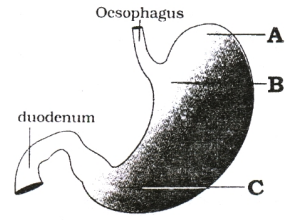
(a) A - Amylase, B - Invertase, C - Maltase, D - Lactase

(b) A - Amylase, B - Lactase, C - Maltase, D - Invertase

(c) A - Amylase, B - Maltase, C - Lactase, D - Invertase

(d) A - Amylase, B - Maltase, C - Invertase, D - Lactase

18.



Anatomical regions of human stomach are –

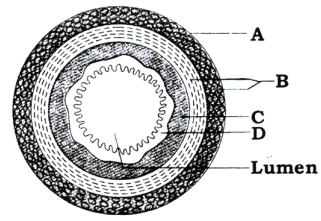
(a) A - Fundus; B - Pyloric; C - Cardiac

(b) A - Cardiac; B - Fundus; C - Pyloric

(c) A - Fundus; B - Cardiac; C - Pyloric

(d) A - Pyloric; B - Fundus; C - Cardiac

19. The below diagram repesents the T.S. of Gut. Identify A, B, C and D –



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

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

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

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

20. Match Column - I with Column - II

	Column - I		**Column - II**
A.	Salivary amylase	1.	Proteins
B.	Bile salts	2.	Milk proteins
C.	Rennin	3.	Starch
D.	Pepsin	4.	Lipids

(a) A → 3; B → 4; C → 2; D → 1

(b) A → 3; B → 4; C → 1; D → 2

(c) A → 4; B → 3; C → 2; D → 1

(d) A → 1; B → 2; C → 3; D → 4

21. Match Column - I with Column - II

	Column - I		**Column - II**
A.	Neck cells	1.	HCl, Intrinsic factor
B.	Peptic / Chief cells	2.	Mucus
C.	Parietal / Oxyntic	3.	Pepsinogen

(a) A → 2; B → 3; C → 1

(b) A → 3; B → 2; C → 1

(c) A → 1; B → 2; C → 3

(d) A → 2; B → 1; C → 3

22. Which of the following statements is incorrect?
(1) Absorption of simple sugar, alcohol, some water and medicines takes place in stomach.
(2) Maximum water absorption occurs in small intestine.
(3) Small intestine is the major site of digestion and absorption of food.
(4) Fatty acid and glycerol are absorbed by lacteals.
(5) Nothing is absorbed in mouth and large intestine.
(a) (1), (4) and (5) (b) (5)
(c) (4) (d) (2) and (3)

23. Which of the following statement is wrong about chylomicrons?
(1) Chylomicrons are produced in the epithelial cells of small intestinal.
(2) It contains triglycerides, cholesterol and phospholipids.
(3) It is protein coated small vesicles.
(4) Chylomicrons released from the epithelial cell into lacteals.
(a) (1) and (4) (b) (2) and (3)
(c) (1), (2), (3) and (4) (d) None of these

DIRECTIONS for Qs. 24 and 25 : Each questions contain STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.
(a) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1
(b) Statement -1 is True, Statement -2 is True ; Statement-2 is NOT a correct explanation for Statement - 1
(c) Statement - 1 is True, Statement- 2 is False
(d) Both the Statements are False.

24. **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.

25. **Statement 1 :** The main part of carbohydrate digestion takes place in small intestine.
Statement 2 : Here pancreatic amylase converts carbohydrates into lactose.

EXERCISE - 3
Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

1. Select what is not true of intestinal villi among following
(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

2. Hepato-pancreatic duct opens into the duodenum and carries
(a) bile
(b) pancreatic juice
(c) both bile and pancreatic juice
(d) saliva

3. One of the following is not a common disorder associated with digestive system
(a) Tetanus (b) Diarrhoea
(c) Jaundice (d) Dysentery

4. A gland not associated with the alimentary canal is
(a) pancreas (b) adrenal
(c) liver (d) salivary glands

5. Match the following columns and select the correct among options given

	Column I		Column II
A.	Biomacromolecules of food	1.	Alimentary canal and associated gland
B.	Human digestive system	2.	Embedded in Jaw bones
C.	Stomach	3.	Outer wall of visceral organs
D.	Thecodont	4.	Converted into simple substances
E.	Serosa	5.	J-shaped bag like structure

(a) A-2, B-1, C-5, D-3, E-4 (b) A-4, B-1, C-5, D-2, E-3
(c) A-1, B-2, C-3, D-4, E-5 (d) A-l, B-3, C-2, D-4, E-5

6. Match the following columns.

	Column I		Column II
A.	Duodenum	1.	A cartilaginous flap
B.	Epiglottis	2.	Small blind sac
C.	Glottis	3.	'U' shaped structure emerging from the stomach.
D.	Caecum	4.	Opening of wind pipe.

(a) A-l, B-2, C-3 , D-4
(b) A-4, B-3, C-2, D-1
(c) A-3, B-1, C-4, D-2
(d) A-2, B-4, C-1, D-3

7. Match the enzyme with their respective substrate and choose the right one among options given.

	Column I		Column II
A.	Lipase	1.	Dipeptides
B.	Nuclease	2.	Fats
C.	Carboxypeptidase	3.	Nucleic acids
D.	Dipeptidases	4.	Proteins, peptones and proteoses

(a) A-2, B-3, C-l , D-4 (b) A-3, B-4, C-2, D-1
(c) A-3, B-1, C-4, D-2 (d) A-2, B-3, C-4, D-1

8. Dental formula in human beings is

(a) $\frac{3223}{3223}$ (b) $\frac{2123}{2123}$

(c) $\frac{1232}{1232}$ (d) $\frac{2233}{2233}$

9. 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 gastrin

10. Mark the right statement among the following
(a) Trypsinogen is an inactive enzyme
(b) Trypsinogen is secreted by intestinal mucosa
(c) Enterokinase is secreted by pancreas
(d) Bile contains trypsin

NEET/AIPMT (2013-2017) Questions

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

	Column I	**Column II**
(a)	Fructose, Na^+	Small intestine, passive absorption
(b)	Glycerol, fatty acids	Duodenum, move as chylomicrons
(c)	Cholesterol, maltose	Large intestine, active absorption
(d)	Glycine, glucose	Small intestine, active absorption

12. A healthy person eats the following diet - 5 gm raw sugar, 4 gm albumin, 10 gm pure buffalo ghee adultrated with 2 gm vegetable ghee (hydrogenated vegetable oil) and 5 gm lignin. How many calories he is likely to get? ***[NEET Kar. 2013]***
(a) 144 (b) 126
(c) 164 (d) 112

13. Which enzymes are likely to act on the baked potatoes eaten by a man, starting from the mouth and as it moves down the alimentary canal? ***[NEET Kar. 2013]***
(a) Salivary maltase → carboxypeptidase → trypsinogen
(b) Pancreatic amylase → salivary amylase → lipases
(c) Disaccharidase like maltase → lipases → nucleases
(d) Salivary amylase → pancreatic amylase → disaccharidases

14. The initial step in the digestion of milk in humans is carried out by ***[2014]***
(a) Lipase (b) Trypsin
(c) Rennin (d) Pepsin

15. Fructose is absorbed into the blood through mucosa cells of intestine by the process called: ***[2014]***
(a) active transport (b) facilitated transport
(c) simple diffusion (d) co-transport mechanism

16. Which of the following statements is not correct? ***[2015 RS]***
(a) Goblet cells are present in the mucosa of intestine and secrete mucus
(b) Oxyntic cells are present in the mucosa of stomach and secrete HCl.
(c) Acini are present in the pancreas and secrete carboxypeptidase
(d) Brunner's glands are present in the submucosa of stomach and secrete pepsinogen

17. Gastric juice of infants contains : ***[2015 RS]***
(a) nuclease, pepsinogen, lipase
(b) pepsinogen, lipase, rennin
(c) amylase, rennin, pepsinogen
(d) maltase, pepsinogen, rennin

18. The primary dentition in human differs from permanent dentition in not having one of the following type of teeth : ***[2015 RS]***
(a) Premolars (b) Molars
(c) Incisors (d) Canine

19. The enzyme that is not present in succus entericus is : ***[2015 RS]***
(a) nucleases (b) nucleosidase
(c) lipase (d) maltase

20. In the stomach, gastric acid is secreted by the ***[2016]***
(a) gastrin secreting cells
(b) parietal cells
(c) peptic cells
(d) acidic cells

21. Which of the following guards the opening of hepatopancreatic duct into the duodenum ? ***[2016]***
(a) Semilunar valve (b) Ileocaecal valve
(c) Pyloric sphincter (d) Sphincter of Oddi

22. Which cells of "Crypts of Lieberkuhn" secrete antibacterial lysozyme ? ***[2017]***
(a) Paneth cells (b) Zymogen cells
(c) Kupffer cells (d) Argentaffin cells

23. The hepatic portal vein drains blood to liver from : ***[2017]***
(a) Stomach (b) Kidneys
(c) Intestine (d) Heart

24. Which of the following options best represents the enzyme composition of pancreatic juice? ***[2017]***
(a) amylase, pepsin, trypsinogen, maltase
(b) peptidase, amylase, pepsin, rennin
(c) lipase, amylase, trypsinogen, procarboxypeptidase
(d) amylase, peptidase, trypsinogen, rennin

25. 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? ***[2017]***
(a) Canines (b) Pre-molars
(c) Molars (d) Incisors

Hints & Solutions

EXERCISE - 1

1.	(c)	2.	(d)	3.	(c)	4.	(b)	5.	(c)	6.	(b)
7.	(b)	8.	(d)	9.	(a)	10.	(b)	11.	(c)	12.	(c)
13.	(a)	14.	(d)	15.	(a)	16.	(d)	17.	(c)	18.	(c)
19.	(d)	20.	(b)	21.	(b)	22.	(d)	23.	(b)	24.	(c)
25.	(c)	26.	(d)	27.	(b)	28.	(d)	29.	(b)	30.	(a)
31.	(a)	32.	(c)	33.	(a)	34.	(c)	35.	(b)	36.	(d)
37.	(a)	38.	(c)	39.	(d)	40.	(b)	41.	(d)		

42. (b) Contraction of gall bladder is induced by Cholecystokinin.

43. (d) Generally, fatty acids upto a chain length of 10 carbon atoms are primarily absorbed through the blood caillaries, but those with higher chain length through lymphatic route (lymph vessels).

44. (d) Pancreatic lipase (formely called steapsin) hydrolyses fats into glycerol and fatty acids.

45. (c) 46. (c)

47. (c) Mammals may drink water and also get it from oxidation of glucose.

48. (b) Because saliva converts starch into maltose.

49.	(b)	50.	(a)	51.	(a)	52.	(b)	53.	(c)	54.	(b)
55.	(c)	56.	(b)	57.	(d)	58.	(d)	59.	(a)	60.	(c)
61.	(b)	62.	(d)	63.	(b)	64.	(a)	65.	(c)	66.	(b)
67.	(c)	68.	(b)	69.	(b)						

70. (b) A child may have a diet containing sufficient carbohydrates and fats but still suffers a serious form of malnutrition. This form of malnutrition is known as Kwashiorkar. It develops in children whose diets are deficient in protein.

71. (d)

72. (a) Fat soluble vitamins are - A, D, E and K and lack of vitamin A causes xerophthalmia.

73. (b)

74. (c)

75. (c) The adult dental formula of human is Incisor $\frac{2}{2}$, Canine $\frac{1}{1}$, Premolar $\frac{2}{2}$, Molar $\frac{3}{3}$.

EXERCISE - 2

1. (a) Anxiety and eating spicy food together in normal healthy man can lead to indigestion which is difficulty in digestion.

2. (b) Presence of microvilli on the epithelial cells of intestine increases the surface area for absorption of food.

3. (b) Secretin and cholecystokinin are secreted in the duodenum.

Action

(i) Secretin : Releases bicarbonates in the pancreatic juice.

(ii) CCKPZ : contracts the gall bladder to release bile, stimulating pancreas to secrete and release digestive enzymes in the pancreatic juice.

4. (b) Angiotensinogen is a protein secreted by liver cells.

5. (c) If the secretion of parietal cells of gastric glands is blocked with an inhibitor, in the absence of HCI secretion, inactive pepsinogen is not converted into the active enzyme pepsin.

6. (b) Small intestine : Starch disaccharide (maltose)

Small intestine is the portion of the alimentary canal between the stomach and large intestine. It is subdivided into the duodenum, jejunum and ileum. It plays an essential role in the final digestion and absorption of food.

7. (d) If breast feeding is replaced by less nutritive food low in proteins and calories; the infants below the age of one year are likely to suffer from marasmus. Marasmus is a form of malnutrition that occurs when there is not enough protein in the diet.

8. (a) Young infant may be feeding entirely on mother's milk which is white in colour but the stools which the infant passes out is quite yellowish because bile pigments passed through bile juice. Bile pigments are any of several coloured compounds derived from porphyrin that are found in bile; principally bilirubin and biliverdin. Bile pigment is produced regularly when old red blood cells are broken down, mainly by the spleen. In some blood-disorders where the red cells are destroyed, more bile pigment is produced.

9. (a) Fructose and amino acids are absorbed through intestinal mucosa with the help of carrier ions like Na^+. Carbohydrates are absorbed as monosaccharides (simple sugars such as glucose, fructose, and galactose that cannot be further broken down by hydrolysis) or as disaccharides (such as sucrose, lactose, maltose, and dextrin that can be hydrolyzed to two monosaccharides). These simpler molecules, however, must be obtained by the breaking down of polysaccharides, (complex carbohydrates) that contain many monosaccharides.Chief among these is amylase, a starch that accounts for 20 percent of dietary carbohydrate.

10. (d) Goblet cells, found in the intestinal mucosal epithelium, secrete mucus. The mucus lubricates the food for an easy passage. So, if for some reason, goblet cells become non-functional, it will adversely affect the smooth movement of food down the intestine.

11. (a) The coughing would have been due to improper movement of epiglottis.

12. (b) Rennin is an enzyme that is essential for the protein digestion. It is active in low acid medium and inactive by normal gastic juice of adult.

13. (d) 14. (c)

15. (a) Physiological value of carbohydrates is 4.0 kcal/g, proteins 4.0 kcal/g and of fats is 9.0 kcal/g. Hence,
5 g raw sugar will yield
$5 \times 4.0 = 20.0$ kcal
4 g albumin (protein) will yield
$4 \times 4.0 = 16.0$ kcal
10 + 2 g of fat will yield
$12 \times 9.0 = 108.0$ kcal
Total yield = 144 kcal.

16. (d) Chemical process of digestion started in the oral cavity by the hydrolytic action of the carbohydrate (potato contains starch) splitting enzyme, the salivary amylase. Carbohydrates in the chyme are hydrolysed by pancreatic amylase into disaccharides.

17. (b) 18. (c) 19. (a) 20. (a) 21. (a)

22. (b) 23 (d)

24. (b) Presence of hydrochloric acid in stomach is necessary for digestion because 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.

25. (c) In small intestine pancreatic amylase converts starch and dextrins into maltoses and small intestine is main site for digestion of carbohydrates.

EXERCISE - 3

Exemplar Questions

1. (d) **Intestinal** villi are the numerous small finger-shaped projections in the small intestine which increase the absorptive surface area. They contain abundant blood capillaries and lymph vessels called **lacteals**. They also possess many minute microvilli which further add to the absorptive surface.
They do not participate in the digestion of fats but help in their **absorption** and absorption of various other food substances such as **water, mineral, salts, amino acids, vitamins,** etc.

2. (c) The **hepatic duct** from the liver and the duct of **gall bladder** form the **common bile duct**. The bile duct and the pancreatic duct together open into the duodenum as a common hepato-pancreatic duct which carries both **bile** and **pancreatic juice**.
Bile is secreted by the hepatic cells of liver and is further stored in a thin muscular sac called as the **gall bladder**. Secretion of pancreatic juices takes place through the exocrine part of the pancreas which consists of round lobules called **acini**. Saliva is produced mainly by the salivary glands.

3. (a) **Tetanus** is a medical condition characterised by a prolonged contraction of the skeletal muscle fibres. This disorder is not associated with digestive system.
Diarrhoea is the unusual frequency of bowel movement and increased liquidity of the faecal discharge. The absorptions of food is highly reduced in diarrhoea.
Jaundice represents one of the symptoms of liver malfunctioning in which bile is not excreted properly. Skin and eyes turn yellow due to the excess accumulation of bile pigments in the blood.
Dysentery is the inflammatory disorder of intestine, especially the colon, resulting in severe diarrhoea containing blood and mucus in the faeces, abdominal pain and fever.

4. (b) **Adrenal gland** is present at the anterior part of each kidney acting as an endocrine gland, involved in regulating body growth and developmental mechanisms. It is not associated with the alimentary canal.
Pancreas located posterior to the stomach in the abdominal cavity, is associated with the secretion of **alkaline pancreatic juices** which are essential in the digestion of starch, protein, fats and nucleic acid. Pancreas also produces hormones like glucagon, insulin, somatostatin are involved in glucose metabolism.
Liver is the largest gland in the body present in the upper right side of the abdominal cavity just below the diaphragm. It is mainly involved in the production of bile which helps in the digestion of fats in small intestine by **process of the emulsification**.
Salivary glands are situated just exterior to the buccal cavity. They discharge their secretions (salivary juices) in the oral cavity, which helps in the mastication of food.

5. (b) **Biomacromolecules of food** like carbohydrates, fats, proteins and nucleic acids are converted into simpler monomers during the process of digestion.
Human digestive system consists of alimentary canal and its associated glands.
Stomach is the widest organ of the alimentary canal. It is a J-shaped bag like structure, and peforms an important role in digestion.
Thecodont are teeth that are embedded in the sockets of the jaw bones.
Serosa is an another name for **serous membrane**, forming the outer wall of the visceral organs.

6. (c) **Duodenum** is a 'U'-shaped structure emerging from the stomach.
Epiglottis is a **cartilaginous flap** that prevents the entry of food into the glottis.
Glottis is the opening of the wind pipe.
Caecum is a small blind sac which hosts some symbiotic microorganisms that helps in the digestion process.

7. (d) **Lipase** is an enzyme that digests fat.
Nuclease digests nucleic acid.
Carboxypeptidase are the enzymes involved in the digestion of proteins, peptones and proteases.
Dipeptidases are the enzymes that break dipeptides into **amino acids**.

8. (b) An adult human possesses 32 permanent teeth which are of four different types, namely **Incisors** (I), **Canine** (C), **Premolar** (PM) and **Molar** (M). Arrangement of teeth in each half of the upper and lower jaw in the order I, C, PM, M is represented by a dental formula, which in humans is $\frac{2123}{2123}$.

9. (d) Liver is involved in the production of bile, which helps in the digestion of fats in the small intestine by the **emulsification process** (conversion of large fat droplets into small ones).
Liver also plays a critical role in controlling rate metabolism by maintaining the glucose concentration in the normal range. Gastrin is secreted by G-cells in the pyrolic region of stomach. It stimulates gastric glands to secrete and release gastric juices.

10. (a) **Trypsinogen** is an inactive pancreatic enzyme that is activated by enterokinase, an enzyme secreted by intestinal mucosa. Active form of trypsinogen is called trypsin, which in turn activates other enzymes present in the pancreatic juice.

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11. (d) Small intestine is major area of absorbtion of nutrients. Approximately 80% of absorbtion take place here. Glucose, fructose, fatty acids, amino acids (Glycine etc.) are absorbed through mucosa into blood and lymph by active absorbtion.

12. (a) Physiological value of carbohydrates is 4.0 kcal/g, proteins 4.0 kcal/g and of fats is 9.0 kcal/g. Hence,
5 g raw sugar will yield $5 \times 4.0 = 20.0$ kcal
4 g albumin (protein) will yield 4×4.0
$= 16.0$ kcal
$10 + 2$ g of fat will yield 12×9.0
$= 108.0$ kcal
Total yield = 144 kcal.

13. (d) Chemical process of digestion starts in the oral cavity by the hydrolytic action of the carbohydrate splitting enzyme, the salivary amylase. Carbohydrates in the chyme are hydrolysed by pancreatic amylase into disaccharides.

14. (c) Rennin (also called chymosin) is an enzyme that occurs in gastric juice and is a constituent of rennet. It coagulates milk by converting caseinogen to casein. The initial step in the digestion of milk in humans is carried out by rennin.

15. (b) Facilitated transport is a form of passive transport in which materials are moved across the plasma membrane by a transport protein down their concentration gradient; hence, it does not require energy.

16. (d) Duodenum contains Brunner's glands which secrete mucus and digestive juices.

17. (b) Gastric juice of infants contains pepsinogen, lipase and rennin. Gastric juice does not contain amylase, maltase & nuclease.

18. (a) The dental formula for milk teeth is $\frac{2102}{2102}$, so premolars are absent in the primary dentition.

19. (a) *Succus entericus* lacks enzyme nucleases.

20. (b) The main constituent of gastric acid is hydrochloric acid which is produced by parietal cells (also called oxyntic cells) in the gastric glands in the stomach.

21. (d) The sphincter of Oddi (or hepatopancreatic sphincter) is a muscular valve that controls the flow of digestive juices (bile and pancreatic juice) through the ampulla of Vater into the second part of the duodenum.

22. (a)
– Kupffer-cells are phagocytic cells present in liver.
– Zymogen cells are enzyme producing cells which are secreted by pancreas.
– Paneth cell secrete lysozyme which acts as anti-bacterial agent, into the lumen of intestine.
– Argentaffin cells are hormone producing cells.

23. (c) In hepatic portal system, hepatic portal vein drains blood to liver from intestine.

24. (c) Rennin and Pepsin enzymes are present in the gastric juice whereas Maltase is present in the intestinal juice.

25. (b) Total number of teeth in a human child is 20. In primary dentition premolars are absent.