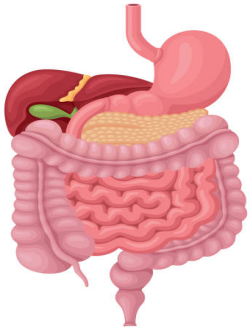

UNIT 9

GASTROINTESTINAL SYSTEM

Structure

9.1 INTRODUCTION

We know that food is essential part of all living beings on this Earth. It is the source of energy to perform various life processes such as respiration, digestion, metabolism, transportation, excretion, circulation of blood and reproduction. The process of conversion of food into small molecules for absorption and assimilation in the body to be used by the body is called digestion.

Our body contains a set of digestive organs responsible for digestion and absorption of food that we eat every day. The organs that are involved in the processing of food are known as digestive organs. Digestive system consists of GIT (Gastrointestinal Tract) and accessory organs such as liver, gall bladder and pancreas; which play an important role in digestion and absorption of food and, elimination of undigested material. The gastrointestinal system is the set of all digestive organs connected in a series for orderly digestion of food material.

In this unit, you will learn the structure and functions of gastrointestinal system. The structure and function of various organs involved in digestion are described. The disorders/diseases associated with the gastrointestinal system are also discussed in the unit.

Expected Learning Outcomes

After studying this unit, you should be able to:

- define Gastrointestinal System;
- discuss the structural organization of GIT;
- enlist the role of digestive organs;
- explain structure and function of stomach, small intestine and large intestine;
- discuss the composition of digestive juice in digestion;
- explain absorption and chemical digestion of dietary nutrients; and
- know the diseases and symptoms of digestive system.

9.2 HUMAN GASTROINTESTINAL SYSTEM

Human digestive system consists of two parts: Gastrointestinal system and accessory organs (salivary glands, liver, gall bladder, pancreas). The components of digestive system are shown in Fig.9.1. The whole process of digestion take place within the alimentary canal or gastrointestinal tract (GIT) which is divided into upper gastrointestinal tract and the lower gastrointestinal tract demarcated by the suspensory muscle of the duodenum.

The GIT consists of organs connected together from the mouth to the anus (Fig. 9.2). The accessory organs are not part of the digestive system but they play an important role in food digestion and absorption. GIT and accessory organs release digestive juice, bile juice, pancreatic enzyme, etc. These contain enzymes which facilitate the breakdown of dietary complex nutrients into small organic molecules for easy absorption in the body.

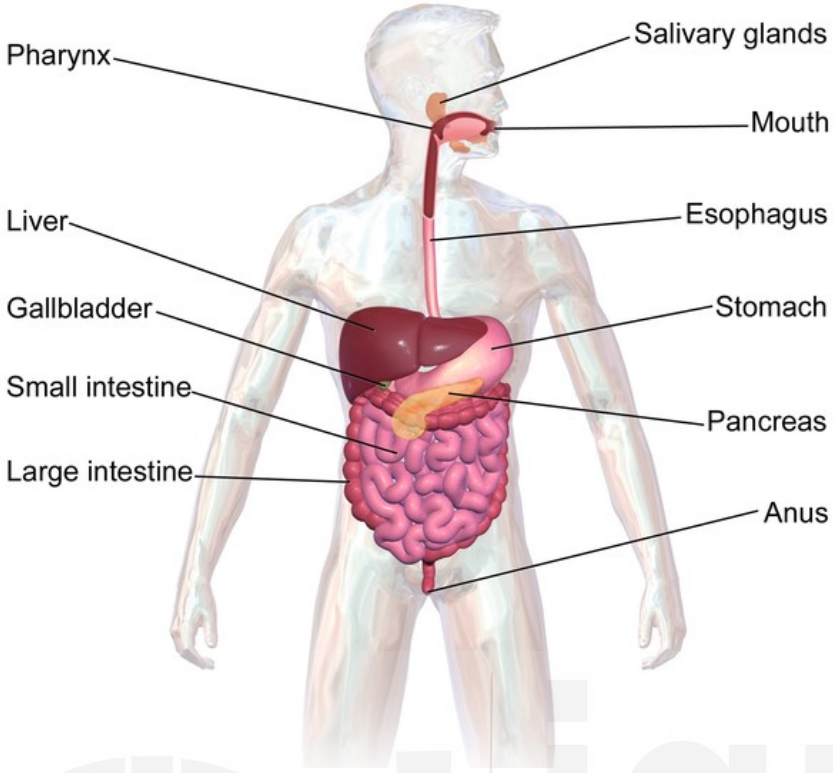

Fig. 9.1: The components of digestive system [Image source: https://commons.wikimedia.org/wiki/File:Blausen_0316_DigestiveSystem.png]

Organs of gastrointestinal tract	Accessory Organs of the Digestive System
1. Mouth 2. Pharynx & Esophagus 3. Stomach 4. Small and Large Intestine 5. Anus	• Salivary Glands • Liver • Gallbladder • Pancreas

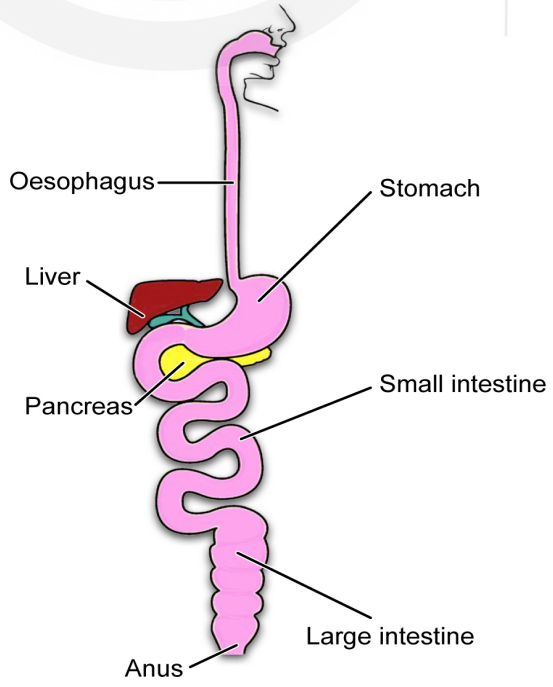

Fig. 9.2: Detailed View of Gastrointestinal system/alimentary canal

- **Mouth** is first part of the digestive system wherein food stuffs are broken down mechanically into bolus by mastication (chewing and swallowing) process with the aid of teeth and tongue. The saliva, released from salivary glands, is added to the food, which lubricates the food as well as helps in the digestion of carbohydrates *via* salivary amylase.
- **Tongue** is a crucial musculo-sensory organ responsible for detecting the food's taste and temperature. It helps in movement and manipulation of the food and facilitates its contact with the teeth for chewing and cutting into smaller parts. It also pushes food material in GI tract *via* the action of swallowing.
- **Pharynx** receives food from the mouth. As it is a common passage for air and food, the involuntary muscle contractions close off the air passageways on entering the food.
- **Esophagus** is the fibromuscular tube through which the food receives from pharynx and passes to the stomach aided by peristaltic contractions. It thus acts as a transport duct between the pharynx and stomach.
- **Stomach** is a hollow and J-shaped organ where protein digestion is initiated and food material is reduced into semi-fluid form. It secretes gastric juice containing protein-digesting enzymes called pepsin and strong hydrochloric acid. The conversion of solid food into semi-fluid form facilitates further chemical digestion in the small intestines.
- **Small Intestine** is an important organ of GIT of digestion and absorption of food. The partially digested food material, received from stomach, is completely broken down into smaller molecules by enzymatic process which are then absorbed in the blood capillaries of small intestine.
- **Large Intestine**: It is the last part of GIT which contains indigestible food residues. It helps in the absorption of water and electrolytes from undigested food stuffs and, formation of feces which is eliminated through anus.

Accessory organs

- **Liver**: It is the main centre of metabolic activities of the body. It plays major role in the digestion process by secreting bile juice in the small intestine. Bile contains containing bile salts which help in emulsification of fats and are crucial for digestion and absorption of fats.
- **Gallbladder:** It is a pear-shaped sac that is connected to the liver by the cystic duct. It stores the bile juice secreted from liver and discharges into the small intestine.
- **Pancreas**: It is a crucial gland which serves both exocrine and endocrine functions. It produces hormones insulin and glucagon which regulate glucose metabolism. Pancreas also produces digestive enzymes; amylase, trypsin, peptidase, and lipase; and release into small intestine. These enzymes are responsible for chemical breakdown of carbohydrates, proteins and fats present in the food.

SAQ 1

Fill in the blanks:

i) Digestion system consists of.....

ii) A mixture of food and digestive juices in stomach is called .....

iii) The digestion begins in..... after ingestion of food.

iv) A chemical liquid .....is required for fat digestion.

v) Undigested part of food is eliminated as .....from the body.

9.3 STRUCTURE OF GASTROINTESTIONAL TRACT

The gastrointestinal tract (GIT) is about 10 feet muscular hollow tube which is bounded by the mouth at one end and the anus at other. It stretches from the mouth to esophagus, stomach, small intestine, large intestine and finally to the anus; through which food is processed for digestion, absorption and elimination of the undigested and unabsorbed part.

The histological architecture of GIT comprises **epithelium, lamina propria, muscularis mucosa, submucosa, submucosa plexus, circular muscle myentric plexus, longitudinal muscle and serosa** (Fig. 9.3).

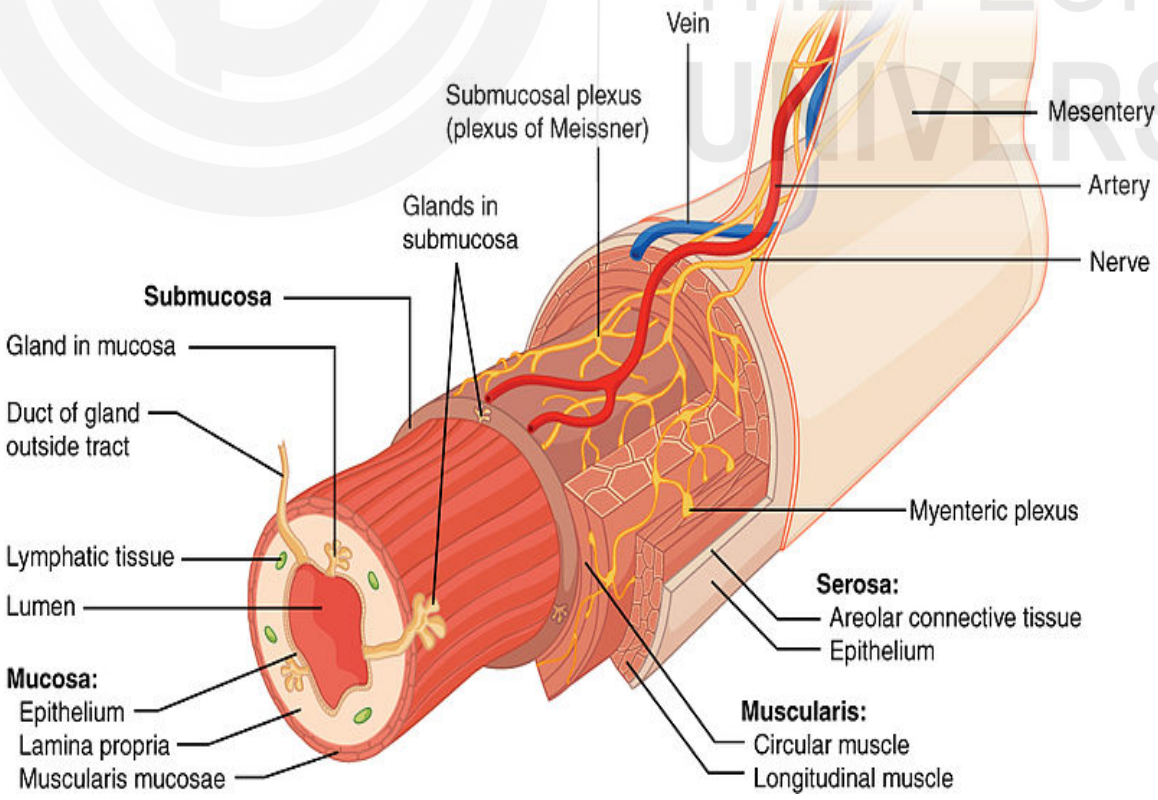

Fig. 9.3: Histological Layers of Gastrointestinal tract.

All these structures are categorised into four layers from outside inwards:

1. **Serosa** forms the outermost protective layer of GIT. It consists of areolar connective tissue and thin mesothelium (squamous epithelium) layer.

2. **Muscularis externa** is responsible for physical motion and segmental contractions during digestion process of food. It is composed of an outer longitudinal muscle, myenteric plexus and an inner circular muscle layer. An inner oblique muscle layer may be present in some regions. Circular muscle layer forms the sphincter that controls flow of food from one compartment to next during segmental contractions.

3. **Submucosa** is a thick vascular layer of GIT. It has connective tissue, glands, lymphatic tissues and nerve plexuses that collectively form a submucosal plexus.

4. **Mucosa** comprises epithelium, lamina propria and muscularis mucosa. It is the innermost layer that folds and ridges (internally invigilates) to create a thumb-like projection which further enhances the surface area for food absorption. Goblet cells present in mucosa produce mucus.

9.4 ULTRASTRUCTURE OF STOMACH AND INTESTINE

Stomach and intestine are two major organs that facilitate the proper digestion and absorption of food material. Let us understand their ultrastructure in detail.

9.4.1 The Stomach

Stomach is the major digestive organ responsible for storage and digestion of food, present between the esophagus and duodenum. It is the J-shaped organ which consists of predominantly of involuntary smooth muscle. Anatomically, stomach is divided into cardia, fundus, corpus, and pyloric region (Fig. 9.4).

- **Cardia** is the first part of stomach that is connected to the oesophagus by a small opening called **cardiac orifice.** It is an inflow part where food enters from esophagus into the stomach.

- **Fundus** is a dome-shaped structure of stomach which is a temporary storage area for food material. It is located superiorly relative to the horizontal plane of the cardiac orifice.

- **Corpus** or **gastric body** is the largest middle area which is continuous with the pyloric region.

- **Pyloric region** represents the outflow section of the stomach. It passes food into the duodenum of small intestine *via* the **pyloric orifice**, the opening and closing of which is controlled by the **pyloric sphincter** (pylorus).

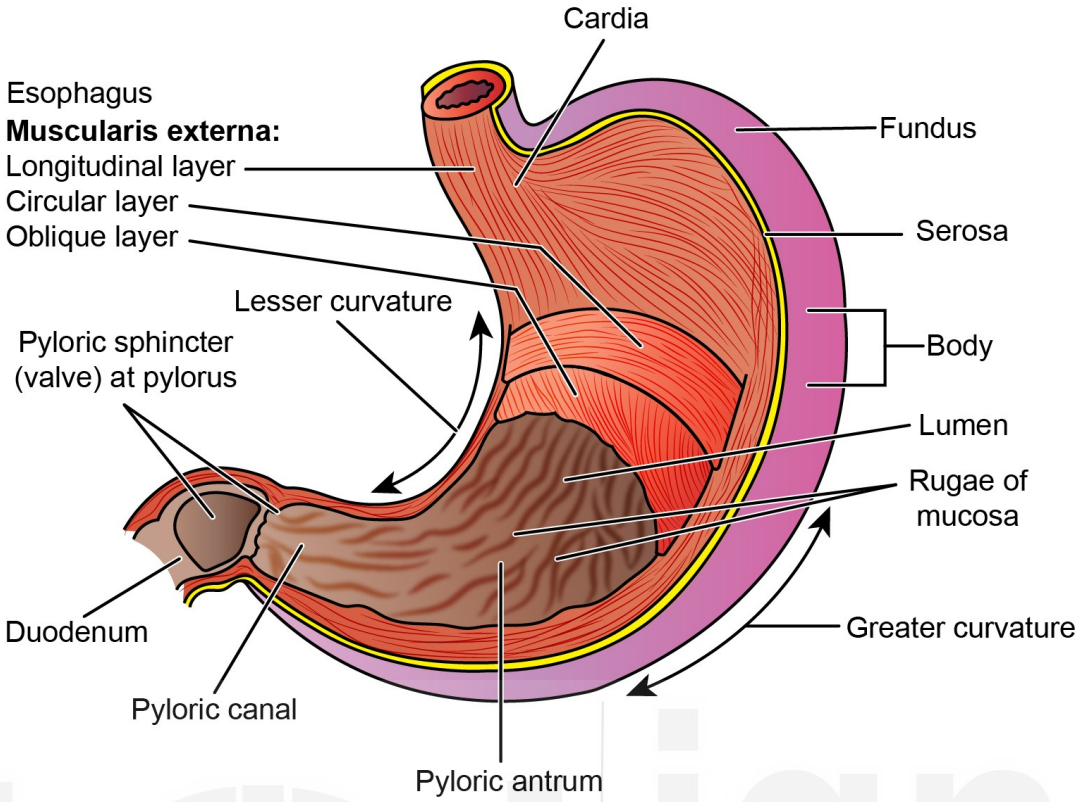

Fig. 9.4: The stomach has four major regions: the cardia, fundus, body, and pylorus.

Like the rest of gastrointestinal tract, stomach is also four-layered muscular structure which serves as a reservoir for ingested food. Fig. 9.5 shows the structural organisation of stomach.

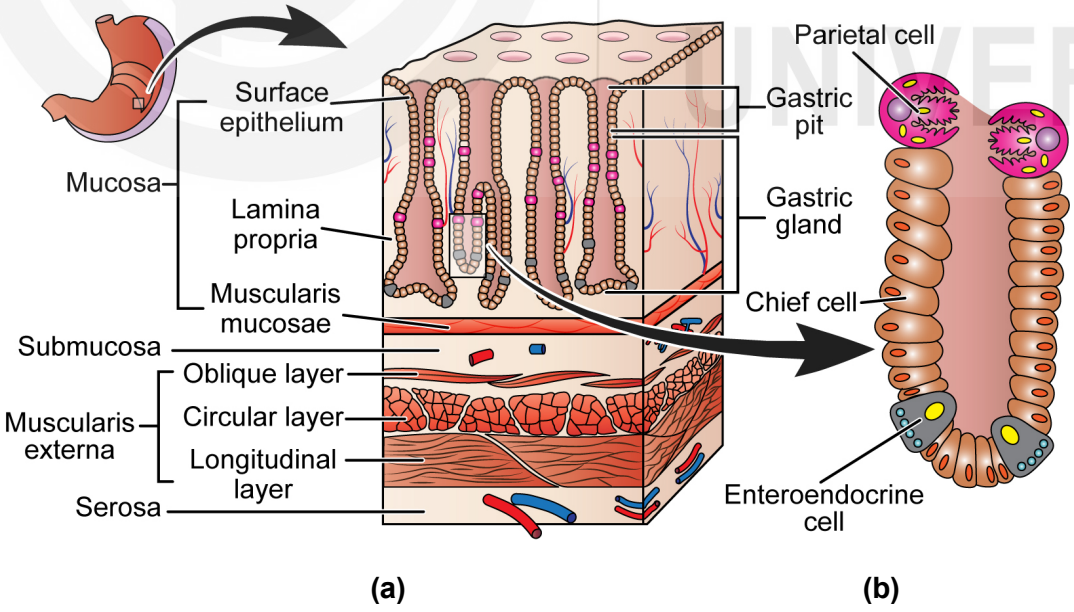

Fig. 9.5: (a) Structural organisation of the stomach (b) A gastric gland.

Mucosa consists of ridges called **gastric folds**. It is lined by **simple columnar epithelium** containing numerous invaginations called **gastric pits** that extend into **gastric glands** (Fig. 9.5b) covered by alkaline mucous layer. Gastric glands consist of three types of cells: mucous, chief, and parietal cells which

collectively secrete gastric juice. Hence these cells are called secretory cells. Mucous cells secrete mucus, chief cells release **pepsin** enzyme which gets activated in the presence of hydrochloric acid secreted by parietal cells. Pepsin breaks dietary proteins into smaller fragments while mucus protects the stomach wall against mechanical injury. The gastric juice also contains an insignificant amount of gastric lipase which breaks down fats in the stomach.

Gastric juice is highly acidic (pH 1.5-3.5) in nature and consists of mostly water (99%) while rest of the components, i.e., hydrochloric acid (0.4-0.5%), pepsin, mucus, lipase, glycoproteins and other electrolytes are present in minute amounts. The acidic nature inactivates infectious agents found in food. This semi-digested semifluid mixture is called **chyme**.

9.4.2 The Small Intestine

The word intestine is derived from a Latin root meaning “internal,” The **small intestine** extends from the pylorus of stomach to the cecum of large intestine. It is approximately 6 meters (20 feet) in length and consists of three parts: duodenum, jejunum and ileum (Fig. 9.6).

i) **The duodenum** is the first part of the small intestine connected with stomach and pancreas. It is often C-shaped section. It has four parts: superior (duodenal bulb/ampulla), descending, horizontal and ascending.

ii) **Jejunum** is the bent section of small intestine which begins at the duodenojejunal flexure in the upper left quadrant of the abdomen.

iii) The **ileum** is longest part of the small intestine in the lower right quadrant of the abdomen. It terminates at the ileal orifice where the cecum of the large intestine begins.

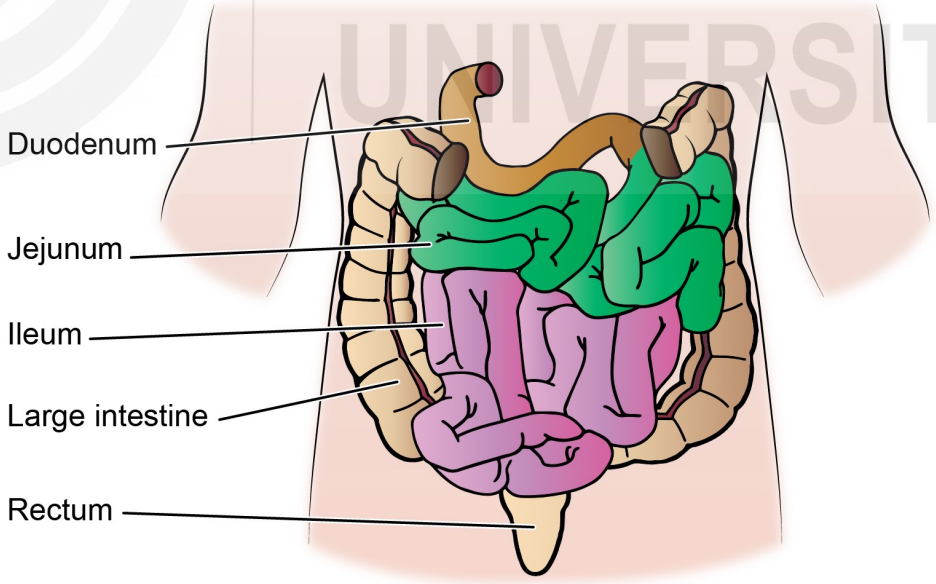

Fig. 9.6: The three regions of the small intestine - duodenum, jejunum, and ileum.

The surface wall of small intestine also consists of four layers - mucosa, submucosa, muscularis externa, and serosa. (Fig. 9.7). The mucosal and submucosa cells have deep ridge circular-folded section containing **villi and microvilli** (Fig 9.8). Villi (singular = villus) look like finger-

like projections (0.5-1.0 mm) which increase large inner surface area enhancing absorption of digested food material. **Microvilli (singular = microvillus), as their name suggests, are much smaller (1 µm) than villi.** They are cylindrical and apical surface extensions of the plasma membrane of the mucosa's epithelial cells, and are supported by microfilaments.

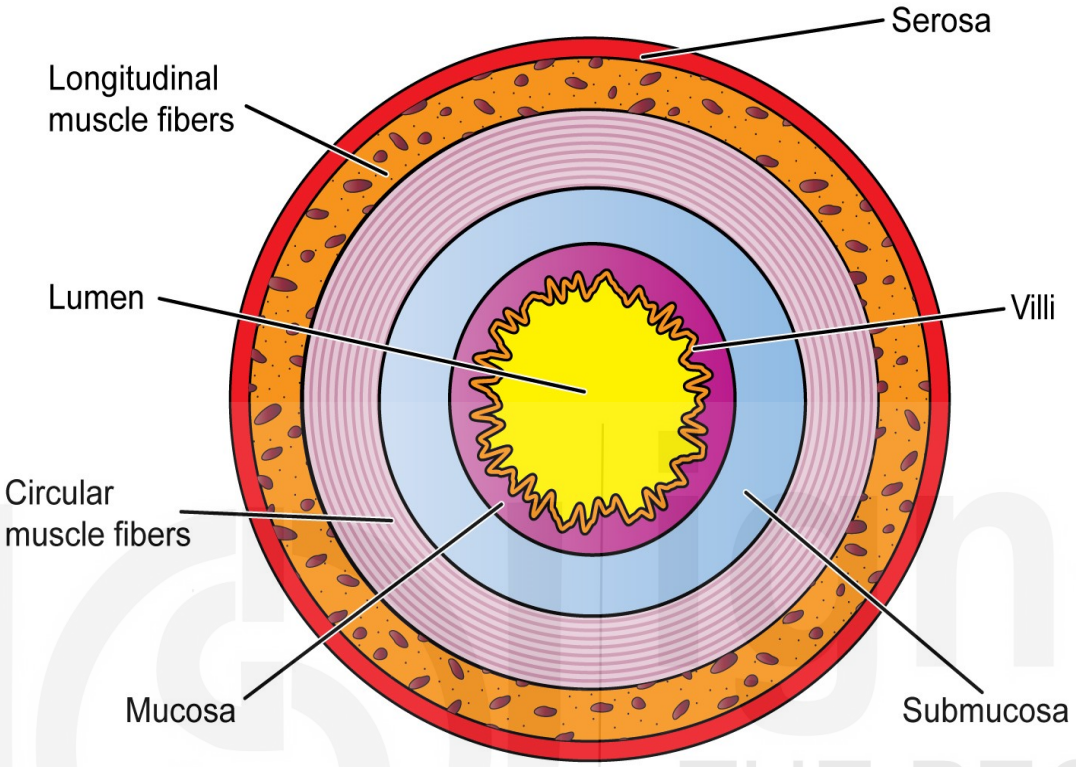

Fig. 9.7: Histological structure of small intestine.

Fig. 9.8: Micrograph of microvilli in small intestine.

(Source:https://commons.wikimedia.org/wiki/File:Small_intestine_(265_23)_Human.jpg)

9.4.4 The Large intestine

The large intestine is the last anatomical part of gastrointestinal tract which extends from small intestine and continues up to anal canal and anus. It is mainly responsible for water absorption from undigested food material and, formation and defection of feces through anus. It shows horse-shoe like morphology and similar to the structure of small intestine except absence of mucosal villi. It is about 1.5m long which is about one-fifth part of the whole length of the GIT. However, its length is small than the small intestine (6 meters). The large intestine has a wider lumen about 7.5 cm (3 inches) compared to the diameter of the small intestine. Hence, it is called the large intestine.

The large intestine consists of four parts: **cecum, colon, rectum, and anus** (Fig 9.9).

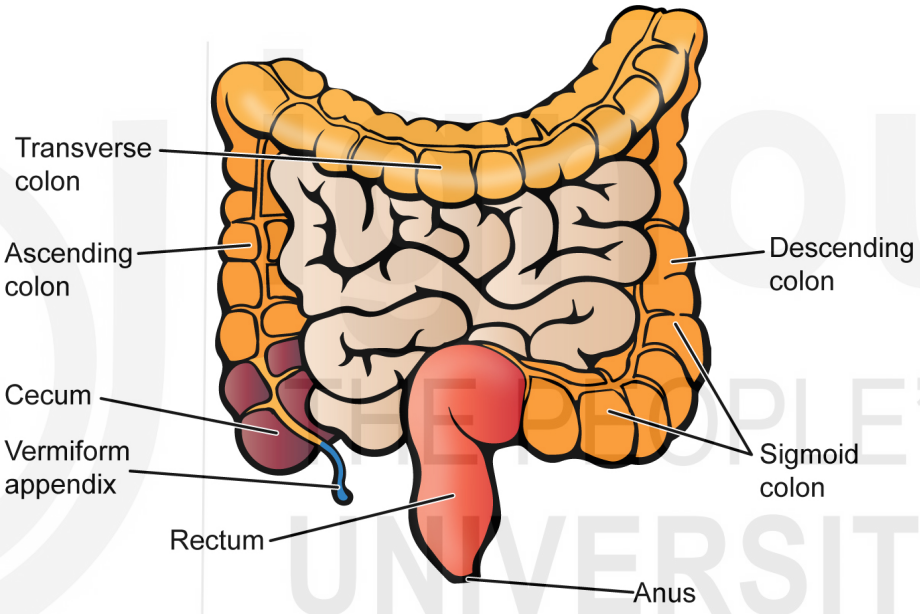

Fig. 9.9: Structure of large intestine (modified, source image: Wikimedia commons).

1. **Cecum** is the first part of large intestine. It is about 6 cm long tube which receives undigested food material from small intestine and moves it upwards to the colon. A small finger-like tubular sac, called appendix, is present at the bottom of caecum which is considered a vestigial organ.

2. **Colon a** largest portion of the large intestine is combination of the **ascending colon, transverse colon** including the colic flexures and transverse mesocolon, **descending colon** and the **sigmoid colon** (the S-shaped region of the large intestine). The food material first moves from the cecum into ascending colon followed by transverse colon, descending colon and finally enters sigmoid colon.

3. **The rectum** is the last section of the large intestine which is continued to the anal canal. It is 3.8-5 cm long, extends from sigmoid colon and

opens to the exterior of the body at the anus. It holds feces temporarily till it is eliminated,

The anal canal is located in the perineum (outside the abdominopelvic cavity). It has Internal anal sphincter surrounded by circular muscles, which normally remain closed and open only during the defecation of feces.

The food passes from the small to the large intestine within 8-9 hours of ingestion. About 90% water is absorbed in the small intestine. The large intestine absorbs most of the remaining water, a process that converts liquid chyme residue into semi-solid stools or feces. The fecal matter consists of 75% water and 25% solid matter. The solid matter includes 30% solid bacteria, 10-20% fats, 2-3% proteins and 30% roughage.

SAQ 2

Do as directed:

a) Choose the correct parentheses from the followings

i) Small intestine is divided into (3/4) parts.

ii) Large intestine is divided into (4/3) parts.

iii) Temporary feces stores in (colon/rectum)

iv) Water is reabsorbed in (small intestine/large intestine)

v) Gut microbes present in (stomach/large intestine)

vi) Microvilli are located in at the surface of (mucosa/ serosa)

b) Name the four layers of GIT.

c) Define microvilli and their functions.

9.5 SECRETORY FUNCTION OF DIGESTIVE SYSTEM (GIT)

You learnt that the gastrointestinal tract secretes various substances to facilitate digestion and absorption of food, protection of GIT lining and regulation of other functions. These secretions are made by cell lining of gastrointestinal tract and glands connected with it.

1. **Salivary Gland:** First secretion is of saliva, which occurs in the oral cavity by three types of salivary glands (parotid, submandibular and sublingual glands) and many small buccal glands.

2. **Stomach**: The wall of the stomach has numerous glands which secrete **gastric juice**. The chief or peptic cells secrete pepsin and lipase enzyme. In children, these cells also secrete rennin enzyme which acts upon casein. The parietal or oxyntic cells produce HCl to activate these gastric enzymes. Mucosa cells produce thick mucus to lubricate and protect the tissue against mechanical injury, self-digestion of stomach

tissue by pepsin, and acid injury by neutralising hydrochloric acid. Argentaffin cells present in the basal part of gastric glands produce histamine, serotonin, endorphins, somatostatin, etc. These also secrete gastrin, a hormone that regulates gastric secretions.

3. **Pancreas**: It produces pancreatic juice containing a mixture of various enzymes for the digestion of proteins, fats and carbohydrates (Fig.9.10). Trypsin, chymotrypsin and carboxypeptidases helps in protein digestion; pancreatic amylase in carbohydrate digestion and, pancreatic lipase/steapsin, cholesterol esterase and phospholipase help in lipids digestion. The pancreas also produces trypsin inhibitor to regulate protein digestion and nucleases to break nucleic acid into nucleotides and nucleosides.

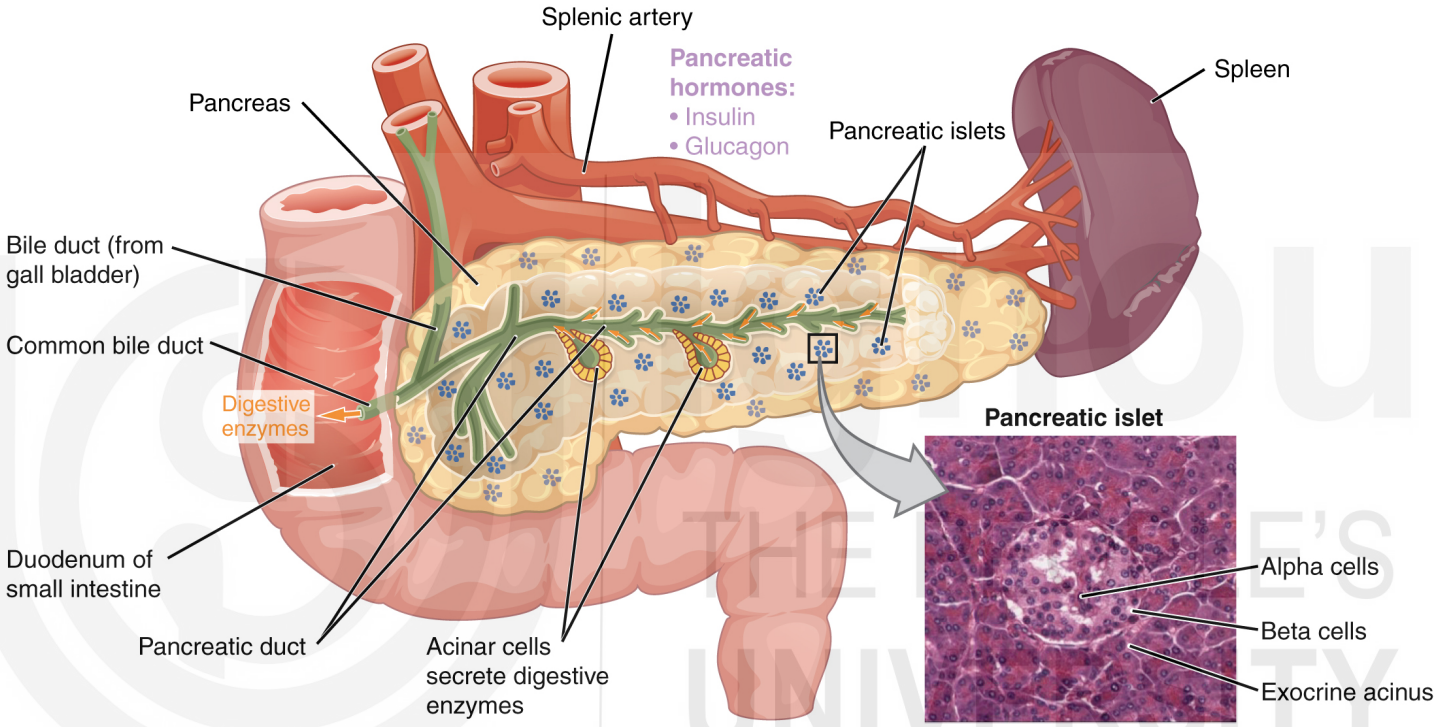

Fig. 9.10 Pancreas. This image by OpenStax is licensed under a Creative Commons Attribution License 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/1-introduction

4. **Liver**: The liver secretes a detergent-like substance, bile, for emulsification of fat material facilitating absorption of digested fat products. It also serves as a carrier for circulatory waste to eventually discarded with the feces.

5. **Small Intestine**: The goblet cells in small intestine produce mucus (a gel-forming mucins) which protects the mucous membrane. The intestinal epithelium also secretes mixture of enzymes in the form of intestinal juice or *succus entericus.* The juice contains erepsin for digestion of dipeptides, enterokinase to active trypsin, lipase to digest fats, nucleosidases to digest nucleic acids and disaccharides, such as maltase, sucrase and lactose to digest respective sugars (maltose,

sucrose, lactose). In addition, enterocytes secrete large volumes of water and electrolytes.

6. **Large intestine:** It only produces mucus to bind fecal material and to protect the intestinal walls from physical excoriation and from the large amount of bacterial present in feces.

Let us understand digestion and absorption of biomoleucles in GIT.

9.5.1 Digestion and absorption of carbohydrates, fats and proteins in the Gastrointestinal tract

Digestion initiates the breaking down of food and converts them smaller nutrients so the body can process for metabolism in order to generate energy for physiological process of the body (Fig. 9.11).

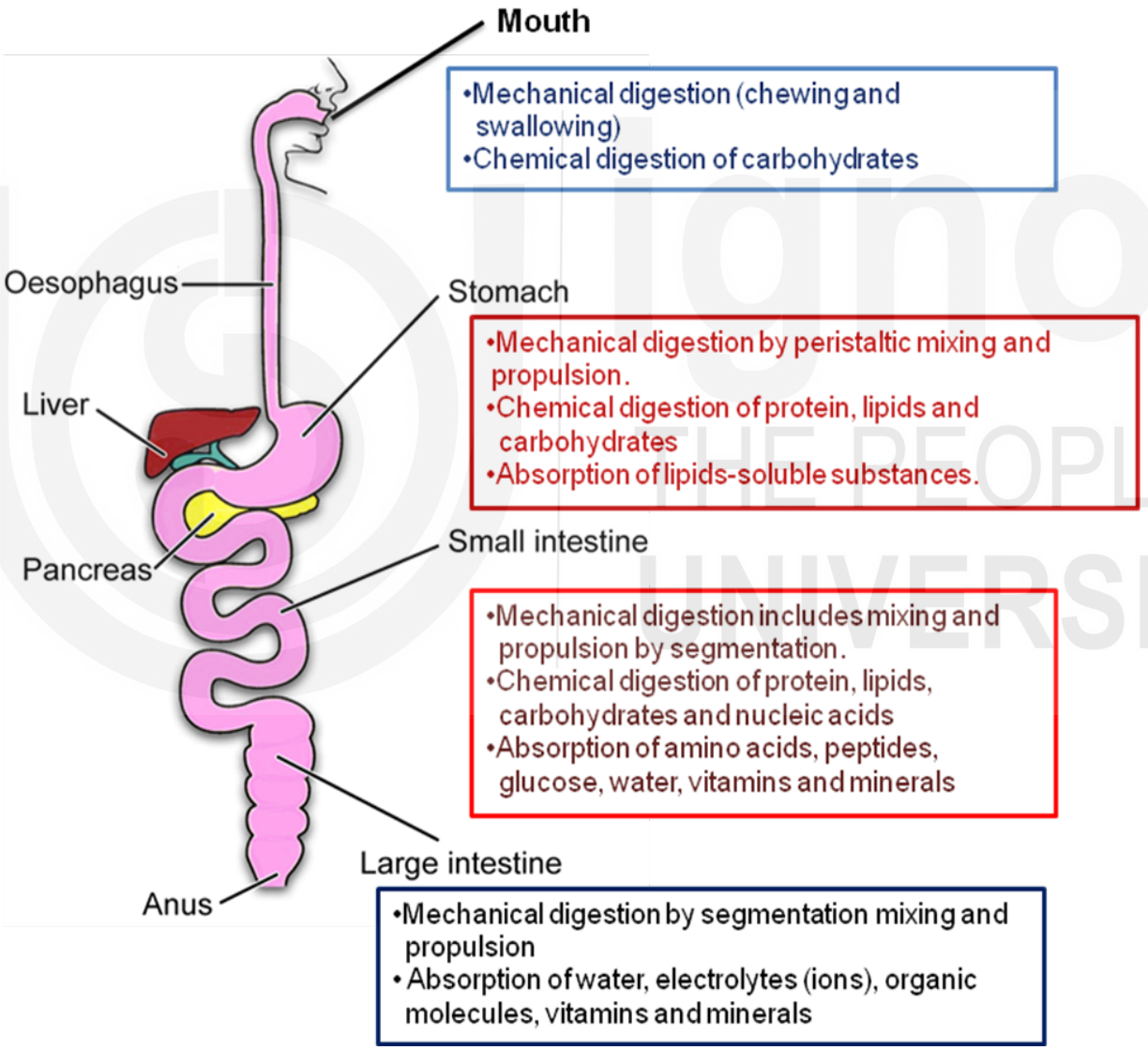

Fig.9.11: Overview of digestion

Digestion and absorption of Carbohydrates

Our daily diet contains approximately 50-60% carbohydrates. The principal carbohydrates are starch (polysaccharide), lactose (milk sugar), sucrose and maltose. Carbohydrates are found in whole-grain breads and cereals,

legumes, fruits, vegetables, milk, and milk products. All carbohydrates need to be digested to glucose, galactose, and fructose for absorption in the body. Breakdown of sugars is initiated in the mouth by salivary amylase. Subsequent digestion of carbohydrates takes place in small intestine with the help of pancreatic amylase and three enzymes secreted by intestinal epithelium (Lactase, Sucrase, and Maltase). Digested carbohydrates are then absorbed by villi present in the small intestine. The end product of polysaccharide and disaccharide is mostly the glucose.

Peristalsis is a web-like series of contraction and relaxation of digestive smooth muscles by which food material (bolus form) move along the wall of the digestive tract.

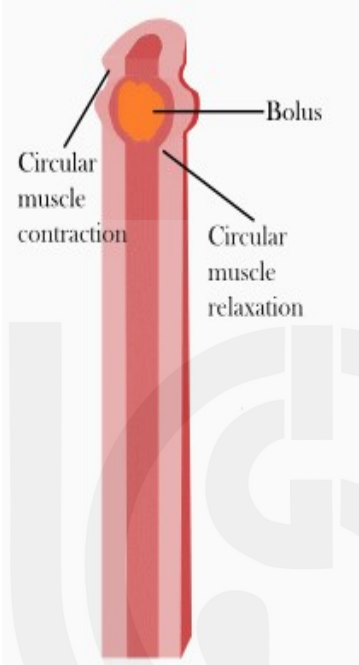

Image credit: https://commons.wikimedia.org/wiki/File:Peristalsis.gif

Salivary Gland

Starch —(Salivary amylase, pH 6.8)→ Maltose

Duodenum

Starch —(Pancreatic amylase, pH 8.3)→ Maltose

Small Intestine

i) *Sucrose* —(**Invertase (sucrase)**, pH 5-7)→ *Glucose and fructose*

ii) *Maltose* —(**Maltase**, pH 5.8-6.2)→ *2 glucose*

iii) *Lactose* —(**Lactase**, pH 5.4-6.0)→ *Glucose and galactose*

The glucose is absorbed by active and passive diffusion in the blood capillaries of jejunum and upper ileum. These are carried to the liver through hepatic portal system.

Digestion and absorption of Proteins

Proteins are the source of amino acids which are important for the growth and development of human body. Protein sources in our diet are milk, milk products, meat, eggs, and legumes. Digestion of protein occurs in the stomach by protease and pepsin enzymes. Acidic pH of stomach helps in protein digestion. Trypsin and chymotrypsin released in duodenum by pancreas digests proteins, peptones and proteoses into dipeptides. In the small intestine, erepsin, a group of several proteolytic enzymes acts primarily and rapidly on peptones and polypeptides, degrading them into simpler molecules amino acids. Proteins are finally digested to amino acids to be

absorbed by the small intestine into the blood, which are then carried throughout the body. The absorption of amino acids is rapid in the duodenum and jejunum.

1.Stomach

i) *Pepsinogen* (Inactive) → *Pepsin* (Active)

ii) *Proteins* —(*Pepsin-HCl mixture*)→ *Protesoses and peptones large polypeptides*

2. *Duodenum*

Trypsinogen (Inactive) —(Enterokinase)→ Trypsin (Active)

Peptones and Proteoses —(Pancreatic proteolytic enzymes, pH 8.0)→ Small polypeptides and amino acids

3. Small intestine

Peptides —(Erepsin, pH 7.6)→ Free amino acids

Digestion and absorption of Fats

Dietary foods such as oil and ghee are source of fats. The triglycerides, fatty acids, glycerol and phospholipids are common form of fats. Fats being hydrophobic are present as insoluble form in stomach. They are emulsified by bile salts present in the bile juice and then digested by **pancreatic lipase** into dilgycerides and monoglycerides with release of associated fatty acids (Fig. 9.12). Bile salts exerts a detergent action to activate lipase for fat digestion.

Upon digestion, fat breaks down to fatty acids and glycerol and then binds with the bile acids, pancreatic electrolytes which spontaneously form polymolecular aggregates structure called ***micelles*.** Micelles are smaller molecules (diameter 3-10 nm) which passively move across the small intestine and form triglycerides. These combine with proteins and form protein-coated fat globules, called ***chylomicrons***, which are transported into the lymph vessels (lacteals) in the villi. These lymph vessels ultimately release the absorbed substances into the blood stream. Fat absorption occurs in the upper part of small intestine.

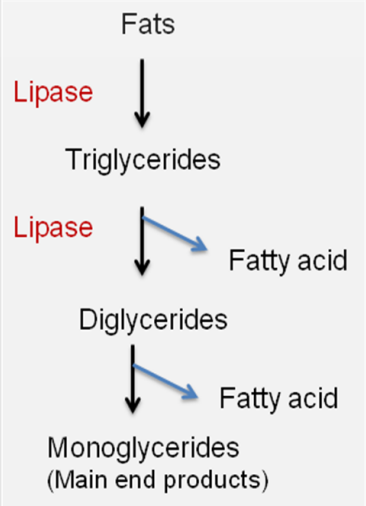

Fig. 9.12: Overview of fat digestion.

SAQ 3

Fill in the blanks:

i) Pepsin breakdown proteins into.....

ii) pancreatic lipase digests .....into .....

iii) Erepsin hydrolyses peptide to.....

iv) Invertase breakdown .....into.....

v) *Lactase converts lactose into.....*

9.6 PATHOPHYSIOLOGY OF THE GIT

Gastrointestinal diseases can occur in the gastrointestinal tract (e.g., reflux esophagitis, peptic ulcer) or these can be a systemic disorder (e.g., inflammatory bowel disease), or as a result of deficiency of vital nutrients required for healthy body (e.g., malabsorption due to vitamin deficiencies). Diseases differ on the basis of the site of origin and causal factors involved. Some common gastrointestinal diseases are briefly explained.

9.6.1 Peptic Ulcer

The common agent of peptic ulcer is the bacterial infection. It is caused by *Helicobacter pylori* (*H. pylori*) that causes internal wounds on the inner lining of stomach (Gastric ulcers) and the small intestine (Duodenal ulcers) (Fig. 9.13). Symptom of peptic ulcer includes burning sensation in stomach and stomach pain. Stress and spicy foods can worsen the symptoms of this disease. The antacids and eating certain foods also help to reduce the symptoms of peptic ulcer.

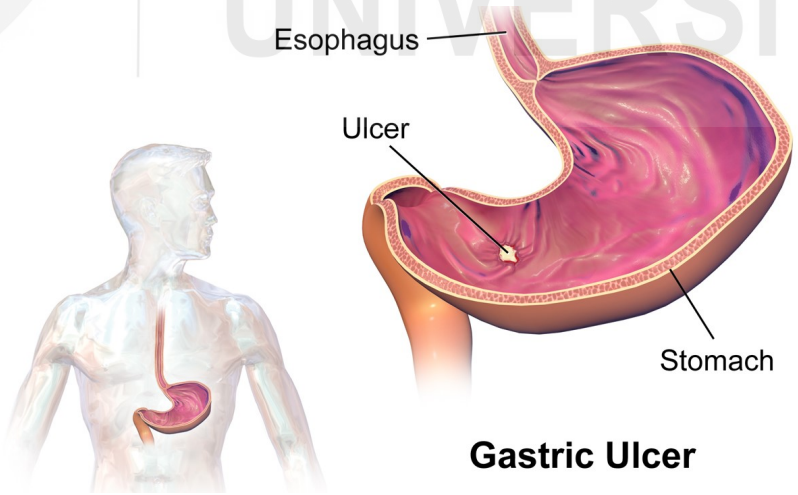

Fig. 9.13: Gastric ulcer (Image Source wikimedia.commons).

9.6.2 Sprue

Sprue is the gastrointestinal malabsorption disease due to inflammation in the small intestine and abnormal flattening of villi. Major causes of Sprue are persistent microbial infections, folic acid deficiency and disrupted intestinal

motility. Initial symptoms include acute diarrhoea, fever and malaise. The symptoms of chronic infection include diarrhoea, weight loss, anorexia and nutritional deficiencies.

Celiac disease also known as **celiac sprue** or **gluten-sensitive enteropathy**, is a hereditary disorder which triggers an autoimmune response on eating gluten, a protein commonly found in grains like wheat, barley, etc. and leads to damage in small intestine. It can develop at any age on consumption of gluten in the form of food or medication. The immune response damages the lining of small intestine and disrupts its nutrient absorption capacity. It often leads to diarrhea, weight loss, fatigue, anemia and can result in serious complications. In children, it affects their growth and development.

Gluten-free diet is suggested to the patients suffering from Celiac disease as no cure is known for the same.

9.6.3 Inflammatory Bowel Disease (IBD)

Inflammatory bowel disease (IBD) is a term for both **Crohn's disease** (inflammation at any part of the gastrointestinal tract mainly the portion of the small intestine just before the large intestine) and **Ulcerative colitis** (inflammation and ulcers in colon and the rectum). The disease is characterized by difficult or incomplete bowel movement along with pain and stiffness. Common symptoms are diarrhea, abdominal pain, bleeding in stools, weight loss and fatigue. Prolonged inflammation leads to the damage in the gastrointestinal tract. Inflammation is triggered by defective immune system. It is also known to be genetic in some cases and depends on the family medical history.

To treat IBD one should increase fiber consumption, stay hydrated, reduce caffeine, minimize stress, get proper sleep and take medications as prescribed by the healthcare personnel.

9.6.4 Regurgitation

Regurgitation is the sudden rise of undigested food along with some gastric juices back up to the mouth; it usually leaves a sour taste in the mouth with a sense of fluid moving up and down in the chest. It is normal in babies for first year of life. In adults it is a symptom of acid reflux, **gastroesophageal reflux disease** (**GERD**) or **rumination disorder**. It occurs mainly due to the eating disorder, blockage of esophagus (due to scarring or cancer), side effect of some medication and smoking. It is usually experienced by the pregnant women.

To treat this condition, you should eat slowly, chew food properly, avoid smoking, avoid food that triggers reflux, walk after every meal and maintain a healthy lifestyle.

9.6.5 Diarrhea

Diarrhea is generally characterized by the frequent bowel movement due to decreased fluid absorption in intestine, and passage of loose liquid stool along

with stomach pain and cramps. It is a common disease in children below age of 5 years. It is generally caused by pathogenic bacteria, viruses and other parasites which enter the body *via* consumption of contaminated food and water, due to poor hygiene and living in unsanitary conditions. The contaminated food contains pathogenic bacteria, virus and other parasites. It can also be a symptom of other bowel disorders like inflammatory bowel disease.

During diarrhea, one should rehydrate himself frequently to overcome excess loss of water from the body. Oral Rehydration Solution (ORS) should be administered which replenishes electrolytes loss in intestine. Zinc supplements also reduce severity of diarrhea. Adding more fluids in the diet along with nutrient-rich meal helps in reducing severity. Maintaining cleanliness, practicing personal hygiene and consumption of clean and preferably boiled drinking water is advised.

9.6.6 Constipation

Constipation is a common functional disorder in the gastrointestinal system. An infrequent and difficult/incomplete bowel movement along with pain and stiffness are the common symptoms which can further develop fissures and hemorrhoids. Its global prevalence is up to 80%, varying with different geographical and cultural variations. It is more common in old age people or adults in 65 or above age group. It occurs mainly due to absence of the fibres in diet, less intake of fluid, unhealthy food habits and sedentary lifestyle. Other reasons can be side effects of medication or as a symptom of some neurological or systematic diseases, etc. It is also seen in pregnant women mainly in the last months of pregnancy due to high levels of sex hormones, lack of movement and medications.

Constipation can be treated by improving dietary habits, inclusion of more fibers and fluids and adopting a healthy lifestyle by including exercise in routine. In severe conditions, one should opt for laxatives as prescribed by physician and also get colon cancer screening done.

SAQ 4

Fill in the blanks:

i) Loose motion is the symptoms of .....

ii) Incomplete bowel movement along with pain and stiffness leads to .....

iii) .....disease is caused by the inflammation in the small intestine and abnormal flattening of villi.

iv) The absence of fibres in your diet, less intake of fluid, unhealthy food habits and sedentary lifestyle causes .....

v) Peptic ulcer is caused by .....

9.7 SUMMARY

- Human digestive system is made up of organs of gastrointestinal tract (GIT) and the accessory organs; salivary glands, liver, gall bladder and pancreas. The digestive system provides adequate water, nutrients, electrolytes, vitamins etc. to the body and keeps it healthy and proper functioning.
- The gastrointestinal tract is a tube-like structure which extends from the mouth to the anus. It is combination of organs such as mouth, esophagus, stomach, small intestine and large intestine.
- Mouth ingests food, teeth help in mechanical chewing and cutting of food, and tongue mixes food with salivary juice secreted by salivary glands. Salivary amylase digests carbohydrates into smaller fragments. Tongue pushes the food from mouth into the pharynx from where food enters the oesophagus. The peristaltic movement of oesophageal wall propels food to the stomach.
- Histologically, the GIT comprises four layers: the innermost mucosa, the outer muscularis mucosa; the submucosa, and the outermost serosa.
- Stomach churns the food and secretes 2.5 – 3 L gastric juice which is mixed with the food to form the chyme. The gastric sceretion initiates chemical breakdown of proteins and inactivates microbial agents present in food.
- Stomach has a verity of cells which perform unique secretory functions. Parietal cells produce hydrochloric acid (HCl), chief cells produce pepsinogen which gets activated to pepsin in presence of HCl; mucous cells secrete mucus. An insignificant amount of lipase is also secreted in the stomach. Pepsin degrades proteins into peptides in the stomach. The partially digested food enters the duodenum as chyme.
- Small intestine is the central place of complete digestion and absorption of dietary nutrients. It produces variety of enzymes which breakdown carbohydrates, proteins, lipids, and nucleic acids, along with vitamins, minerals. It performs physical digestion and absorption of food at a rate slow enough via segmentation.
- The chyme is acted on by the pancreatic juice, bile released from liver and finally by the enzymes in the *succus entericus*, to complete the digestion.
- Carbohydrates are digested into monosaccharides like glucose, fructose and galactose. Proteins are broken down into amino acids while fats are converted to fatty acids and glycerol.
- Ileum is the principal site for the absorption of food. The wall of ileum has numerous irregular finger-like folds called villi which are thin-walled and increase the surface area of the intestine for the absorption of food.
- The simple sugars and amino acids are absorbed in the blood capillaries present in villi while fatty acids are absorbed in the lymph. The absorbed

food is transported into the body and reaches each and every cell for utilisation.

- Large intestine absorbs most residual water, electrolytes, and vitamins produced by enteric bacteria. It propels undigested part of food as feces toward rectum.
- The infection, contaminated food material, unhealthy life habits etc. cause the digestive diseases, like ulcer, diarrhea, Inflammatory bowel, sprue and constipation. These diseases cause damage/infection in the gastrointestinal tract.

9.8 TERMINAL QUESTIONS

1. Define the gastrointestinal system.
2. Enlist key function of digestive organs.
3. What are the role of liver and pancreas in digestion system.
4. Draw the neat and clean and labeled diagrame of digestive system.
5. Discuss the structural organisation of GIT.
6. Explain the structure of stomach and its role as secretary function.
7. Describe the structure of small intestine in details.
8. Explain the digestion and absorption process of food in GIT.
9. Enlist the enzymes and location side for digestion of proteins, carbohydrates and fats in digestive tract.
10. Discuss the role of different parts of large intestine.
11. Write short notes on digestive diseases.

9.9 ANSWERS

Self Assessment Questions

1. i) Gastrointestinal tract and accessory organs
   ii) Chyme
   iii) Mouth
   iv) Bile acids
   v) Feces
2. a) i) Three
      ii) Four
      iii) Rectum
      iv) Large intestine

v) Large intestine

vi) Mucosa

b) The four layers are **m**ucosa, **s**ubmucosa, **m**uscularis externa, and **s**erosa.

c) Microvilli is the microscopic folding of intestinal cell surface that:

1. increases the cellular surface area of small intestine
2. helps in absorption of dietary nutrients.
3. secretes digestive enzymes

3. i) Polypeptides

ii) Fats into fatty acids

iii) Free amino acids

iv) Sucrose into glucose and fructose

v) *2 glucose molecules.*

4. i) Diarrhea.

ii) Inflammatory bowel disease

iii) Sprue

iv) Constipation

v) Helicobacter pylori

Terminal Questions

1. Refer to section 9.2
2. Refer to section 9.2
3. Refer to section 9.2
4. Refer to section 9.2
5. Refer to section 9.3
6. Refer to subsection 9.4.1 and section 9.5
7. Refer to subsection 9.5.2
8. Refer to subsection 9.5.1 and Fig.9.11
9. Refer to subsection 9.5.1
10. Refer to subsection 9.4.4
11. Refer to subsection 9.11