

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

(In the Name of Allah, the Most Merciful, the Most Compassionate.)

BIOLOGY

10



BASED ON REVISED NATIONAL CURRICULUM OF PAKISTAN 2023



**PUNJAB EDUCATION, CURRICULUM,
TRAINING AND ASSESSMENT AUTHORITY**

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AUTHOR

- Dr. Zaheer ud Din, Government College University, Lahore
- Dr. Raheela Nadeem, Registrar, UBAS, Lahore
- Dr. Adnan Ahmad, Senior Research Officer, PCSIR, Lahore

EDITOR

- Dr. Hafiz Muhammad Usman Tariq, Demonstrator (Physiology), Akhtar Saeed Medical & Dental College, Lahore

Review Committee

- Mr. Muhammad Naveed Asghar, Lahore Grammar School, Township, Lahore
- Dr. Najiya Al-Arifa, Lahore College for Women University, Lahore
- Dr. Kausar Hussain Shah, Bahaudin Zakariya University, Multan
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- Mr. Anil Yousaf, Sr. Demonstrator, Forman Christian College (A Chartered University), Lahore
- Mr. Ghulam Yasin, Sr. Headmaster, Govt. High School, Baga Sher, Muzaffargarh
- Ms. Saima Bashir, SST (Sc.), Govt. Girls High School, Tajpura Scheme, Lahore
- Dr. Robeela Shabbir, Subject Specialist, PECTAA, Lahore
- Dr. Malik Aadil Abbas (HED)
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- Muhammad Hamayun Atta (SED)
- Mr. Awais Fida (SED)
- Ms. Maryam Munir (SED)

Supervision

- Dr. Robeela Shabbir

Director

(Curriculum & Compliance)

- Aamir Riaz

Deputy Director

(Compliance Sciences)

- Syed Saghir-ul-Hassnain Tirmizi

Incharge

(Art Cell)

- Mst. Aisha Saidq

Layout & Designing

- Hafiz Inam-ul-Haq

Prepared by:

Al-Faisal Nashran, Urdu Bazar, Lahore

04237230777
03349941510

EXPERIMENTAL
EDITION



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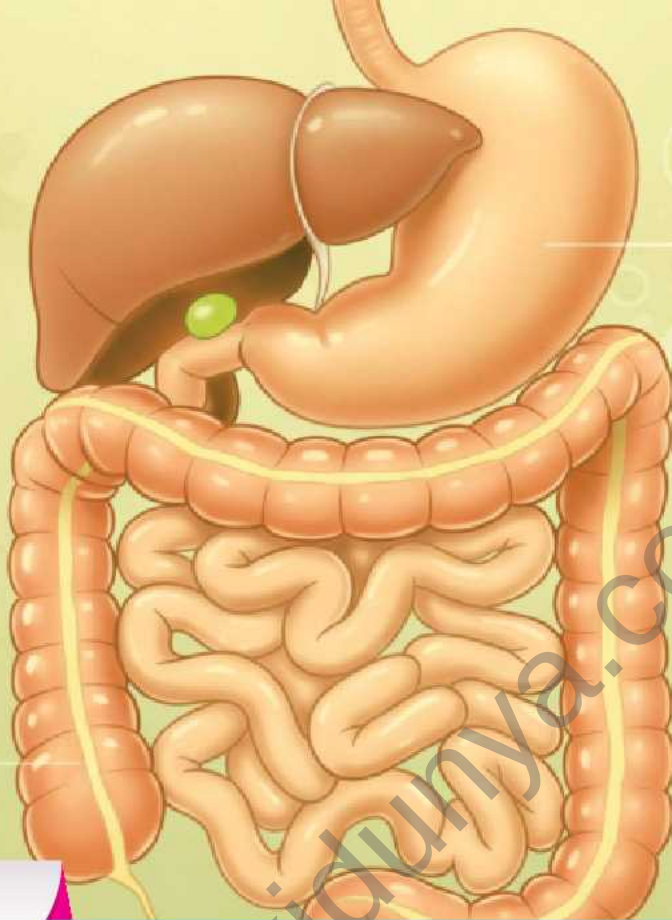
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1

HUMAN DIGESTIVE SYSTEM



Students Learning Outcomes

After studying this chapter, students will be able to:

- ✿ Describe the needs of ingestion, digestion, absorption, assimilation and egestion.
- ✿ Identify and describe the structures of the main regions of the alimentary canal and the associated organs.
- ✿ Describe swallowing and peristalsis.
- ✿ Sort out the action of enzymes in specific regions of alimentary canal, with respect to their substrates and products.
- ✿ State the role of the liver.
- ✿ Describe the structure of a villus, including the roles of capillaries and lacteals.
- ✿ State the signs and symptoms, causes, treatments and preventions of the disorders of gut i.e., diarrhoea, constipation, and ulcer.

Everything our body does - like moving, growing, and staying healthy - depends on nutrients. In order to get these nutrients, the food must first be broken down into simpler parts so the body cells can absorb them. This process happens inside our digestive system. In this chapter, we will discover how the digestive system works to turn food into usable nutrients.

1.1 NUTRITION AND ITS IMPORTANCE

Nutrition is how organisms get and use nutrients. It helps them to grow, stay healthy, and repair their bodies. Animals, including humans, cannot make their own food. They get it from other organisms. This is called **heterotrophic** nutrition. In animals, nutrition takes place in the following main steps:

1. **Ingestion:** Taking in food and drinks through the mouth.
2. **Digestion:** Breaking food into smaller parts the body can absorb.
3. **Absorption:** Moving nutrients from the digested food into the blood or lymph.
4. **Assimilation:** Using the absorbed nutrients in cells and tissues.
5. **Egestion:** Removing undigested food and waste from the body.

Autotrophic nutrition is a mode of nutrition in which organisms produce their own food from inorganic substances using light or chemical energy.

Heterotrophic nutrition is a mode of nutrition in which organisms obtain their food by consuming other organisms or organic matter.

The food we eat consists of polymers i.e., large molecules like carbohydrates, proteins, and fats. They cannot pass through cell membranes. These polymers must be broken down into smaller, soluble parts called monomers - like sugars, amino acids, and fatty acids. This process is called **digestion**. These small molecules can enter the cells.

1.2 HUMAN DIGESTIVE SYSTEM

The human digestive system consists of a long tube and some helper (accessory) organs. The tube is called the **alimentary canal**. It starts at the mouth and ends at the anus. The salivary glands, liver, and pancreas send their juices into the alimentary canal and aid in digestion.

1. Oral Cavity

The space behind mouth is called oral cavity or mouth cavity. It contains **taste buds** on the surface of tongue for the taste of food. The **mechanical digestion** of food begins in oral cavity. During mechanical digestion, the teeth cut and grind

During this grinding, tongue keeps the food between the teeth.

food into smaller pieces.

In oral cavity, **partial chemical digestion** of carbohydrates is done by three pairs of **salivary glands**. These glands are attached with oral cavity and secrete **saliva** - a mixture of water, mucus, and a digestive enzyme called **salivary amylase**. Water and mucous moisten the food pieces. Salivary amylase breaks down the starch present in food into maltose.

Starch is a polysaccharide (made up of many glucose molecules). Maltose is a disaccharide (made of two glucose molecules).

Swallowing: After the physical and partial chemical digestion, the food mass in oral cavity is called **bolus**. It is swallowed by pushing it into the pharynx. For swallowing, the tongue moves the bolus to the back of the oral cavity. The swallowed food enters the pharynx.

During swallowing, the palate (roof of oral cavity) moves upward to close the opening of the nasal cavity.

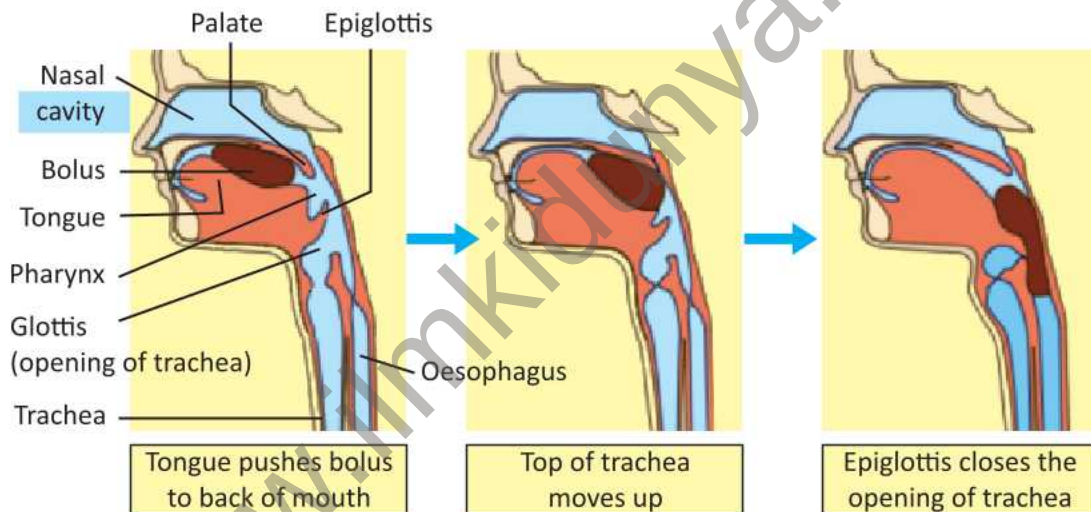


FIGURE 1.1: Oral cavity and steps in swallowing

2. Pharynx and Oesophagus

Pharynx is a short tube-like part behind oral cavity. It connects oral cavity to **oesophagus** and also connects nose to windpipe (trachea). The process of chemical digestion that started in oral cavity continues here. An important function of pharynx is to prevent the entry of food particles into lungs. It is done with the help of an elastic cartilage tissue called **epiglottis**. When swallowed food passes through the pharynx, the top of trachea (windpipe) is pushed up against epiglottis. In this way, the opening of trachea (glottis) closes and the swallowed food passes over it.

Oesophagus is a long tube (about 25 cm long). It connects the pharynx to the stomach. When food enters oesophagus, successive waves of contraction are generated in its muscular walls. These waves of contractions move food along the oesophagus to the stomach. These waves of muscular contraction are called **peristalsis**.

3. Stomach

J-shaped stomach is located in the upper left side of the abdominal cavity, below the diaphragm. The part of stomach immediately after oesophagus is called **cardiac end** while the part before small intestine is called **pyloric end**. At the junction of the oesophagus and stomach, there is sphincter (ring of muscles) called **cardiac sphincter** (lower oesophageal sphincter). It prevents food from flowing back from stomach into the oesophagus. Similarly, **pyloric sphincter** is present between stomach and small intestine.

Stomach is responsible for the mechanical and partial chemical digestion of food. It also stores food. The walls of stomach are made of thick smooth muscles. When food arrives in stomach, these muscles contract rigorously. Their contractions help in the churning (breaking down) of food into smaller particles. Heat is also produced due to this churning. This heat helps to melt the lipids.

Many small **gastric glands** present in the inner walls of stomach secrete **gastric juice**. It contains hydrochloric acid, an inactive enzyme pepsinogen, and mucus. Hydrochloric acid converts **pepsinogen** into an active enzyme **pepsin**. Pepsin breaks large proteins into shorter chains of amino acids called **peptides**. Hydrochloric acid also kills pathogenic bacteria present in food.

The **mucus** forms a protective layer on the inner walls of stomach where, it neutralizes the HCl. So, pepsinogen cannot be activated and the walls are

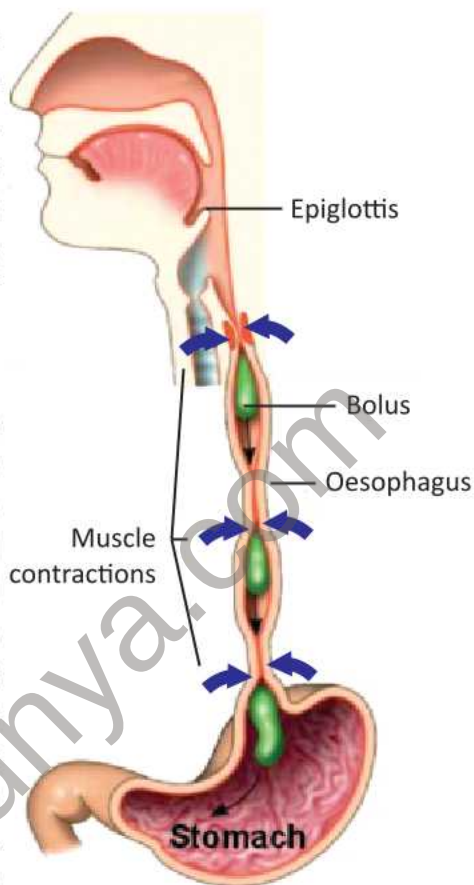


FIGURE 1.2: Peristalsis

The stomach's HCl is so strong that it can dissolve metal! But your stomach is protected by the thick mucus lining that keeps it safe from its own acid.

protected from breakdown.

Food usually remains in stomach for three to four hours. Due to the actions in stomach, the food becomes a soup-like mixture called **chyme**. The pyloric sphincter controls the flow of chyme. Each time the pyloric sphincter opens, about 5 to 15 mL of chyme moves into the small intestine.

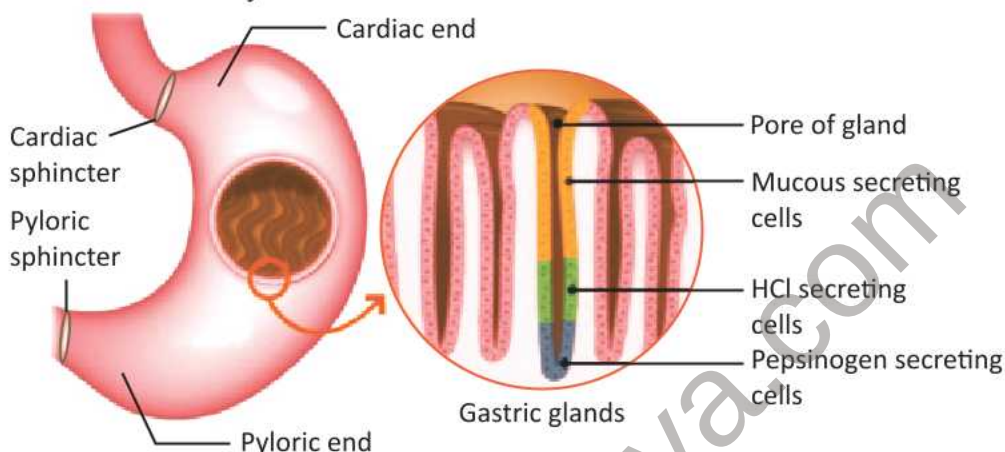


FIGURE 1.3: Structure of stomach

4. Small Intestine

Small intestine is highly coiled tube and is nearly 7 m long. It has three parts:

- i. **Duodenum** is the first part. It is about 25 cm long.
- ii. **Jejunum** is the middle part. It is about 2.5 m long.
- iii. **Ileum** is the last part. It is about 4 m (about 13 feet) long.

In duodenum, secretions of liver and pancreas act on food. The secretion of liver i.e., **bile** enters duodenum through common bile duct. It contains salts which break large fats into small droplets. In this way, a milky fluid is formed in which fat droplets are kept separate. This process is called **emulsification**. The secretion of pancreas i.e., **pancreatic juice** enters duodenum through pancreatic duct, which joins the common bile duct before entering duodenum.

Bile also contains pigments that are formed when RBCs are broken in liver. These pigments are removed from the body with faeces.

Pancreatic juice contains many enzymes e.g., **trypsin**, **pancreatic amylase** and **lipase**. These enzymes digest proteins, carbohydrates and lipids respectively. Pancreatic juice also contains sodium bicarbonate that neutralizes the acidity of chyme. The glands present in the walls of small intestine also secrete enzymes for the complete digestion of all types of food.

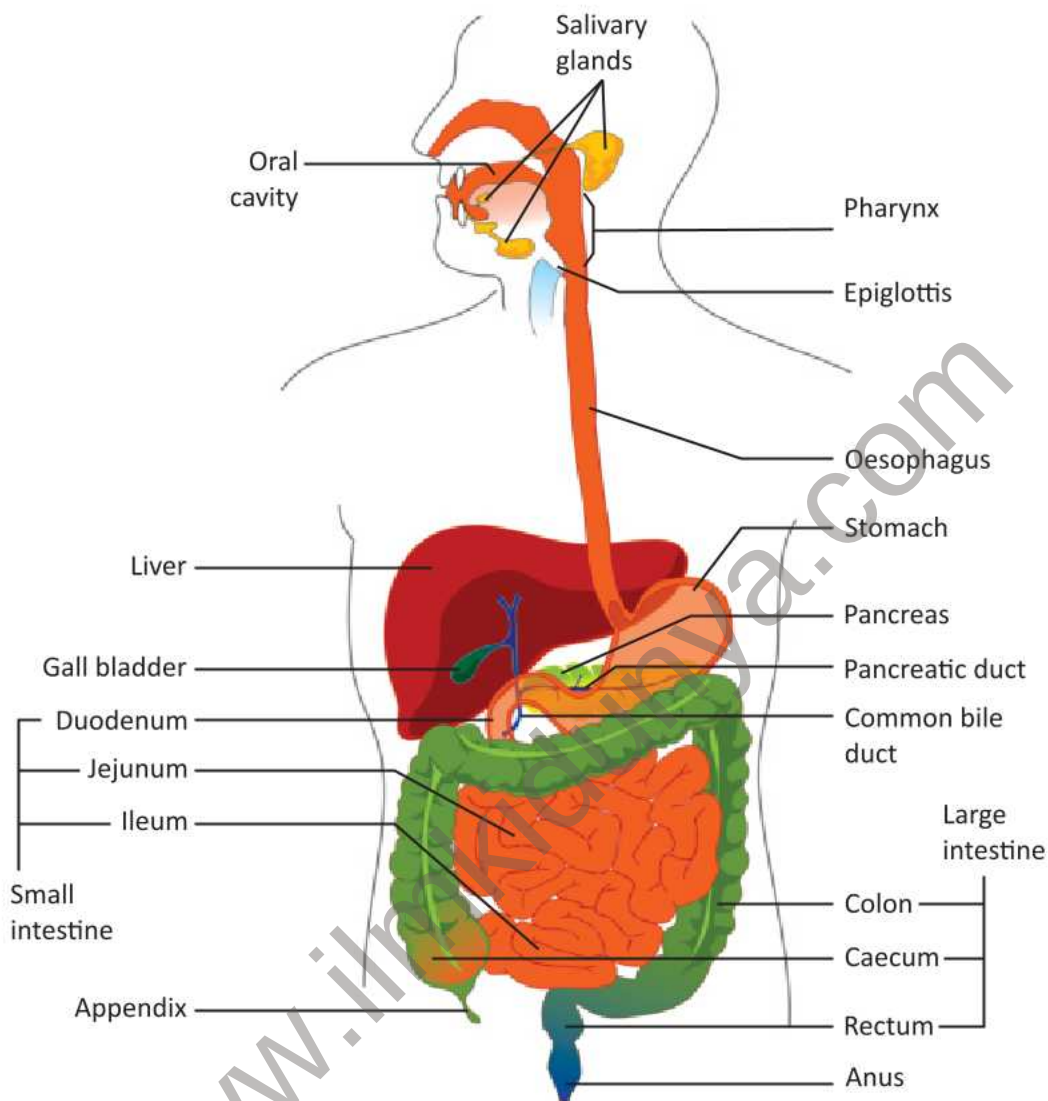


FIGURE 1.4: Human digestive system

Absorption of Food

After the complete digestion of food, the end products i.e., amino acids, simple sugars, glycerol, and fatty acids etc. move from alimentary canal into the circulatory system. The inner walls of small intestine are highly folded. Moreover, these folds have millions of finger-like projections called **villi** (singular; villus). The folds and villi provide a large surface area for the absorption of food. Food molecules are absorbed through this surface through diffusion and active transport. The wall of a villus is made of a single layer of cells. Inside the villus,

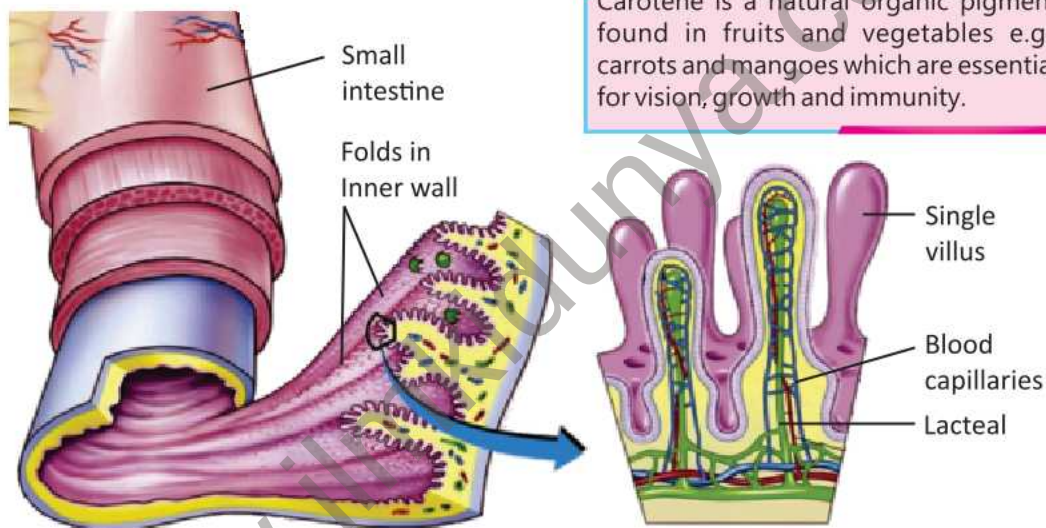
there are **blood capillaries** and a lymph vessel called **lacteal**.

The glycerol and fatty acids present in small intestine enter the lacteals of villi. The lacteals carry them to the main lymph vessels, which empty into the blood vessels near the heart. Amino acids and simple sugars enter the blood capillaries of villi. These capillaries join to make **hepatic portal vein** which carries the amino acids and sugars to liver. From liver, the hepatic vein carries these nutrients to heart and then to all parts of the body.

There is a small finger-like **appendix** at the blind end of caecum.

Infection in appendix causes severe pain. If infected appendix is not removed surgically, it can burst and infection may spread in abdomen.

5. Large intestine



Carotene is a natural organic pigment found in fruits and vegetables e.g., carrots and mangoes which are essential for vision, growth and immunity.

FIGURE 1.5: Small intestine and Villi

Table 1.1: The action of enzymes in the regions of alimentary canal

Region	Enzyme	Substrate	Product
Oral Cavity	Salivary Amylase	Starch	Maltose
Stomach	Pepsin	Proteins	Peptides
Small Intestine	Pancreatic Amylase	Starch	Maltose
	Trypsin	Proteins	Peptides
	Chymotrypsin	Proteins	Peptides
	Peptidase	Peptides	Amino acids and peptides
	Lipase	Fats	Fatty acids glycerol

Nucleases	Nucleic acids	Nucleotides
Maltase	Maltose	Glucose
Sucrase	Sucrose	Glucose and Fructose
Lactase	Lactose	Glucose and Galactose
Dipeptidases	Dipeptides	Amino acids

After the absorption of digested food material and some water, the undigested material and water move to the large intestine by peristalsis. Large intestine has 3 parts i.e. **caecum** (a pouch that forms junction with small intestine), the **colon**, and **rectum**. Absorption of more water occurs from large intestine. Due to it, the undigested material solidifies and is now called **faeces**. The faeces contain the undigested material, large number of bacteria, broken cells of alimentary canal, bile pigments and water. Faeces are temporarily stored in the rectum. During egestion, faeces are expelled out through anus.

Role of liver

Liver is a large organ located to the right of the stomach. In an adult human, it weighs about 1.5 kg. There is a sac-like organ, called **gall bladder**, on the ventral side of liver. Liver secretes bile, which is stored in gall bladder. The common bile duct carries bile from gall bladder into duodenum. Bile does not contain enzymes but it has salts which break fats into small droplets. Bile salts also keep fat droplets separate from one another. It helps the enzymes to attack on lipids. Liver also performs many other functions in the body. For example,

- Stores glucose as glycogen and breaks glycogen to glucose when required.
- Stores of fat-soluble vitamins.
- Breaks amino acids. In this process, harmful ammonia is produced.
- Converts ammonia into less toxic urea for excretion through urine.
- Breaks toxic substances e.g., alcohol.
- Breaks the RBCs which have completed their life spans.
- Prepares vitamin A from carotene.
- Produces heat in cold temperatures by speeding up metabolism.

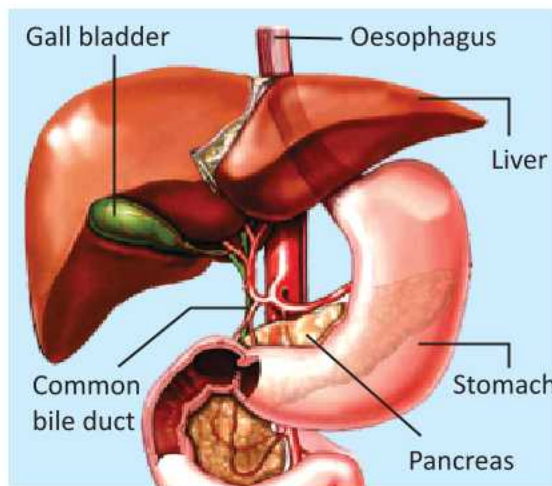


FIGURE 1.6: Liver and associated organs

1.3 DISORDERS OF THE DIGESTIVE SYSTEM

1. Diarrhoea

Diarrhoea is characterized by frequent, loose, or watery stools. Diarrhoea can lead to dehydration, especially in children and the elderly.

Signs and Symptoms: Abdominal cramps or pain, bloating, and dehydration (thirst, dry mouth, dark urine).

Causes: Infections (bacterial, viral, or parasitic), food allergies, stress, certain medications (e.g., antibiotics).

Treatment: Drinking plenty of fluids, use of ORS, eating a soft diet, using anti-diarrheal medications, taking antibiotics or other treatments (in severe cases).

Prevention: Washing hands regularly, especially before eating or after using the bathroom, avoiding contaminated food or water, avoid stress

2. Constipation

Constipation is a condition in which faeces are not eliminated from the body at regular intervals.

Signs and Symptoms: Infrequent or difficult bowel movements (less than 3 times a week), hard and dry stools, abdominal discomfort or bloating.

Causes: Lack of fibre in diet, dehydration, lack of physical activity, certain medicines (e.g., painkillers, iron supplements), other diseases (e.g., diabetes).

Treatment: Increasing fibre intake (fruits, vegetables, whole grains), drinking plenty of water, regular exercise, use medicines as prescribed by the doctor.

Prevention: Eating a high-fibre diet, drinking plenty of fluids.

3. Ulcers

Peptic ulcers are sores that develop in the walls of alimentary canal. Ulcer usually develops in the walls of stomach and is called **gastric ulcer**. However, ulcers may also develop in duodenum (duodenal ulcer) or oesophagus (oesophageal ulcer).

Signs and Symptoms:

Burning stomach pain, rush of saliva after regurgitation, loss of

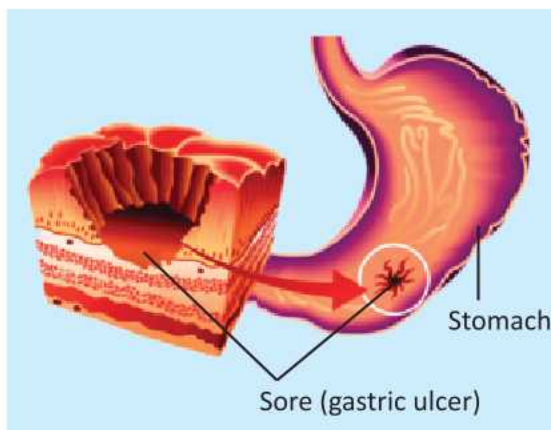


FIGURE 1.7: Gastric ulcers

appetite, weight loss, blood vomiting (in severe cases).

Causes: Infection due to *Helicobacter pylori* bacteria, long-term use of nonsteroidal anti-inflammatory drugs (NSAIDs), excessive alcohol consumption, smoking, stress (though not a direct cause, it can make symptoms worse).

Treatment: Antibiotics to clear *H. pylori* infection, medicines called antacids and proton pump inhibitors.

Prevention: Avoiding excessive use of painkillers (NSAIDs), avoiding spicy foods, eating a balanced diet.



EXERCISE

A. Select the correct answers for the following questions.

- The three portions of the small intestine, in the correct order, are;
a) Duodenum, jejunum, ileum b) Ileum, duodenum, jejunum
c) Colon, caecum, rectum d) Caecum, colon, rectum
- The wavelike movement of muscles that pushes food through the digestive system is called;
a) Chemical digestion b) Mechanical digestion
c) Peristalsis d) Absorption
- The part of the digestive system where no chemical digestion takes place is;
a) Oral cavity b) Oesophagus
c) Stomach d) Duodenum
- Which group of enzymes breaks up starches?
a) Proteases b) Lipases
c) Amylases d) Pepsin
- The pancreas produces digestive enzymes and releases them into;
a) Colon b) Gall bladder
c) Liver d) Duodenum
- In stomach, pepsinogen is converted into pepsin by the action of;
a) Bile salts d) Hormones
c) HCl d) Bicarbonate
- In which part are the carbohydrates, lipids and proteins digested?
a) Oral cavity b) Stomach
c) Small intestine d) Large intestine

8. The enzyme trypsin is found in;
a) Pancreatic juice
b) Bile
c) Gastric juice
d) Saliva
9. The common bile duct carries bile from gall bladder to;
a) Stomach
b) Duodenum
c) Colon
d) Pancreas
10. Why the small intestine has many folds and contains villi and microvilli?
a) To slow down the passage of food.
b) To promote food absorption.
c) To prevent the backflow of chyme.
d) To produce enzymes.

B. Write short answers.

1. State the role of salivary glands in digestion.
2. What do the terms swallowing and peristalsis mean?
3. What are the functions of HCl in gastric juice?
4. State the role of pancreatic juice in digestion of food.
5. Write a brief note on the structure of villi.
6. What are the causes and symptoms of ulcers?

C. Write answers in detail.

1. Describe the absorption of food in small intestine.
2. Explain the role of oral cavity in the digestive system.
3. Explain the structure and functions of stomach.
4. Justify the importance of liver and pancreas in digestion.

D. Inquisitive Questions

1. Why does someone with liver disease have difficulty in digesting fats?
2. Why is it important to maintain a healthy balance of gut bacteria?
3. How can a malfunction in the cardiac sphincter lead to acid reflux?
4. Why is it necessary to store bile in the gallbladder before it is released?