

STUDENTS LEARNING OUTCOMES (SLO's)

After studying this unit, the students will be able to

- ✎ Explain swallowing and peristalsis. c
- ✎ Illustrate with a diagram the structure of the stomach and relate each component with the mechanical and chemical digestion in the stomach.
- ✎ Identify the role of the nervous system and gastrin hormone on the secretion of gastric juice.
- ✎ Describe the major actions carried out on food in the three regions of the small intestine.
- ✎ Trace the absorption of digested products from the small intestine lumen to the blood capillaries and lacteals of the villi.
- ✎ Describe the component parts of large intestine with their respective roles.
- ✎ Correlate the involuntary reflex for egestion in infants and the voluntary control in adults.
- ✎ Explain the storage and metabolic role of the liver.
- ✎ Describe composition of bile and relate the constituents with respective roles.
- ✎ Outline the structure of pancreas and explain its function as an exocrine gland.
- ✎ Relate the secretion of bile and pancreatic juice with the secretin hormone.

INTRODUCTION

Definition

Digestion is the process by which the body breaks down food into smaller, absorbable components.

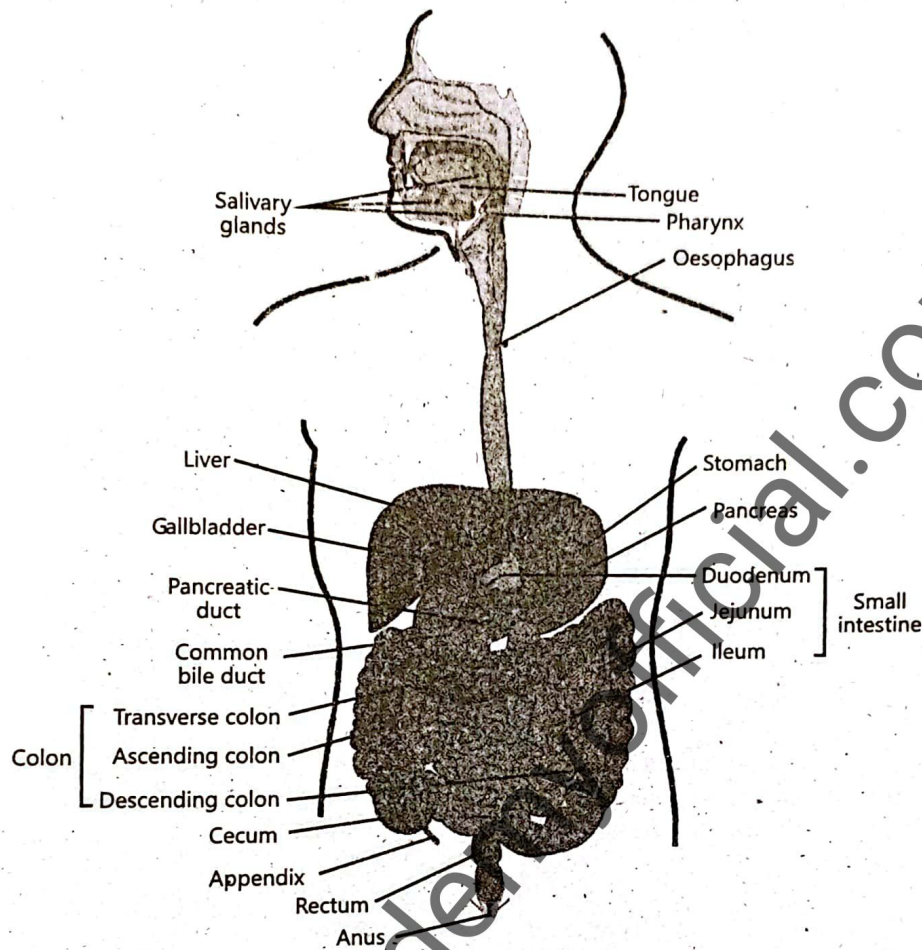


Fig 9.1 - Human Digestive System

Importance of Digestion

Digestion is 'crucial' for converting food into energy and raw materials required for growth, repair, and maintenance of body functions.

Role in Immune Support

Efficient digestion supports the immune system by aiding in nutrient absorption and eliminating harmful substances.

Nutrient Supply and Overall Health

It provides essential nutrients and ensures overall health by supporting cellular functions and bodily systems.

Prevention of Deficiencies

Effective digestion helps prevent nutrient deficiencies that could otherwise impair body function and development.

Support for Metabolism and Energy

It supports metabolism and maintains energy levels, making it vital for sustaining life and daily activities.

9.1 ANATOMY & PHYSIOLOGY OF DIGESTIVE SYSTEM

The **human digestive system** is composed of the **gastrointestinal (GI) tract** and **accessory digestive organs**. The GI tract is a continuous tube that extends from mouth to anus. It includes oral cavity, pharynx, oesophagus, stomach, small intestine and large intestine. The accessory digestive organs include the salivary glands, liver, gallbladder and pancreas.

ORAL CAVITY



Describe the structure and functions of the oral cavity. Also, discuss the roles of the pharynx and oesophagus?

Ans. It is a cavity immediately after the opening of the mouth. Lips are made of highly vascularized, skeletal muscle tissue with many sensory nerve endings. Lips help to retain food as it is being chewed. They also play a role in phonation (the modification of sound). The important functions performed by the oral cavity are as follows:

Selection of Food

The muscular tongue plays a role in the selection of food through its taste buds. When food enters the oral cavity, it is tasted and physically felt. If the taste or smell is unpleasant or if hard objects like bone or dirt are present in the food, it is rejected. The senses of smell and sight also play a role in the selection of food.

Mechanical Digestion of Food

The ingested food is physically broken down by the teeth through a process called mastication (chewing). Chewing breaks down food into smaller and more manageable pieces, increasing the surface area for enzymatic action.

Chemical Digestion of Food

As the chewing of food goes on, the salivary glands pour their secretion, saliva, into the oral cavity. Palate, tongue and cheeks help in the mixing of chewed food with saliva. There are three pairs of salivary glands which pour saliva into the oral cavity. These three pairs are:

- **Sublingual glands**, situated below the tongue
- **Submaxillary glands**, located behind the jaws
- **Parotid glands**, located in front of the ears

Saliva contains water and mucus that moisten and lubricate the food. Saliva also contains bicarbonate ions, which buffer chemicals in the oral cavity, and thiocyanate ions, which kill microorganisms. Fresh saliva is alkaline (pH: 8) but it quickly loses CO_2 and gets pH 6.

Saliva also contains an enzyme, **salivary amylase**. It partially digests the polysaccharides (starch and glycogen) to disaccharides (maltose). After the mechanical and chemical digestive processes in the oral cavity, the food mass is in the form of a small moist mass called a **bolus**.

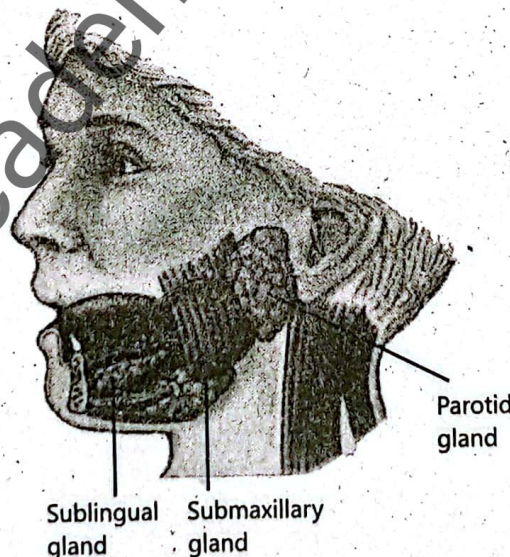


Fig 9.2 – Location of Salivary Glands

PHARYNX

Introduction

The pharynx is a crucial part of both the digestive and respiratory systems. It serves as a connecting chamber located behind the oral cavity and plays a significant role in the passage of both food and air.

Structure of the Pharynx

The pharynx is a cavity behind the mouth. It serves as a pathway that connects the nasal and oral cavities to the larynx (voice box) and esophagus. Its anatomical position enables it to function in both breathing and swallowing.

Function as a common passageway

It is the common passageway for both the digestive and respiratory tracts. This dual functionality makes it a unique and essential structure in the human body. Air from the nasal cavity and food from the mouth both pass through the pharynx.

The beginning of the swallowing action is voluntary, but once the food reaches the back of the mouth, swallowing becomes automatic.

Role in Swallowing

The bolus is pushed to the back of the mouth and is swallowed through the pharynx. During swallowing, the pharynx ensures that the food bolus moves safely from the oral cavity to the esophagus, while also preventing it from entering the respiratory tract.

After being swallowed, the food enters the tube called **oesophagus**. It connects the pharynx to the stomach. The previous digestive actions of saliva continue in oesophagus. In adult human, the oesophagus is about **25 cm** long and its lower end opens in stomach. Food moves down through the oesophagus to the stomach by peristalsis. The exit of food from the oesophagus to the stomach is controlled by the lower Oesophageal sphincter or cardiac sphincter, which opens in response to the pressure exerted by food. It also prevents the backflow of stomach contents into the oesophagus.

OESOPHAGUS

• Antiperistalsis

Occasionally, the peristaltic movements may reverse in a process called **antiperistalsis**, pushing food from the intestines back into the stomach and oral cavity, leading to vomiting.

• Hunger Contractions

Hunger contractions are peristaltic movements triggered by low blood glucose levels, creating the uncomfortable

sensation known as **hunger pangs**.

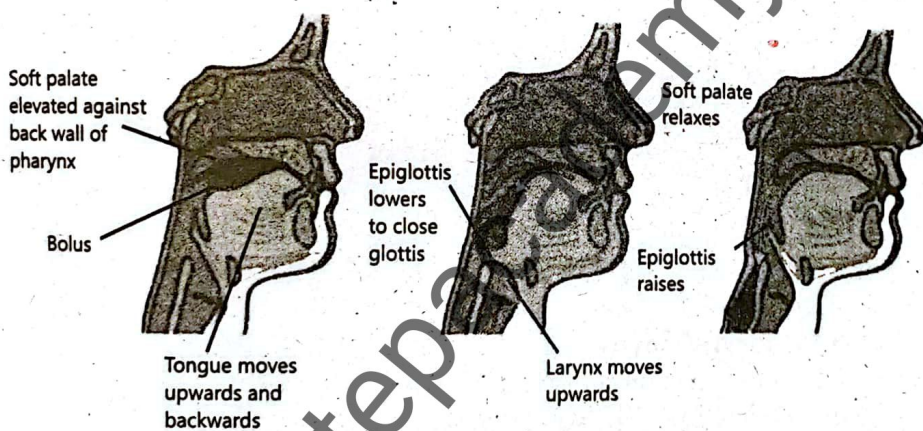


Fig 9.3 - Swallowing of Food

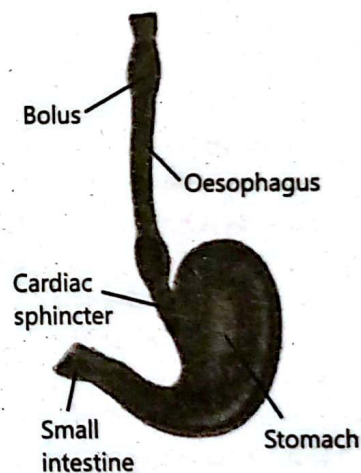


Fig 9.4 - Oesophagus and its connections

mQs

1. **What is the oral cavity?**
 A) A digestive gland
 B) A part of stomach
 C) A cavity immediately after the opening of mouth ✓
 D) A nasal chamber
2. **Which type of tissue are lips made of?**
 A) Smooth muscle
 B) Skeletal muscle ✓
 C) Cardiac muscle
 D) Connective tissue
3. **Which of the following is NOT a function of lips?**
 A) Helping to retain food
 B) Phonation

- C) Smelling food ✓
 D) Containing sensory nerve endings
4. **What is phonation?**
 A) Swallowing food
 B) Production of saliva
 C) The modification of sound ✓
 D) Mechanical digestion
5. **Which structure helps in the selection of food?**
 A) Teeth
 B) Tongue ✓
 C) Cheeks
 D) Palate

6. **How does the tongue assist in food selection?**
 - A) By secreting enzymes
 - B) By detecting temperature
 - C) Through its taste buds ✓
 - D) By grinding food
7. **What happens if unpleasant taste or smell is detected in food?**
 - A) Food is swallowed
 - B) Food is accepted
 - C) Food is rejected ✓
 - D) Saliva increases
8. **Which senses assist the tongue in food selection?**
 - A) Hearing and touch
 - B) Sight and smell ✓
 - C) Taste and touch
 - D) Pressure and temperature
9. **What is mastication?**
 - A) Saliva production
 - B) Swallowing food
 - C) Physical breakdown of food ✓
 - D) Chemical digestion
10. **Which organ performs mastication?**
 - A) Tongue
 - B) Cheeks
 - C) Palate
 - D) Teeth ✓
11. **What is the benefit of chewing food?**
 - A) It kills microorganisms
 - B) It moistens food
 - C) It increases surface area for enzymes ✓
 - D) It decreases appetite
12. **What do salivary glands pour into the oral cavity?**
 - A) Enzymes only
 - B) Water
 - C) Saliva ✓
 - D) Hormones
13. **Which of these structures help in mixing food with saliva?**
 - A) Tongue, palate and cheeks ✓
 - B) Teeth, lips and ears
 - C) Esophagus, stomach, and liver
 - D) Gums, nostrils and throat
14. **How many pairs of salivary glands are present?**
 - A) 1
 - B) 2
 - C) 3 ✓
 - D) 4
15. **Where are sublingual glands located?**
 - A) Behind jaws
 - B) In front of ears
 - C) Below the tongue ✓
 - D) On the palate
16. **What is the location of submaxillary glands?**
 - A) Behind jaws ✓
 - B) Below the tongue
 - C) On the cheeks
 - D) In front of ears
17. **Which glands are situated in front of the ears?**
 - A) Parotid glands ✓
 - B) Sublingual glands
 - C) Submaxillary glands
 - D) Buccal glands
18. **Which ions in saliva buffer chemicals in the oral cavity?**
 - A) Calcium ions
 - B) Bicarbonate ions ✓
 - C) Sodium ions
 - D) Chloride ions
19. **What is the function of thiocyanate ions in saliva?**
 - A) Aid in digestion
 - B) Neutralize acids
 - C) Kill microorganisms ✓
 - D) Lubricate food
20. **What is the moist mass of chewed food called?**
 - A) Chyme
 - B) Bolus
 - C) Pellicle ✓
 - D) Lumen



1. What is the oral cavity?

Ans. It is a cavity immediately after the opening of the mouth.

2. What type of tissue are lips made of?

Ans. Lips are made of highly vascularized, skeletal muscle tissue with many sensory nerve endings.

3. What is the function of lips in relation to food?

Ans. Lips help to retain food as it is being chewed.

4. What is the role of lips in sound production?

Ans. Lips also play a role in phonation (the modification of sound).

5. What role does the muscular tongue play in the oral cavity?

Ans. The muscular tongue plays a role in the selection of food through its taste buds.

6. How is food evaluated when it enters the oral cavity?

Ans. When food enters the oral cavity, it is tasted and physically felt.

7. What happens if the taste or smell of food is unpleasant?

Ans. If the taste or smell is unpleasant or if hard objects like bone or dirt are present in the food, it is rejected.

8. Besides taste, what other senses assist in food selection?

Ans. The senses of smell and sight also play a role in the selection of food.

9. How is food mechanically digested in the oral cavity?

Ans. The ingested food is physically broken down by the teeth through a process called mastication (chewing).

10. What is the purpose of chewing?

Ans. Chewing breaks down food into smaller and more manageable pieces, increasing the surface area for enzymatic action.

11. What happens chemically in the oral cavity during chewing?

Ans. As the chewing of food goes on, the salivary glands pour their secretion, saliva, into the oral cavity.

12. **Which parts help in mixing chewed food with saliva?**
 Ans. Palate, tongue and cheeks help in the mixing of chewed food with saliva.
13. **How many pairs of salivary glands are there?**
 Ans. There are three pairs of salivary glands which pour saliva into the oral cavity.
14. **Where are the sublingual glands located?**
 Ans. Sublingual glands are situated below the tongue.
15. **Where are the submaxillary glands located?**
 Ans. Submaxillary glands are located behind the jaws.
16. **Where are the parotid glands located?**
 Ans. Parotid glands are located in front of the ears.
17. **What are the components and functions of saliva?**
 Ans. Saliva contains water and mucus that moisten and lubricate the food. Saliva also contains bicarbonate ions, which buffer chemicals in the oral cavity, and thiocyanate ions, which kill microorganisms.
18. **What is the pH of fresh saliva and how does it change?**
 Ans. Fresh saliva is alkaline (pH: 8) but it quickly loses CO_2 and gets pH 6.
19. **What digestive enzyme is present in saliva and what does it do?**
 Ans. Saliva contains an enzyme, salivary amylase. It partially digests the polysaccharides (starch and glycogen) to disaccharides (maltose).
20. **What is the final form of food after digestion in the oral cavity?**
 Ans. After the mechanical and chemical digestive processes in the oral cavity, food mass is in the form of a small moist mass called a bolus.



2. **Describe the structure and functions of the stomach in detail. Also explain the layers of the stomach wall and the regulation of gastric juice secretion?**

Ans. Structure of the Stomach

The **stomach** is an elastic muscular bag (**J-shaped**) situated after oesophagus and before duodenum. It is located in the left side in abdominal cavity, right below the diaphragm. It has three portions.

- The **cardiac portion** is present immediately after oesophagus.
- **Fundus portion** is present on a side of the cardiac portion.
- **Pyloric portion** is located beneath the cardiac portion.

Sometimes there is a back flush of acidic chyme from stomach into the oesophagus. It causes a burning sensation in the chest & this condition is known as pyrosis or heartburn.

The cardiac sphincter opens when a wave of peristaltic contraction and allows food to enter the stomach.

Mechanical Digestion of Food

The stomach wall is made of the four layers which are:

- **Mucosa:** It is the inner layer of stomach which contain glands. These glands secrete digestive enzymes, HCl and mucus.
- **Submucosa:** It is a layer of connective tissue which contain blood vessels, lymphatic and nerve.
- **Muscularis externa:** It is a layer of muscle i.e., outer longitudinal muscles, middle circular muscles and the inner oblique muscles.
- **Serosa:** It is an outermost thin layer that forms part of peritoneum and provides protection.

The muscular walls of stomach contract and vigorously and help in churning of food (mechanical digestion) and mixing the food with stomach secretions. These contractions also generate enough heat that melts the solid fats.

Gastric Glands

These consist of three types of cells:

- Mucus cells:** These cells secrete thick secretion that covers the inside of the stomach and protects it from HCl and digestive enzymes.
- Parietal (oxyntic) cells:** These secrete hydrochloric acid. It adjusts the pH of stomach contents to about 2-3. HCl also softens the food, activates the pepsinogen and kills microorganisms.
- Chief cells:** These secrete enzyme, pepsinogen.

All the secretions of gastric glands are collectively called **gastric juice**. When the bolus enters the stomach, the gastric glands secrete gastric juice. The H^+ ions of the HCl activate pepsinogen into pepsin. Pepsin catalyses the

breakdown of proteins to yield polypeptides and peptides. About three to four hours after a meal, the stomach contents have been sufficiently mixed and are semi-liquid acidic mass called **chyme**. The **pyloric sphincter** regulates the release of the chyme into the small intestine.

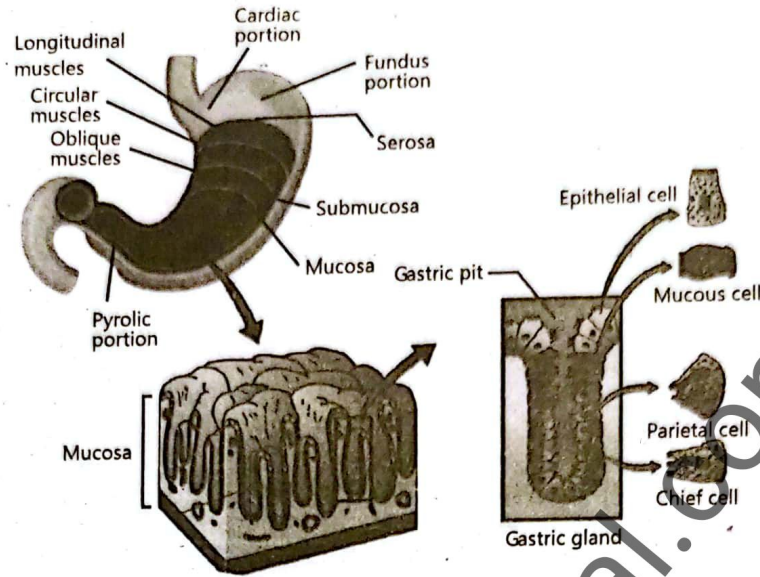


Fig. 9.6 - Stomach; external and internal structure

Regulation of Secretion of Gastric Juice

The secretion of gastric juice is regulated by both the nervous system and hormonal mechanisms. In reaction to the smell, sight, or thought of food, the medulla of brain sends message to the gastric glands to secrete small amounts of gastric juice.

When food arrives in stomach, the distension of stomach and decrease in the pH of the gastric contents stimulate more secretion and powerful contractions. The presence of proteins in food stimulates special endocrine cells present in the mucosa of stomach to release a hormone called **gastrin**.

Gastrin is carried by blood to the gastric glands where it stimulates them to produce and secrete more gastric juice. When food moves from stomach to small intestine, a hormone called **somatostatin** stops the release of hydrochloric acid.

The mucosa of stomach is susceptible to damage from acid and pepsin if it had no protection. Protection of the mucosa is provided in two ways; viscous mucous and bicarbonate, which neutralizes acid.

MCQs ✓

- | | |
|--|--|
| <p>1. What is the shape of the human stomach?
 A) Oval
 B) Spherical
 C) J-shaped ✓
 D) L-shaped</p> <p>2. Where is the stomach located in the human body?
 A) Right side of the abdominal cavity
 B) Left side of the abdominal cavity ✓
 C) Center of the chest
 D) Below the small intestine</p> <p>3. Which of the following is the correct order of the stomach regions from oesophagus onward?
 A) Fundus → Pyloric → Cardiac
 B) Cardiac → Fundus → Pyloric ✓
 C) Pyloric → Cardiac → Fundus
 D) Fundus → Cardiac → Pyloric</p> <p>4. The cardiac portion of the stomach is located?
 A) At the bottom of the stomach</p> | <p>B) Beneath the pyloric portion
 C) Immediately after the oesophagus ✓
 D) Between the liver and pancreas</p> <p>5. What is the function of the cardiac sphincter?
 A) Churns the food
 B) Releases gastric juice
 C) Opens to allow food into the stomach ✓
 D) Prevents food from entering small intestine</p> <p>6. What type of digestion occurs due to stomach contractions?
 A) Enzymatic digestion
 B) Mechanical digestion ✓
 C) Chemical digestion
 D) Bacterial digestion</p> <p>7. What effect do stomach contractions have on fats?
 A) Convert fats to amino acids
 B) Digest fats chemically
 C) Melt solid fats ✓
 D) Absorb fats into blood</p> |
|--|--|

8. How many layers make up the wall of the stomach?
 A) Two B) Three
 C) Four ✓ D) Five
9. Which of the following is the innermost layer of the stomach wall?
 A) Serosa B) Mucosa ✓
 C) Muscularis externa D) Submucosa
10. What does the mucosa layer of the stomach contain?
 A) Smooth muscles only B) Fat-absorbing cells
 C) Glands secreting enzymes, HCl, and mucus ✓
 D) Goblet cells secreting bile
11. What does the submucosa layer primarily contain?
 A) Only muscle fibers
 B) Mucus-producing glands
 C) Blood vessels, lymphatics, and nerves ✓
 D) Hormone-secreting glands
12. Which layer contains longitudinal, circular, and oblique muscles?
 A) Serosa B) Mucosa
 C) Muscularis externa ✓ D) Submucosa
13. What is the function of the serosa layer?
 A) Absorption B) Secretion of enzymes
 C) Protection ✓ D) Protein digestion
14. What protects the stomach lining from hydrochloric acid?

- A) Goblet cells
 B) Mucus secreted by mucus cells ✓
 C) Gastrin D) Bile
15. What do parietal (oxyntic) cells secrete?
 A) Pepsinogen B) Mucus ✓
 C) Gastrin D) Hydrochloric acid
16. What is the role of hydrochloric acid in the stomach?
 A) Absorbs nutrients
 B) Activates pepsinogen and kills microbes ✓
 C) Neutralizes stomach content D) Produces bile
17. Which cells secrete the enzyme pepsinogen?
 A) Parietal cells B) Chief cells ✓
 C) Mucus cells D) Endocrine cells
18. What is gastric juice?
 A) Water mixed with bile
 B) Digestive enzymes of pancreas
 C) All secretions of gastric glands ✓
 D) Fluid from liver and spleen
19. What activates pepsinogen to pepsin?
 A) Gastrin B) Mucus
 C) H^+ ions from HCl ✓ D) Bile
20. What stops the release of hydrochloric acid when food reaches the intestine?
 A) Gastrin B) Pepsin
 C) Somatostatin ✓ D) Secretin



1. What is the shape and position of the stomach in the human body?

Ans. The stomach is an elastic muscular bag (J-shaped) situated after oesophagus and before duodenum.

It is located in the left side in abdominal cavity, right below the diaphragm.

2. How many portions does the stomach have?

Ans. The stomach has three portions: the cardiac portion, fundus portion, and pyloric portion.

3. Where is the cardiac portion of the stomach located?

Ans. The cardiac portion is present immediately after oesophagus.

4. What is the location of the fundus portion in the stomach?

Ans. The fundus portion is present on a side of the cardiac portion.

5. Describe the location of the pyloric portion in the stomach.

Ans. The pyloric portion is located beneath the cardiac portion.

6. What is the role of the cardiac sphincter in the stomach?

Ans. The cardiac sphincter opens when a wave of peristaltic contractions coming down the oesophagus reaches it and allows food to enter the stomach.

7. What is the function of the muscular walls of the stomach in digestion?

Ans. The muscular walls of the stomach contract and vigorously help in churning of food (mechanical digestion) and mixing the food with stomach secretions.

8. How does mechanical digestion generate heat?

Ans. The contractions of the stomach generate enough heat that melts the solid fats.

9. How many layers does the stomach wall consist of?

Ans. The stomach wall is made of four layers: mucosa, submucosa, muscularis externa, and serosa.

10. What is the mucosa layer of the stomach?

Ans. Mucosa is the inner layer of the stomach which contains glands. These glands secrete digestive enzymes, HCl, and mucus.

11. What is the submucosa and what does it contain?

Ans. Submucosa is a layer of connective tissue which contains blood vessels, lymphatic, and nerve.

12. Describe the muscularis externa layer of the stomach.

Ans. Muscularis externa is a layer of muscle, i.e., outer longitudinal muscles, middle circular muscles, and the inner oblique muscles.

13. What is the serosa layer and what is its function?

Ans. Serosa is an outermost thin layer that forms part of peritoneum and provides protection.

14. What protects the inner lining of the stomach from digestive enzymes?

Ans. Mucus cells secrete thick secretion that covers the inside of the stomach and protects it from HCl and digestive enzymes.

15. What are parietal (oxyntic) cells and what do they secrete?

Ans. Parietal (oxyntic) cells secrete hydrochloric acid. It adjusts the pH of stomach contents to about 2–3, softens the food, activates pepsinogen, and kills microorganisms.

16. What is the function of chief cells in the stomach?

Ans. Chief cells secrete the enzyme pepsinogen.

17. What is gastric juice and how is it formed?

Ans. All the secretions of gastric glands are collectively called gastric juice. When the bolus enters the stomach, the gastric glands secrete gastric juice.

18. How is pepsinogen activated and what is its function?

Ans. The H^+ ions of the HCl activate pepsinogen into pepsin. Pepsin catalyses the breakdown of proteins to yield polypeptides and peptides.

19. What is chyme and how is it formed?

Ans. About three to four hours after a meal, the stomach contents have been sufficiently mixed and are semi-liquid acidic mass called chyme.

20. How is the secretion of gastric juice regulated?

Ans. The secretion of gastric juice is regulated by both the nervous system and hormonal mechanisms. In reaction to the smell, sight, or thought of food, the medulla of brain sends message to the gastric glands to secrete small amounts of gastric juice. When food arrives in stomach, the distension of stomach and decrease in the pH stimulate more secretion and powerful contractions. The presence of proteins stimulates endocrine cells to release gastrin, which further enhances secretion. When food moves to the intestine, somatostatin stops the release of hydrochloric acid.



3. Describe the structure and functions of the small intestine, highlighting its role in digestion and absorption?

Ans. The Small Intestine

It is the longest part of alimentary canal. It starts after the stomach and ends at the large intestine. In adult man it is about 2–3 cm in diameter and 6 m in length. Small intestine is responsible not only for the final digestion of all kinds of food but also for the absorption of digested food into blood and lymph. Small intestine consists of three parts i.e., duodenum, jejunum and ileum.

Duodenum

The first 20–25 cm long portion is the duodenum. It is concerned with the digestion of food. It also contains glands, which produce an alkaline secretion containing bicarbonate. Two main secretions are poured into duodenum.

a. Pancreatic Juice

It is the secretion of pancreas and is poured into duodenum. It is slightly alkaline (pH: 8) due to the presence of bicarbonate. It neutralizes the acidity of chyme. The important enzymes in pancreatic juice are:

- **Pancreatic amylase**, which digests polysaccharides into maltose and even glucose.
- **Trypsinogen**, which is in inactive form. Another enzyme **enterokinase** (secreted by the walls of duodenum) activates trypsinogen into trypsin, which digests proteins into polypeptides.
- **Chymotrypsin and carboxypeptidase**, which digest proteins into smaller peptides and then into amino acids.
- **Pancreatic lipase**, which digests lipids to glycerol and fatty acids.
- **Pancreatic nucleases**, which digest DNA and RNA into nucleotides.

Fats are insoluble in water. So, they cannot be attacked readily by lipase enzymes of pancreatic juice. Bile salts act as detergent molecules. They break fats into droplets and keep them separate from one another.

b. Bile

It is the secretion of liver. Before its release, it is stored in gallbladder. It contains salts which emulsify fats and break them into small droplets (emulsion). These droplets provide large surface areas for effective action of lipids-digesting enzymes.

Jejunum and Ileum

Jejunum is **2.4 meters** long part, next to duodenum. Ileum is the last three fifth i.e., about **3.5 meters** long part of small intestine. These parts carry out the rest of digestion and absorption of food. The walls of jejunum and ileum contain glands which secrete intestinal juice. It contains various enzymes; **for example:**

- **Aminopeptidase** digests polypeptides into dipeptides
- **Erypsin** digests dipeptides into amino acids
- **Lipase** digests fats into fatty acids and glycerol
- **Maltase** digests maltose into glucose
- **Sucrase** digests sucrose into glucose and fructose
- **Lactase** digests lactose into glucose and galactose

After the action of enzymes of intestinal juice, the chyme is converted into an alkaline emulsion, called **chyle**.

Absorption of Digested Food and Water

and a vessel of lymphatic system, called **lacteal**. The blood capillaries and lacteal are covered by a single-cell thick epithelium. The epithelial cells of villi have countless cytoplasmic projections, called **microvilli**. The total surface area of absorption becomes extraordinarily large due to villi and microvilli.

Absorption of Simple Sugars and Amino Acids

Simple sugars (e.g., glucose) and amino acids are absorbed by diffusion or active transport into the epithelial cells of villi. From here, these molecules enter the blood capillaries of villi. Blood capillaries of villi join to form **hepatic portal vein** which carries sugars and amino acids to liver. Liver stores extra glucose and amino acids in the form glycogen and proteins respectively. From liver, the required amounts of these products pass to heart via **hepatic vein**.

Absorption of Fatty Acids and Glycerol

The products of fat digestion i.e., fatty acids and glycerol are absorbed by passive transport into the epithelial cells of villi. Inside villi, they combine to form **triglycerides**. The triglycerides are coated with proteins. In this way small droplets, called **chylomicrons**, are formed.

The chylomicrons enter the lacteals of villi. From the lacteals, the chylomicrons move into **thoracic lymphatic duct**, from where they enter in bloodstream. Blood plasma has enzymes which hydrolyze chylomicrons back into fats and proteins. Fats are ultimately hydrolyzed into fatty acids and glycerol and enter body cells.

If bile pigments are prevented from leaving digestive tract, they may accumulate in blood, causing a condition known as **jaundice**.

Due to the presence of folds and numerous villi, the internal surface of jejunum and ileum appears velvety.

The absorption of digested food, water, and dissolved minerals occurs in jejunum and ileum. The inner wall of jejunum and ileum contains large circular folds. These folds have numerous finger-like projections called **villi**.

Each villus is richly supplied with blood capillaries a

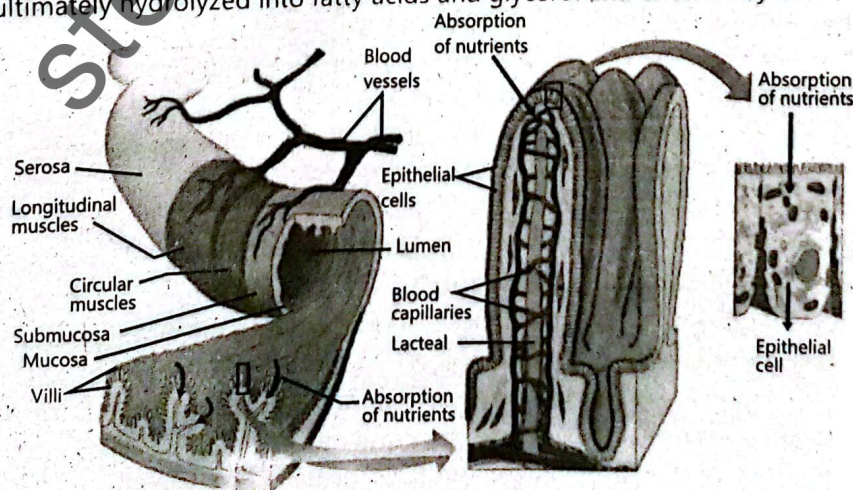


Fig. 9.7 - Intestinal wall and detailed structure of villi

1. Which part of the alimentary canal is the longest?
A) Esophagus B) Large intestine
C) Small intestine ✓ D) Rectum
2. What is the approximate length of the small intestine in an adult man?
A) 3 m B) 6 m ✓
C) 9 m D) 1.5 m
3. What is the main function of the small intestine?
A) Storage of food
B) Production of hormones
C) Digestion and absorption ✓
D) Elimination of waste
4. The small intestine is structurally divided into?
A) Duodenum, colon, ileum
B) Duodenum, jejunum, ileum ✓
C) Duodenum, rectum, ileum
D) Colon, rectum, jejunum
5. What is the length of the duodenum?
A) 40–50 cm B) 10–15 cm
C) 20–25 cm ✓ D) 30–35 cm
6. Which secretion neutralizes the acidity of chyme?
A) Saliva B) Bile
C) Pancreatic juice ✓ D) Gastric juice
7. The pH of pancreatic juice is?
A) 3 B) 5
C) 7 D) 8 ✓
8. Which enzyme in pancreatic juice digests proteins into polypeptides?
A) Amylase B) Lipase
C) Trypsin ✓ D) Lactase
9. Which enzyme activates trypsinogen to trypsin?
A) Amylase B) Enterokinase ✓
C) Pepsin D) Sucrase
10. The function of bile is to?
A) Digest starch B) Emulsify fats ✓
C) Absorb water D) Hydrolyze proteins
11. Which part of the small intestine is 2.4 meters long?
A) Duodenum B) Ileum
C) Jejunum ✓ D) Rectum
12. The last portion of the small intestine is?
A) Jejunum B) Colon
C) Duodenum ✓ D) Ileum
13. Intestinal juice contains all the following enzymes EXCEPT?
A) Aminopeptidase B) Lactase
C) Pepsin ✓ D) Maltase
14. What is chyle?
A) Acidic emulsion B) Undigested food
C) Alkaline emulsion after digestion ✓
D) Gastric fluid
15. Which structure increases the surface area in the small intestine?
A) Pylorus B) Cilia
C) Villi and microvilli ✓ D) Sphincters
16. Simple sugars and amino acids are absorbed into?
A) Lacteals B) Lymph
C) Blood capillaries of villi ✓ D) Pancreatic duct
17. Absorbed sugars and amino acids are transported to the liver via?
A) Hepatic duct B) Hepatic portal vein ✓
C) Renal vein D) Vena cava
18. In the liver, glucose is stored as?
A) Starch B) Glycogen ✓
C) Cellulose D) Glucagon
19. In epithelial cells, fatty acids and glycerol combine to form?
A) Lactose B) Polypeptides
C) Triglycerides ✓ D) Chylomicrons
20. Chylomicrons are transported via?
A) Hepatic artery B) Lacteals ✓
C) Bile duct D) Capillaries



1. What is the small intestine and where is it located in the alimentary canal? Ans. ?

Ans. The small intestine is the longest part of the alimentary canal. It starts after the stomach and ends at the large intestine.

2. What are the dimensions of the small intestine in an adult man?

Ans. In an adult man, the small intestine is about 2–3 cm in diameter and 6 m in length.

3. What are the main functions of the small intestine?

Ans. The small intestine is responsible not only for the final digestion of all kinds of food but also for the absorption of digested food into blood and lymph.

4. How is the small intestine structurally divided?

Ans. The small intestine consists of three parts: duodenum, jejunum, and ileum.

5. What is the length and function of the duodenum?

Ans. The duodenum is the first 20–25 cm long portion. It is concerned with the digestion of food.

6. What is the nature of secretions in the duodenum?

Ans. The duodenum contains glands, which produce an alkaline secretion containing bicarbonate.

7. What are the two main secretions poured into the duodenum?

Ans. The two main secretions poured into the duodenum are pancreatic juice and bile.

8. What is the source and pH of pancreatic juice?

Ans. Pancreatic juice is the secretion of pancreas and is slightly alkaline (pH: 8) due to the presence of bicarbonate.

9. What is the role of pancreatic juice in digestion?

Ans. Pancreatic juice neutralizes the acidity of chyme and contains enzymes for digesting polysaccharides, proteins, lipids, and nucleic acids.

10. What are the enzymes present in pancreatic juice and their functions?

- i. Pancreatic amylase digests polysaccharides into maltose and even glucose.
- ii. Trypsinogen is activated by enterokinase into trypsin, which digests proteins into polypeptides.
- iii. Chymotrypsin and carboxypeptidase digest proteins into smaller peptides and then into amino acids.
- iv. Pancreatic lipase digests lipids to glycerol and fatty acids.
- v. Pancreatic nucleases digest DNA and RNA into nucleotides.

11. What is bile, and how does it aid digestion?

Ans. Bile is the secretion of liver, stored in gallbladder before release. It contains salts which emulsify fats and break them into small droplets, providing large surface areas for effective action of lipids-digesting enzymes.

12. What are the lengths of jejunum and ileum?

Ans. Jejunum is 2.4 meters long and next to duodenum, while ileum is the last three fifth, i.e., about 3.5 meters long part of the small intestine.

13. What functions do jejunum and ileum perform?

Ans. Jejunum and ileum carry out the rest of digestion and absorption of food.

14. What is intestinal juice and what enzymes does it contain?

Ans. Intestinal juice is secreted by the glands in the walls of jejunum and ileum. It contains enzymes such as:

- Aminopeptidase, which digests polypeptides into dipeptides
- Erypsin, which digests dipeptides into amino acids
- Lipase, which digests fats into fatty acids and glycerol
- Maltase, which digests maltose into glucose
- Sucrase, which digests sucrose into glucose and fructose
- Lactase, which digests lactose into glucose and galactose

15. What is chyle?

Ans. After the action of enzymes of intestinal juice, the chyme is converted into an alkaline emulsion called chyle.

16. Where does absorption of digested food and water occur in the small intestine?

Ans. The absorption of digested food, water, and dissolved minerals occurs in jejunum and ileum.

17. What structures increase the surface area for absorption in the small intestine?

Ans. The inner wall of jejunum and ileum contains large circular folds with finger-like projections called villi, and the epithelial cells of villi have countless cytoplasmic projections called microvilli. These structures greatly increase the surface area for absorption.

18. How are simple sugars and amino acids absorbed?

Ans. Simple sugars (e.g., glucose) and amino acids are absorbed by diffusion or active transport into the epithelial cells of villi. From here, they enter the blood capillaries of villi, which join to form hepatic portal vein carrying them to the liver.

19. What does the liver do with absorbed sugars and amino acids?

Ans. The liver stores extra glucose and amino acids in the form of glycogen and proteins respectively. From the liver, the required amounts of these products pass to heart via hepatic vein.

20. How are fatty acids and glycerol absorbed and transported in the body?

Ans. Fatty acids and glycerol are absorbed by passive transport into the epithelial cells of villi, where they combine to form triglycerides. These are coated with proteins to form chylomicrons, which enter lacteals, then thoracic lymphatic duct, and finally enter bloodstream. Blood plasma enzymes hydrolyze chylomicrons back into fats and proteins, which are ultimately hydrolyzed into fatty acids and glycerol and enter body cells.

THE LARGE INTESTINE



4. Describe the structure and functions of the large intestine along with the control of egestion?

Ans. The large intestine is the last part of the alimentary canal. It is much shorter than the small intestine, occupying about the last meter of the intestinal tract. It is involved in the absorption of water and salts and vitamin 'K' from the

lumen of the intestine into the blood. The large intestine is not convoluted and its inner surface area does not possess villi. It consists of three parts.

Caecum

It is a blind sac that projects from the area of large intestine between ileum and colon. From the blind end of caecum there arises a finger-like process called vermiform appendix. In human digestive system, appendix performs no function so is vestigial.

Colon

Next to caecum is the colon. It has an **ascending**, a **transverse**, and a **descending limb**. Its main function is to absorb water from the alimentary canal. As the water is absorbed, the remaining material becomes more solid. These waste products, called **faeces**, consist of a large number of bacteria, indigestible plant fibres (e.g., cellulose), other undigested food stuff, sloughed off mucosal cells, bile pigments, and water.

Rectum

It is the last part of the large intestine where faeces are temporarily stored. At its distal end, the rectum opens out through the **anus**. Anus is surrounded by two sphincters; the **internal sphincter** is made of smooth muscles and the **outer** is made of striated muscles.

Under normal conditions when the rectum is filled up with faeces, it gives rise to a **defecation reflex**. The defecation reflex is consciously inhibited in adults but in infants it is controlled involuntarily. During growth, the child learns to bring this reflex under voluntary control.

Role of Bacteria in Colon

Many bacteria, for example **E. coli**, live and actively divide within the colon. During their metabolism, they produce **amino acids and vitamin K**. Vitamin K is necessary for man for the **coagulation of blood**. It is absorbed from the large intestine into the blood.

Control of Egestion

The involuntary reflex for egestion in infants and the voluntary control in adults represents two stages of **neurological and muscular development**.

In infants, egestion is an **involuntary reflex** mediated by the spinal cord, where rectal distension triggers automatic relaxation of the internal anal sphincter and expulsion of waste. This occurs because the **higher brain centers responsible for voluntary control are not yet fully developed**.

In adults, egestion becomes **voluntary** as the **cerebral cortex matures**, allowing conscious regulation of the external anal sphincter to delay or initiate defecation. This transition reflects the integration of **reflex pathways with cognitive control**, adapting to social and environmental demands.

Appendicitis is the inflammation of the appendix. It is usually due to bacterial infection. The infected appendix must be removed surgically otherwise it may burst and the inflammation may spread in the entire lining of the abdomen. The surgical removal of appendix is called **appendectomy**.

MCQs

1. What is the position of the large intestine in the alimentary canal?
A) First part B) Middle part
C) Last part ✓ D) Before the stomach
2. What is the approximate length of the large intestine?
A) 5 meters B) 2 meters
C) 10 meters D) 1 meter ✓
3. Which of the following is absorbed by the large intestine?
A) Amino acids only
B) Water, salts, and vitamin K ✓
C) Proteins and fats D) Glucose and oxygen
4. Which of these is not a feature of the large intestine?
A) Convoluted structure ✓ B) No villi
C) Absorbs water D) Has appendix
5. How many main parts does the large intestine have?
A) Two B) Four
C) Three ✓ D) Five
6. What is the caecum?
A) A part of the small intestine
B) A type of digestive enzyme
C) A blind sac between ileum and colon ✓
D) A bile-producing organ
7. What is the vermiform appendix?
A) A digestive enzyme B) A hormone
C) A finger-like process from the caecum ✓
D) A part of the stomach
8. What is the function of appendix in humans?
A) Digests fats B) Absorbs vitamins
C) No function; vestigial ✓ D) Produces enzymes
9. Which of the following is not a part of the colon?

- A) Ascending limb
C) Transverse limb
B) Descending limb
D) Circular limb ✓
10. **What is the main function of the colon?**
A) Absorption of fats
C) Production of bile
B) Absorption of water ✓
D) Protein digestion
11. **What happens to the material in the colon after water absorption?**
A) Becomes more fluid
C) Becomes more solid ✓
B) Turns into enzymes
D) Is digested completely
12. **Which of these is not a component of faeces?**
A) Undigested food
C) Digestive enzymes ✓
B) Bile pigments
D) Water
13. **What is the role of the rectum?**
A) Digests proteins
C) Temporarily stores faeces ✓
B) Stores bile
D) Produces vitamin K
14. **What surrounds the anus?**
A) Only smooth muscles
C) A single circular muscle
B) Two sphincters ✓
D) Cartilage ring
15. **What is the composition of the anal sphincters?**
A) Both made of smooth muscles
B) Both made of striated muscles

- C) Inner is striated, outer is smooth
D) Inner is smooth, outer is striated ✓
16. **What triggers the defecation reflex?**
A) Hunger
B) Rectum filled with faeces ✓
C) Empty stomach
D) Smell of food
17. **How is defecation reflex controlled in infants?**
A) Voluntarily
C) Involuntarily ✓
B) Inhibited consciously
D) Through pancreas
18. **What is the role of the cerebral cortex in adults regarding defecation?**
A) Produces faeces
C) Allows voluntary control ✓
B) Stores waste
D) Absorbs vitamins
19. **Which bacteria lives in the colon and produces vitamin K?**
A) Streptococcus
C) Salmonella
B) E. coli ✓
D) Lactobacillus
20. **What is the importance of vitamin K for humans?**
A) Digestion of protein
C) Coagulation of blood ✓
B) Growth of hair
D) Production of energy



1. What is the large intestine?

Ans. The large intestine is the last part of the alimentary canal. It is much shorter than the small intestine, occupying about the last metre of the intestinal tract.

2. What is the function of the large intestine?

Ans. It is involved in the absorption of water and salts and vitamin 'K' from the lumen of intestine into the blood.

3. How does the structure of the large intestine differ from the small intestine?

Ans. The large intestine is not convoluted and its inner surface area does not possess villi.

4. How many parts does the large intestine consist of?

Ans. It consists of three parts.

5. What is the caecum?

Ans. It is a blind sac that projects from the area of large intestine between ileum and colon.

6. What arises from the blind end of the caecum?

Ans. From the blind end of caecum there arises a finger-like process called vermiform appendix.

7. What is the function of appendix in human digestive system?

Ans. In human digestive system, appendix performs no function so is vestigial.

8. What part of the large intestine follows the caecum?

Ans. Next to caecum is the colon.

9. What are the parts of the colon?

Ans. The colon has an ascending, a transverse and a descending limb.

10. What is the main function of the colon?

Ans. Its main function is to absorb water from the alimentary canal.

11. What happens to the material after water is absorbed in the colon?

Ans. As the water is absorbed, the remaining material becomes more solid.

12. What do faeces consist of?

Ans. These waste products, called faeces, consist of a large number of bacteria, indigestible plant fibres (e.g., cellulose), other undigested food stuff, sloughed off mucosal cells, bile pigments and water.

13. What is the rectum?

Ans. It is the last part of large intestine where faeces are temporarily stored.

14. Where does the rectum open out?

Ans. At its distal end, the rectum opens out through anus.

15. What are the muscles surrounding the anus?

Ans. Anus is surrounded by two sphincters; the internal sphincter is made of smooth muscles and the outer is made of striated muscles.

16. What triggers the defecation reflex?

Ans. Under normal conditions when the rectum is filled up with faeces, it gives rise to a defecation reflex.

17. How is the defecation reflex controlled in infants?

Ans. The defecation reflex is consciously inhibited in adults but in infants it is controlled involuntarily.

18. How do children gain voluntary control of defecation?

Ans. During growth, the child learns to bring this reflex under voluntary control.

19. What is the role of bacteria in colon?

Ans. Many bacteria, for example *E. coli*, live and actively divide within colon. During their metabolism, they produce amino acids and vitamin K.

20. What is the importance of vitamin K and how is it absorbed?

Ans. Vitamin K is necessary for man for the coagulation of blood. It is absorbed from the large intestine into the blood.



5. Explain the structure, functions, and hormonal regulation of the accessory digestive organs, specifically focusing on the liver, gallbladder, and pancreas. Include the role of these organs in digestion, storage, metabolism, and how their secretions are controlled.

Ans.

1. Liver and Gallbladder

Role of the Liver in Digestion

The liver plays a vital role in digestion by producing bile, which is essential for fat digestion. Bile emulsifies fats, making them easier to digest.

Cholesterol, secreted by the liver, may precipitate in the gall bladder to produce gall stones, which may block release of bile.

Additional Functions of the Liver

The liver also processes nutrients absorbed from the small intestine, detoxifies harmful substances, synthesizes proteins, and stores glycogen for energy.

Function of the Gallbladder

The gallbladder stores and concentrates bile produced by the liver. When food enters the small intestine, the gallbladder releases bile through the bile duct.

2. Pancreas

Location and Structure

The pancreas is a large gland situated just ventral to the stomach. It has exocrine and endocrine portions.

Exocrine Portion and Its Function

The exocrine (ducted) portion secretes its secretion i.e., pancreatic juice into the pancreatic duct. The pancreatic duct joins with the common bile duct from the liver and enters the duodenum. Pancreatic juice contains enzymes for the digestion of all groups of food. Its major enzymes include trypsin, chymotrypsin, lipases, amylases, nucleases etc.

Endocrine Portion and Its Function

The endocrine (ductless) portion of pancreas secretes its secretion i.e., insulin and glucagon hormones into extracellular fluid from where they diffuse into nearby capillaries.

Hormonal Control of the Secretions of Pancreas and Liver

Regulation of Secretions through Nervous System and Hormones

We have studied the regulation of gastric secretions through nervous system and hormones. The release of secretions from pancreas and liver is also controlled by hormones.

Role of Secretin

When chyme enters duodenum from stomach, its acidity stimulates duodenal walls to release a hormone, secretin.

Role of Cholecystokinin (CCK)

Similarly, the partially digested proteins and fats present in chyme stimulate the duodenal walls to secrete another hormone, cholecystokinin (CCK).

Effect of Secretin and CCK on Pancreas and Gallbladder

Both these hormones stimulate pancreas to release pancreatic juice, and gallbladder to release bile.

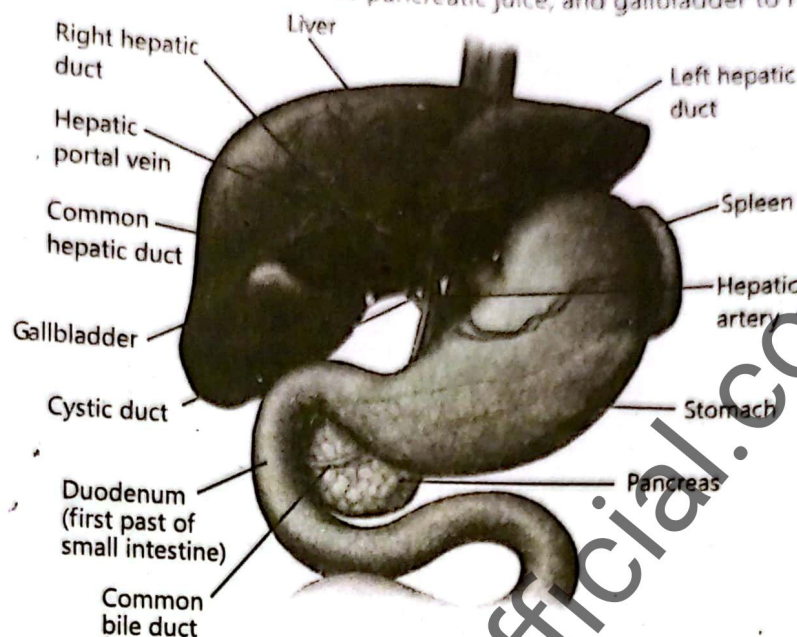


Fig. 9.8 - Accessory Digestive Organs

Storage and Metabolic Role of the Liver

Storage of Nutrients

The liver performs many important functions, especially in storing nutrients and regulating metabolism. It stores excess nutrients from the food and releases them when the body needs energy or building materials. These nutrients stored in the liver include glucose (stored as glycogen), vitamins (like A, D, B12, and K), minerals (e.g., iron and copper), and fats and fat-soluble substances.

Central Role in Metabolism

It also plays a central role in metabolism. It helps in breaking down, building up, and converting substances in the body. For example, it converts excess glucose into glycogen and back when needed.

Fat Metabolism and Energy Production

It also breaks down fats to produce energy and forms cholesterol and lipoproteins.

Amino Acid Conversion and Detoxification

It converts amino acids and removes harmful ammonia by turning it into urea, which is excreted in urine.

Detoxification of Blood

It breaks down and removes toxins, drugs, and alcohol from the blood.

Hormone Regulation

The liver also helps in breaking down and regulating hormones.

mQs(✓)

1. What substance does the liver produce that is essential for fat digestion?

- A) Insulin
- B) Bile ✓
- C) Gastric juice
- D) Pancreatic juice

2. What is the primary function of bile in digestion?

- A) Digest proteins
- B) Emulsify fats ✓
- C) Absorb vitamins
- D) Break down carbohydrates

3. Which organ stores and concentrates bile produced by the liver?

- A) Pancreas
- B) Small intestine
- C) Gallbladder ✓
- D) Stomach

4. Where is the pancreas located in the body?

- A) Above the liver
- B) Ventral to the stomach ✓
- C) Behind the small intestine

- D) Near the gallbladder
5. **What are the two portions of the pancreas?**
 A) Cardiac and pyloric
 B) Exocrine and endocrine ✓
 C) Anterior and posterior D) Superficial and deep
 6. **What does the exocrine portion of the pancreas secrete?**
 A) Insulin and glucagons B) Bile
 C) Pancreatic juice ✓ D) Gastric acid
 7. **Where does the pancreatic duct join the common bile duct?**
 A) At the stomach B) At the jejunum
 C) At the duodenum ✓ D) At the ileum
 8. **Which of the following is NOT an enzyme found in pancreatic juice?**
 A) Trypsin B) Amylase
 C) Lipase D) Pepsin ✓
 9. **Which hormones are secreted by the endocrine portion of the pancreas?**
 A) Secretin and CCK
 B) Insulin and glucagon ✓
 C) Gastrin and motilin
 D) Thyroxine and adrenaline
 10. **What triggers the duodenal walls to release secretin?**
 A) Partially digested fats B) Presence of bile
 C) Acidity of chyme entering the duodenum ✓
 D) High glucose concentration
 11. **What is the function of cholecystokinin (CCK)?**
 A) Stimulate bile and pancreatic juice release ✓
 B) Break down carbohydrates
 C) Increase blood glucose D) Absorb vitamins
 12. **Which nutrients are stored in the liver?**
 A) Proteins and nucleic acids
 B) Glucose as glycogen, vitamins, minerals, fats ✓
 C) Enzymes and hormones D) Water and salts
 13. **How does the liver store excess glucose?**
 A) As starch B) As glycogen ✓
 C) As fat D) As protein
 14. **What does the liver convert amino acids into for safe excretion?**
 A) Urea ✓ B) Ammonia
 C) Carbon dioxide D) Glucose
 15. **Which of the following substances does the liver detoxify?**
 A) Vitamins B) Hormones
 C) Drugs and alcohol ✓ D) Fats
 16. **How does the liver contribute to hormone regulation?**
 A) By synthesizing hormones only
 B) By breaking down and regulating hormones ✓
 C) By storing hormones
 D) By transporting hormones
 17. **Which enzyme in pancreatic juice digests proteins?**
 A) Lipase B) Amylase
 C) Trypsin ✓ D) Nuclease
 18. **What happens when bile is released from the gallbladder?**
 A) It digests carbohydrates
 B) It emulsifies fats in the small intestine ✓
 C) It breaks down proteins in the stomach
 D) It neutralizes acids in the stomach
 19. **What stimulates the pancreas to release pancreatic juice?**
 A) High blood sugar
 B) Hormones secretin and CCK ✓
 C) Presence of bile in the liver
 D) Digestion in the stomach
 20. **What is the role of glycogen stored in the liver?**
 A) Immediate energy source
 B) Long-term energy storage ✓
 C) To store excess protein D) To detoxify blood



1. What is the role of the liver in digestion?

Ans. The liver plays a vital role in digestion by producing bile, which is essential for fat digestion. Bile emulsifies fats, making them easier to digest.

2. How does bile assist in fat digestion?

Ans. Bile emulsifies fats, which means it breaks down large fat droplets into smaller ones, making fats easier to digest.

3. Besides producing bile, what other functions does the liver perform?

Ans. The liver processes nutrients absorbed from the small intestine, detoxifies harmful substances, synthesizes proteins, and stores glycogen for energy.

4. What is the function of the gallbladder?

Ans. The gallbladder stores and concentrates bile produced by the liver and releases bile through the bile duct when food enters the small intestine.

5. Where is the pancreas located in the body?

Ans. The pancreas is a large gland situated just ventral to the stomach.

6. What are the two portions of the pancreas and their functions?

Ans. The pancreas has exocrine and endocrine portions. The exocrine portion secretes pancreatic juice into the pancreatic duct, while the endocrine portion secretes insulin and glucagon hormones into extracellular fluid.

7. **How does the exocrine portion of the pancreas contribute to digestion?**
 Ans. The exocrine portion secretes pancreatic juice containing enzymes into the pancreatic duct. These enzymes help digest all groups of food.
8. **What major enzymes are found in pancreatic juice?**
 Ans. Major enzymes in pancreatic juice include trypsin, chymotrypsin, lipases, amylases, nucleases, etc.
9. **How does the endocrine portion of the pancreas function?**
 Ans. The endocrine portion secretes insulin and glucagon hormones into extracellular fluid from where they diffuse into nearby capillaries.
10. **How is the release of secretions from the pancreas and liver controlled?**
 Ans. The release of secretions from pancreas and liver is controlled by hormones, which regulate these secretions in response to chyme entering the duodenum.
11. **What role does secretin play in regulating digestive secretions?**
 Ans. When chyme enters the duodenum, its acidity stimulates the duodenal walls to release secretin, a hormone that stimulates pancreatic juice release.
12. **How does cholecystikinin (CCK) regulate pancreatic and gallbladder secretions?**
 Ans. Partially digested proteins and fats in chyme stimulate the duodenal walls to secrete CCK, which stimulates the pancreas to release pancreatic juice and the gallbladder to release bile.
13. **What important functions does the liver perform related to nutrient storage?**
 Ans. The liver stores excess nutrients from food and releases them when the body needs energy or building materials.
14. **What types of nutrients are stored in the liver?**
 Ans. Nutrients stored in the liver include glucose (stored as glycogen), vitamins (A, D, B12, and K), minerals such as iron and copper, and fats and fat-soluble substances.
15. **What is the liver's role in metabolism?**
 Ans. The liver plays a central role in metabolism by breaking down, building up, and converting substances in the body.
16. **How does the liver manage excess glucose?**
 Ans. The liver converts excess glucose into glycogen for storage and converts glycogen back into glucose when the body needs energy.
17. **How does the liver handle fats?**
 Ans. The liver breaks down fats to produce energy and forms cholesterol and lipoproteins.
18. **How does the liver process amino acids and remove harmful substances?**
 Ans. The liver converts amino acids and removes harmful ammonia by turning it into urea, which is then excreted in urine.
19. **What detoxification processes occur in the liver?**
 Ans. The liver breaks down and removes toxins, drugs, and alcohol from the blood.
20. **How does the liver assist in hormone regulation?**
 Ans. The liver helps in breaking down and regulating hormones, maintaining balance in the body.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

- Where does chemical digestion of carbohydrates begin?**
 (a) Stomach (b) Oesophagus (c) Small intestine (d) Mouth ✓
- Which enzyme in saliva starts breaking down starch?**
 (a) Lipase (b) Amylase (Ptyalin) ✓ (c) Trypsin (d) Pepsin
- What prevents food from entering the trachea during swallowing?**
 (a) Epiglottis ✓ (b) Oesophageal sphincter (c) Uvula (d) Tongue

4. **Why does the enzyme activity drop in the stomach when pH rises?**
 (a) Acid blocks food entry (b) Enzymes denature in low Ph
 (c) Enzymes need acidic pH to work ✓ (d) Saliva dilutes gastric juice
5. **Which change would most affect protein digestion?**
 (a) Blocking bile release (b) Inhibiting salivary glands
 (c) Inhibiting pepsin production ✓ (d) Slowing peristalsis
6. **Why is lipase not active in the stomach?**
 (a) It is destroyed by acid (b) It needs alkaline pH to work
 (c) It is secreted by the liver (d) It digests only proteins ✓
7. **Which stomach secretion activates pepsin and kills bacteria?**
 (a) Bile (b) Hydrochloric acid (HCl) ✓
 (c) Sodium bicarbonate (d) Mucus
8. **Why is segmentation important in the small intestine?**
 (a) It absorbs bile ✓ (b) It breaks down enzymes
 (c) It mixes food with digestive juices (d) It pushes food to the rectum
9. **What is the function of villi and microvilli in the small intestine?**
 (a) Produce enzymes (b) Increase surface area for absorption
 (c) Store bile ✓ (d) Neutralize stomach acid
10. **Which best explains the liver's role in digestion?**
 (a) It produces insulin (b) It stores undigested food
 (c) It produces bile for fat digestion ✓ (d) It secretes enzymes into the colon

SHORT ANSWER QUESTIONS

1. **What is the main function of the digestive system?**

Ans. To break down food into smaller molecules so nutrients can be absorbed and used by the body.

2. **What is the mode of action of saliva in mouth?**

Ans. Saliva moistens food and contains the enzyme amylase, which begins the breakdown of starch.

3. **What is role of tongue in the mouth?**

Ans. The tongue helps in mixing food with saliva, forming a bolus, and pushing it towards the pharynx for swallowing.

4. **What role does the epiglottis play during swallowing?**

Ans. It closes over the windpipe (trachea) to prevent food from entering the respiratory tract.

5. **What is the composition of gastric juice?**

Ans. Gastric juice contains hydrochloric acid (HCl), pepsin, mucus, and intrinsic factor.

6. **Why is hydrochloric acid (HCl) important in the stomach?**

Ans. It kills bacteria, activates pepsinogen to pepsin, and provides an acidic environment for digestion.

7. **What is the difference between bolus and chyme?**

Ans. Bolus is the chewed and swallowed mass of food; chyme is the semi-liquid mixture formed in the stomach after digestion.

8. **Which organ produces bile, and what is its function?**

Ans. The liver produces bile; it emulsifies fats, aiding their digestion and absorption.

9. **Differentiate between physical and chemical digestion.**

Ans. Physical digestion involves mechanical breakdown (chewing), while chemical digestion involves enzymatic breakdown of food.

10. **What do you understand by emulsification of fats?**

Ans. It is the process by which bile breaks large fat globules into smaller droplets, increasing the surface area for enzyme action.

11. **What is the role of the pyloric sphincter in digestion?**

Ans. It controls the passage of chyme from the stomach into the small intestine and prevents backflow.

12. **How do villi and microvilli help in nutrient absorption?**

- ✓ Ans. They increase the surface area of the small intestine, enhancing the absorption of nutrients.
13. **What are the main functions of the large intestine?**
 Ans. It absorbs water and salts, and forms and stores feces.
14. **What causes jaundice in the digestive system?**
 Ans. It is caused by the buildup of bilirubin due to liver dysfunction or blockage of bile ducts.
15. **How does stress negatively impact digestion?**
 Ans. Stress can reduce enzyme secretion, slow down digestion, and lead to issues like indigestion or constipation.

LONG QUESTIONS

- Q1. **Explain the complete process of digestion, starting from ingestion in the mouth to egestion in the large intestine. Include the roles of mechanical and chemical digestion at each stage.**
 Ans. : See Long Question No. 01 to 04
- Q2. **Describe the structure and function of the stomach in digestion.**
 Ans. : See Long Question No. 02
- Q3. **Compare and contrast the roles of the small intestine and large intestine in Digestion?**
 Ans. : See Long Question No. 03 & 04
- Q4. **Explain the absorption of food from the small intestine?**
 Ans. : See Long Question No. 03
- Q5. **Discuss accessory organs (liver, gallbladder and pancreas) and their contributions in digestion?**
 Ans. : See Long Question No.05
- Q6. **Describe the hormonal and nervous regulation of gastric acid secretion?**
 Ans. : See Long Question No. 05

INQUISITIVE QUESTIONS

1. **Why does the small intestine need both peristalsis and segmentation?**
 Ans. Peristalsis moves food forward, while segmentation mixes food with digestive juices and increases contact with the intestinal walls for better absorption.
2. **How does the liver help digestion without using enzymes?**
 Ans. The liver produces bile, which emulsifies fats, making them easier to digest by enzymes, even though bile itself contains no enzymes.
3. **Why do we need bile if we already have enzymes for fat digestion?**
 Ans. Bile breaks down large fat globules into smaller droplets (emulsification), increasing the surface area for enzymes like lipase to work more effectively.
4. **How does the pancreas "know" when to release its enzymes?**
 Ans. Hormones like secretin and cholecystokinin (CCK), released by the small intestine in response to food, signal the pancreas to release its digestive enzymes.
5. **Why are pancreatic secretions alkaline, not acidic?**
 Ans. Pancreatic juice contains bicarbonate, which neutralizes the acidic chyme from the stomach, creating an optimal pH for enzyme activity in the small intestine.

Self-Assessment Unit 9

Time allowed 60 Mins

Max. Marks: 28

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. **Where does the enzymatic breakdown of carbohydrates first occur?**
(a) Stomach (b) Oesophagus (c) Small intestine (d) Mouth
2. **Which salivary enzyme initiates the digestion of starch in the mouth?**
(a) Lipase (b) Amylase (Ptyalin) (c) Trypsin (d) Pepsin
3. **What structure ensures that swallowed food does not enter the windpipe?**
(a) Epiglottis (b) Oesophageal sphincter (c) Uvula (d) Tongue
4. **Why does enzyme activity in the stomach decrease if pH becomes less acidic?**
(a) Acidity blocks food entry
(b) Enzymes denature at low pH
(c) Most enzymes require acidic conditions to function
(d) Saliva reduces the acidity
5. **Which factor would most interfere with protein breakdown in the digestive tract?**
(a) Stopping bile release (b) Disabling salivary glands
(c) Blocking pepsin secretion (d) Reducing muscular movement
6. **Why is lipase enzyme generally inactive inside the stomach?**
(a) It is broken down by stomach acid
(b) It requires an alkaline environment
(c) It originates from the liver
(d) It only digests carbohydrates
7. **Which stomach substance activates pepsin and eliminates harmful microbes?**
(a) Bile (b) Hydrochloric acid (HCl)
(c) Sodium bicarbonate (d) Mucus
8. **What is the main role of segmentation in the small intestine?**
(a) To absorb bile salts (b) To break down digestive enzymes
(c) To mix chyme with digestive fluids (d) To move waste toward the rectum
9. **What is the key function of villi and microvilli in the intestinal lining?**
(a) Enzyme production (b) Maximizing nutrient absorption
(c) Bile storage (d) Acid neutralization
10. **Which statement best describes the liver's contribution to digestion?**
(a) It secretes insulin
(b) It stores waste material
(c) It produces bile to aid in fat breakdown
(d) It releases enzymes into the large intestine

Q2. Write short answers to the following questions.

(5x2=10)

1. What is the main function of the digestive system?
2. What is the mode of action of saliva in mouth?
3. What is the composition of gastric juice?
4. What is the difference between bolus and chyme?
5. How does stress negatively impact digestion?

Q3. Write detailed answer to the following question

(4+4=8)

1. Describe the structure and function of the stomach in digestion.
2. Explain the absorption of food from the small intestine?