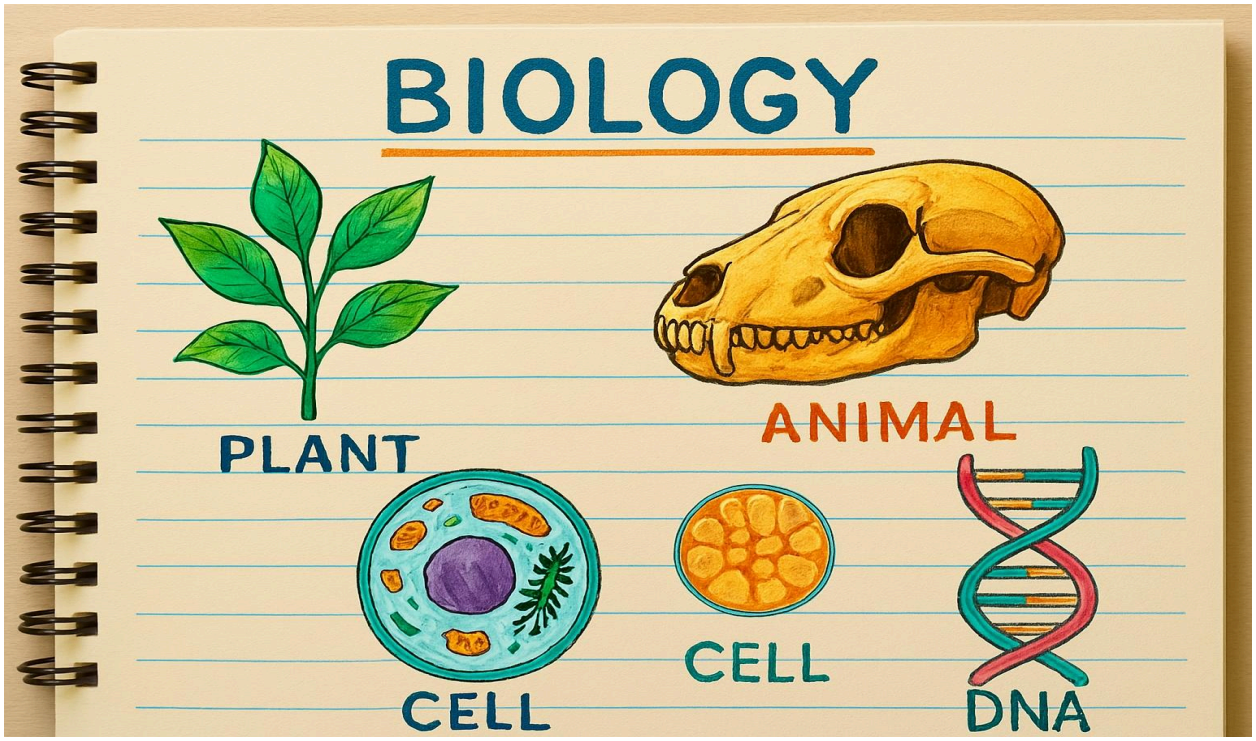


Class: 11th

Subject: Biology

Chapter 9: HUMAN DIGESTIVE SYSTEM

❖ Important MCQs:

1. Digestion is the process of:

(a) Absorbing oxygen

(b) Breaking down food into smaller absorbable components ✅

(c) Producing hormones

(d) Circulating blood

2. The digestive system is composed of:

(a) Gastrointestinal tract only

(b) Accessory digestive organs only

(c) Gastrointestinal tract and accessory digestive organs ✅

(d) Mouth and stomach only

3. Which of the following is part of the GI tract?

(a) Liver

(b) Oesophagus ✅

(c) Pancreas

(d) Gallbladder

4. Which of the following is an accessory digestive organ?

(a) Stomach

(b) Small intestine

(c) Liver ✅

(d) Pharynx

5. The cavity immediately after the mouth is called:

(a) Pharynx

(b) Oral cavity ✅

(c) Larynx

(d) Nasal cavity

6. Which organ helps in the selection of food through taste buds?

(a) Lips

(b) Tongue ✅

(c) Teeth

(d) Cheeks

7. Chewing of food is called:

(a) Mastication ✅

(b) Peristalsis

(c) Segmentation

(d) Digestion

8. Chewing increases surface area for:

(a) Respiration

(b) Enzymatic action ✅

(c) Circulation

(d) Absorption of water

9. How many pairs of salivary glands are present in humans?

(a) One

(b) Two

(c) Three ✅

(d) Four

10. Which salivary glands are located below the tongue?

(a) Parotid glands

(b) Sublingual glands ✅

(c) Submaxillary glands

(d) Pancreatic glands

11. Which salivary glands are located in front of the ears?

(a) Parotid glands ✅

(b) Sublingual glands

(c) Submaxillary glands

(d) Liver glands

12. Saliva contains which enzyme?

(a) Lipase

(b) Salivary amylase ✅

(c) Trypsin

(d) Pepsin

13. Salivary amylase digests:

(a) Proteins

(b) Fats

(c) Starch ✅

(d) Vitamins

14. The moist mass of chewed food is called:

(a) Chyme

(b) Bolus ✅

(c) Fibre

(d) Plasma

15. The pharynx is a common passage for:

(a) Digestive tract only

(b) Respiratory tract only

(c) Digestive and respiratory tracts ✅

(d) Circulatory system

16. The flap that closes the trachea during swallowing is:

(a) Palate

(b) Epiglottis ✅

(c) Tongue

(d) Pharynx

17. The tube that connects pharynx to stomach is called:

(a) Trachea

(b) Oesophagus ✅

(c) Intestine

(d) Larynx

18. The length of adult human oesophagus is about:

(a) 10 cm

(b) 15 cm

(c) 25 cm ✅

(d) 40 cm

19. Food moves through oesophagus by:

(a) Diffusion

(b) Peristalsis ✅

(c) Osmosis

(d) Segmentation

20. The sphincter preventing backflow of stomach contents is:

(a) Pyloric sphincter

(b) Cardiac sphincter ✅

(c) Anal sphincter

(d) Ileocaecal valve

21. Rhythmic waves of contraction in alimentary canal are called:

(a) Segmentation

(b) Peristalsis ✅

(c) Antiperistalsis

(d) Digestion

22. Back-and-forth movement of food in intestines is called:

(a) Peristalsis

(b) Segmentation ✅

(c) Antiperistalsis

(d) Absorption

23. Reverse movement of food from intestines to stomach is called:

(a) Segmentation

(b) Peristalsis

(c) Antiperistalsis ✅

(d) Absorption

24. What triggers hunger contractions?

(a) Full stomach

(b) Low blood glucose ✅

(c) Acidic food

(d) High blood pressure

25. Efficient digestion is important because it:

(a) Prevents nutrient deficiencies ✅

(b) Produces hormones

(c) Circulates oxygen

(d) Filters blood

26. The stomach is located in which part of the abdominal cavity?

(a) Right side, below diaphragm

(b) Left side, below diaphragm ✅

(c) Central, above diaphragm

(d) Near intestines

27. The cardiac portion of the stomach is:

(a) At the bottom near pylorus

(b) Immediately after oesophagus ✅

(c) On the side of fundus

(d) Outer layer of stomach

28. Which sphincter allows food to enter the stomach from oesophagus?

(a) Pyloric sphincter

(b) Cardiac sphincter ✅

(c) Anal sphincter

(d) Lower oesophageal sphincter

29. Which of the following is NOT a layer of stomach wall?

(a) Mucosa

(b) Submucosa

(c) Muscularis externa

(d) Endothelium ✅

30. Which layer contains glands that secrete HCl, pepsinogen, and mucus?

(a) Submucosa

(b) Mucosa ✅

(c) Muscularis externa

(d) Serosa

31. Heartburn or pyrosis is caused by:

(a) Acid reflux from stomach into oesophagus ✅

(b) Low stomach enzyme production

(c) Overactivity of pyloric sphincter

(d) High bile secretion

32. The muscularis externa of stomach consists of:

(a) Outer circular, middle oblique, inner longitudinal

(b) Outer longitudinal, middle circular, inner oblique ✅

(c) Outer oblique, middle circular, inner longitudinal

(d) Outer longitudinal, middle oblique, inner circular

33. Serosa layer of stomach:

(a) Secretes gastric juice

(b) Provides protection and is part of peritoneum ✅

(c) Activates pepsinogen

(d) Controls pyloric sphincter

34. Mechanical digestion in the stomach is facilitated by:

(a) Gastrin hormone

(b) Contractions of stomach muscles ✅

(c) HCl secretion only

(d) Chief cells

35. HCl secreted by parietal cells:

(a) Adjusts pH to 2-3 ✅

(b) Activates somatostatin

(c) Neutralizes chyme

(d) Digests fats

36. Pepsinogen is secreted by:

(a) Parietal cells

(b) Chief cells ✅

(c) Mucus cells

(d) Endocrine cells

37. Gastric juice is collectively composed of:

(a) HCl only

(b) Pepsin only

(c) HCl, pepsinogen, and mucus ✅

(d) Lipase and bile

38. Semi-liquid acidic mass formed in the stomach after digestion is called:

(a) Chyme ✅

(b) Bolus

(c) Saliva

(d) Gastrin

39. Which hormone stimulates gastric glands to produce more gastric juice?

(a) Somatostatin

(b) Gastrin ✅

(c) Insulin

(d) Secretin

40. Somatostatin regulates digestion by:

(a) Stimulating pepsinogen

(b) Stopping the release of HCl ✅

(c) Increasing gastric contractions

(d) Activating chief cells

41. The pancreas secretes pancreatic juice into which part of the small intestine?

(a) Jejunum

(b) Ileum

(c) Duodenum ✅

(d) Colon

42. Which enzyme in pancreatic juice digests proteins into smaller peptides?

(a) Pancreatic amylase

(b) Trypsin ✅

(c) Lipase

(d) Maltase

43. Chymotrypsin is produced by:

(a) Liver

(b) Pancreas ✅

(c) Gallbladder

(d) Stomach

44. Pancreatic nucleases digest:

(a) Proteins

(b) Carbohydrates

(c) DNA and RNA ✅

(d) Lipids

45. The liver secretes bile, which is stored in:

(a) Duodenum

(b) Pancreas

(c) Gallbladder ✅

(d) Jejunum

46. Bile salts help digestion by:

(a) Neutralizing amino acids

(b) Emulsifying fats ✅

(c) Breaking down proteins

(d) Absorbing water

47. Which of the following is NOT a function of bile?

(a) Emulsifying fats

(b) Neutralizing chyme

(c) Digesting carbohydrates ✅

(d) Providing large surface area for lipase

48. The main enzyme in saliva responsible for starch digestion is:

(a) Lipase

(b) Salivary amylase ✅

(c) Pepsin

(d) Trypsin

49. Trypsinogen is secreted in inactive form to:

(a) Prevent self-digestion of pancreas ✅

(b) Digest carbohydrates

(c) Emulsify fats

(d) Neutralize chyme

50. The hormone gastrin stimulates:

(a) Liver to produce bile

(b) Gastric glands to secrete more gastric juice ✅

(c) Pancreas to release insulin

(d) Gallbladder to store bile

51. Somatostatin regulates digestion by:

(a) Stimulating bile secretion

(b) Stopping HCl release ✅

(c) Activating pepsin

(d) Increasing peristalsis

52. Chyle is formed in the small intestine after:

(a) Action of enzymes on chyme ✅

(b) Absorption of water in large intestine

(c) Neutralization by bile in stomach

(d) Mechanical digestion in oesophagus

53. Villi and microvilli in small intestine increase:

(a) Motility

(b) Surface area for absorption ✅

(c) Secretion of HCl

(d) Production of bile

54. Fatty acids and glycerol combine in villi to form:

(a) Glucose

(b) Amino acids

(c) Triglycerides ✅

(d) Maltose

55. Chylomicrons enter which lymphatic vessel?

(a) Hepatic portal vein

(b) Thoracic duct ✅

(c) Lacteals of colon

(d) Rectum

56. The large intestine lacks:

(a) Circular folds

(b) Villi ✅

(c) Goblet cells

(d) Muscular layer

57. The internal anal sphincter is made of:

(a) Striated muscles

(b) Smooth muscles ✅

(c) Cardiac muscles

(d) Oblique muscles

58. Bacteria in the colon produce:

(a) Vitamin K ✅

(b) Gastrin

(c) Pepsin

(d) Bile salts

59. Appendicitis is treated by:

(a) Antibiotics only

(b) Appendicectomy ✅

(c) Bile removal

(d) Gastric juice inhibition

60. Absorption of amino acids and simple sugars into blood occurs via:

(a) Lacteals

(b) Blood capillaries of villi ✅

(c) Colon

(d) Gallbladder

61. The main role of bile produced by the liver is to:

(a) Digest proteins

(b) Emulsify fats ✅

(c) Absorb vitamins

(d) Neutralize enzymes

62. Where is bile stored before being released into the small intestine?

(a) Duodenum

(b) Gallbladder ✅

(c) Pancreas

(d) Liver lobules

63. Gallstones are primarily formed due to:

(a) Excess pancreatic enzymes

(b) Precipitation of cholesterol in gallbladder ✅

(c) Low bile production

(d) High glucose levels

64. Pancreas has which two main functional portions?

(a) Lobular and tubular

(b) Exocrine and endocrine ✅

(c) Parietal and chief

(d) Mucosa and submucosa

65. The exocrine portion of pancreas secretes:

(a) Insulin and glucagon

(b) Pancreatic juice containing digestive enzymes ✅

(c) Bile

(d) Gastric juice

66. The endocrine portion of pancreas secretes:

(a) Gastrin

(b) Pancreatic juice

(c) Insulin and glucagon ✅

(d) Bile salts

67. Which hormone stimulates the pancreas to release pancreatic juice in response to acidic chyme?

(a) Gastrin

(b) Secretin ✅

(c) Cholecystokinin

(d) Somatostatin

68. Which hormone stimulates both pancreas and gallbladder in response to partially digested proteins and fats?

(a) Gastrin

(b) Secretin

(c) Cholecystokinin (CCK) ✅

(d) Insulin

69. The liver stores glucose in the form of:

(a) Fructose

(b) Glycogen ✅

(c) Starch

(d) Maltose

70. Ammonia produced from amino acid breakdown in liver is converted into:

(a) Urea ✅

(b) Bile

(c) Glucose

(d) Fatty acids

📘 EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. Where does chemical digestion of carbohydrates begin?

(a) Stomach

(b) Oesophagus

(c) Small intestine

(d) Mouth ✅

2. Which enzyme in saliva starts breaking down starch?

(a) Lipase

(b) Amylase (Ptyalin) ✅

(c) Trypsin

(d) Pepsin

3. 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

SECTION 2: SHORT QUESTIONS

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

Ans: The digestive system breaks down large, complex food molecules into smaller, absorbable components. It provides energy for the body, supplies raw materials for growth, repair, and maintenance, supports the immune system, and ensures overall health. Efficient digestion prevents nutrient deficiencies and keeps metabolism active.

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

Ans: Saliva moistens and lubricates food, making it easier to chew and swallow. It contains salivary amylase, which starts breaking down starch into maltose. Saliva also has bicarbonate ions to maintain pH, and thiocyanate ions that kill microorganisms, protecting the mouth from infection.

3. What is role of tongue in the mouth?

Ans: The tongue helps in selecting food through its taste buds and senses its texture. It also moves food during chewing, mixes it with saliva, and finally pushes the bolus toward the pharynx for swallowing. Additionally, it plays a role in phonation (sound production).

4. What role does the epiglottis play during swallowing?

Ans: The epiglottis acts as a protective flap that closes over the trachea during swallowing. This ensures that food passes safely into the oesophagus and prevents choking or entry of food into the respiratory tract.

5. What is the composition of gastric juice?

Ans: Gastric juice is secreted by the stomach lining and contains hydrochloric acid (HCl), pepsinogen, mucus, and other digestive enzymes. HCl provides acidic pH for enzyme activation, pepsinogen digests proteins, and mucus protects the stomach wall from damage.

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

Ans: HCl creates an acidic environment (pH 2–3) necessary to activate pepsinogen into pepsin, which digests proteins into peptides. It also softens food, kills harmful microorganisms, and helps in breaking down nutrients for absorption in the small intestine.

7. What is the difference between bolus and chyme?

Ans: Bolus is the soft, moist mass of chewed food formed in the mouth, ready for swallowing. Chyme is the semi-liquid, acidic mass formed in the stomach after mechanical churning and chemical digestion by gastric juice. Bolus is formed in the oral cavity, while chyme is in the stomach.

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

Ans: Liver produces bile, which is stored in the gallbladder. Bile emulsifies fats, breaking them into small droplets to increase the surface area for the action of lipase enzymes. It also helps in the absorption of fat-soluble vitamins (A, D, E, K).

9. Differentiate between physical and chemical digestion.

Answer:

Physical (mechanical) digestion: Food is broken down into smaller pieces without changing its chemical structure, e.g., chewing in mouth, churning in stomach.

Chemical digestion: Food molecules are broken down into simpler substances by enzymes and chemicals, e.g., starch → maltose by amylase, proteins → peptides by pepsin.

10. What do you understand by emulsification of fats?

Ans: Emulsification is the process in which bile salts break large fat droplets into smaller droplets. This increases the surface area, making it easier for lipase enzymes to digest fats into fatty acids and glycerol.

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

Ans: The pyloric sphincter is a muscular valve at the junction of the stomach and small intestine. It regulates the release of chyme from the stomach into the duodenum and prevents backflow of intestinal contents into the stomach.

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

Ans: Villi are finger-like projections in the small intestine, and microvilli are tiny projections on epithelial cells of villi. Together, they increase the surface area enormously, allowing efficient absorption of amino acids, glucose, fatty acids, glycerol, water, and minerals into blood and lymph.

13. What are the main functions of the large intestine?

Ans: The large intestine absorbs water, salts, and vitamin K from undigested food. It converts remaining material into faeces, stores it in the rectum, and eliminates it through the anus. It also houses bacteria (e.g., E. coli) that produce essential vitamins.

14. What causes jaundice in the digestive system?

Ans: Jaundice occurs when there is excess bilirubin in the blood, often due to liver disease, bile duct blockage, or liver malfunction. It causes yellowing of skin and eyes and indicates a problem in bile production or excretion.

15. How does stress negatively impact digestion?

Ans: Stress affects digestion by reducing saliva and digestive enzyme secretion, slowing stomach motility, and altering gut movements. It may cause indigestion, acid reflux, constipation, or diarrhea due to nervous system imbalance.

SECTION 3: 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.

❖ **Answer:**

Digestion is the process by which food is broken down into smaller, absorbable components to provide energy, nutrients for growth, repair, and maintenance of the body. It begins at the mouth and ends at the anus with egestion. The process involves both mechanical and chemical digestion at different stages.

1. Mouth (Oral Cavity)

When food enters the mouth, mechanical digestion occurs through chewing (mastication) by the teeth, which breaks food into smaller pieces. The tongue moves the food, helps in mixing it with saliva, and allows tasting.

Chemical digestion begins in the mouth as saliva, secreted by the sublingual, submandibular, and parotid glands, contains salivary amylase, which starts breaking down starch into maltose. Saliva also moistens the food, kills some microbes, and buffers the pH. The chewed and moistened food is formed into a bolus ready for swallowing.

2. Pharynx and Oesophagus

The bolus passes from the mouth into the pharynx, a common passageway for food and air. The epiglottis prevents food from entering the trachea. Swallowing is voluntary at first but becomes automatic when the bolus reaches the pharynx.

The bolus then moves through the oesophagus by peristalsis, a series of wave-like muscle contractions. The lower oesophageal sphincter opens to allow the bolus into the stomach and prevents backflow. No major chemical digestion occurs in the oesophagus.

3. Stomach

The stomach is a muscular, J-shaped organ where mechanical digestion occurs as the muscular walls churn and mix the food with gastric secretions. This process also softens food and generates heat that melts fats.

Chemical digestion in the stomach is carried out by gastric juice, which contains hydrochloric acid (HCl) and pepsinogen. HCl lowers the pH to 2–3, softens food, kills microbes, and activates pepsinogen into pepsin, which digests proteins into polypeptides and peptides. Mucus secreted by the stomach lining protects it from HCl. The food is converted into a semi-liquid acidic mass called chyme. The pyloric sphincter controls the release of chyme into the small intestine.

4. Small Intestine

The small intestine is the longest part of the alimentary canal and consists of the duodenum, jejunum, and ileum.

In the duodenum, chemical digestion continues. Pancreatic juice containing amylase, lipase, trypsin, chymotrypsin, and nucleases is released from the pancreas. Bile, secreted by the liver and stored in the gallbladder, emulsifies fats into small droplets, making them easier for lipase to digest. Proteins are broken down into peptides and amino acids, carbohydrates into simple sugars, and fats into fatty acids and glycerol.

In the jejunum and ileum, digestion is completed with intestinal juice enzymes such as maltase, sucrase, lactase, lipase, and peptidases.

Absorption occurs in the villi and microvilli of the small intestine. Simple sugars and amino acids are absorbed into blood capillaries and transported to the liver via the hepatic portal vein. Fatty acids and glycerol are absorbed into lacteals, forming chylomicrons, which enter the lymphatic system and eventually the bloodstream.

5. Large Intestine

The large intestine absorbs water, salts, and vitamin K. The remaining material is compacted into faeces, which contains undigested food, cellulose, bacteria, bile pigments, and sloughed-off cells.

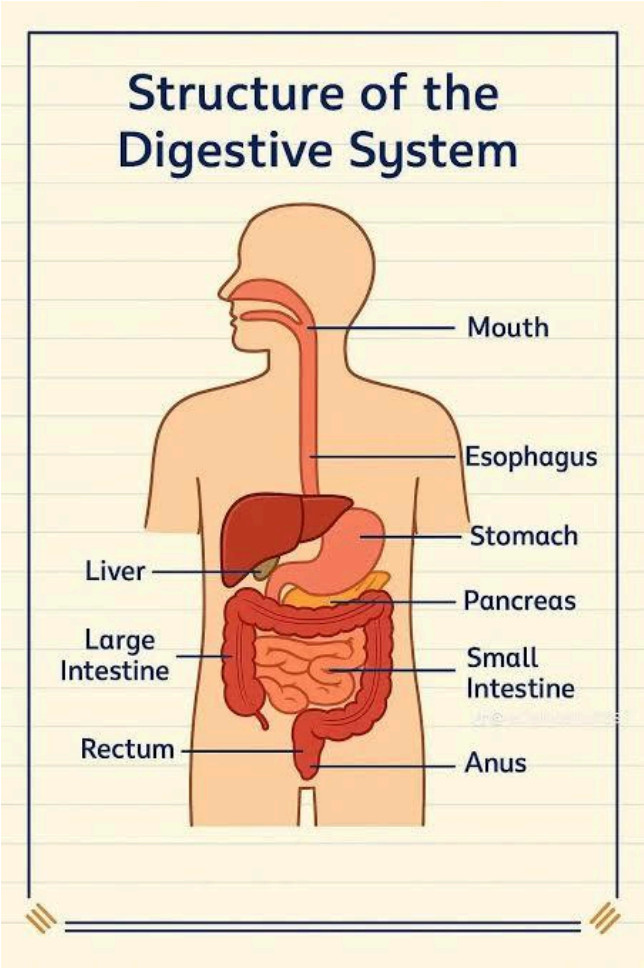
Faeces are stored in the rectum until egestion. The internal anal sphincter is involuntary, while the external anal sphincter is voluntary. Defecation is the process of expelling faeces through the anus.

✦ **Summary:**

- Digestion begins in the mouth (mechanical + chemical).

- Bolus moves via pharynx and oesophagus by peristalsis.
- **Stomach:** Mechanical churning + chemical digestion of proteins.
- **Small intestine:** Digestion of carbohydrates, proteins, and fats; absorption via villi and microvilli.
- **Large intestine:** Absorption of water, salts, vitamin K; formation and egestion of faeces.
- **Accessory organs:** Salivary glands, liver, gallbladder, pancreas aid in digestion.

Diagram:



🌟 **Q2: Describe the structure and function of the stomach in digestion.**

❖ **Answer:**

The stomach is a J-shaped, muscular, and elastic organ situated in the left side of the abdominal cavity, just below the diaphragm. It connects the oesophagus to the duodenum of the small intestine. The stomach has three main regions:

1. **Cardiac portion** – located immediately after the oesophagus.
2. **Fundus** – the dome-shaped upper part beside the cardiac portion.
3. **Pyloric portion** – the lower part which connects to the small intestine through the pyloric sphincter.

The stomach wall is composed of four layers, each with distinct roles in digestion:

1. Mucosa – the innermost layer, containing gastric glands that secrete gastric juice, including hydrochloric acid (HCl), pepsinogen, and mucus. The mucus protects the stomach lining from acidic juice.

2. Submucosa – connective tissue containing blood vessels, lymphatics, and nerves.

3. Muscularis externa – three layers of muscles (longitudinal, circular, and oblique) that contract to mix and churn food (mechanical digestion).

4. Serosa – thin outer layer forming part of the peritoneum and providing protection.

✦ Functions of the Stomach in Digestion

1. Mechanical Digestion – The muscular walls of the stomach contract to churn and mix the food with gastric juice, breaking it into smaller pieces and converting it into a semi-liquid mass called chyme. These contractions also generate heat that melts fats.

2. Chemical Digestion –

1. **Hydrochloric acid (HCl):** Lowers pH to 2–3, softens food, activates pepsinogen into pepsin, and kills microorganisms.
2. **Pepsin:** Breaks proteins into smaller peptides.
3. **Mucus:** Protects the stomach lining from acidic and enzymatic damage.

3. Storage – The stomach temporarily stores food and releases it gradually into the small intestine through the pyloric sphincter.

4. Regulation – The secretion of gastric juice is controlled by:

- **Nervous system:** Sight, smell, or thought of food stimulates gastric secretion.
- **Hormones:** Gastrin stimulates gastric glands to release more gastric juice, while somatostatin stops HCl release when food moves into the small intestine.

✦ **Summary:**

- Stomach is a J-shaped muscular organ with cardiac, fundus, and pyloric regions.
- Wall has mucosa, submucosa, muscularis externa, and serosa layers.
- **Mechanical digestion:** Churning and mixing food.

- **Chemical digestion:** Proteins digested by pepsin in acidic environment.
- **Storage and controlled release:** Food stored temporarily and gradually enters small intestine.
- Gastric juice secretion is nervous and hormonal controlled.

Diagram:

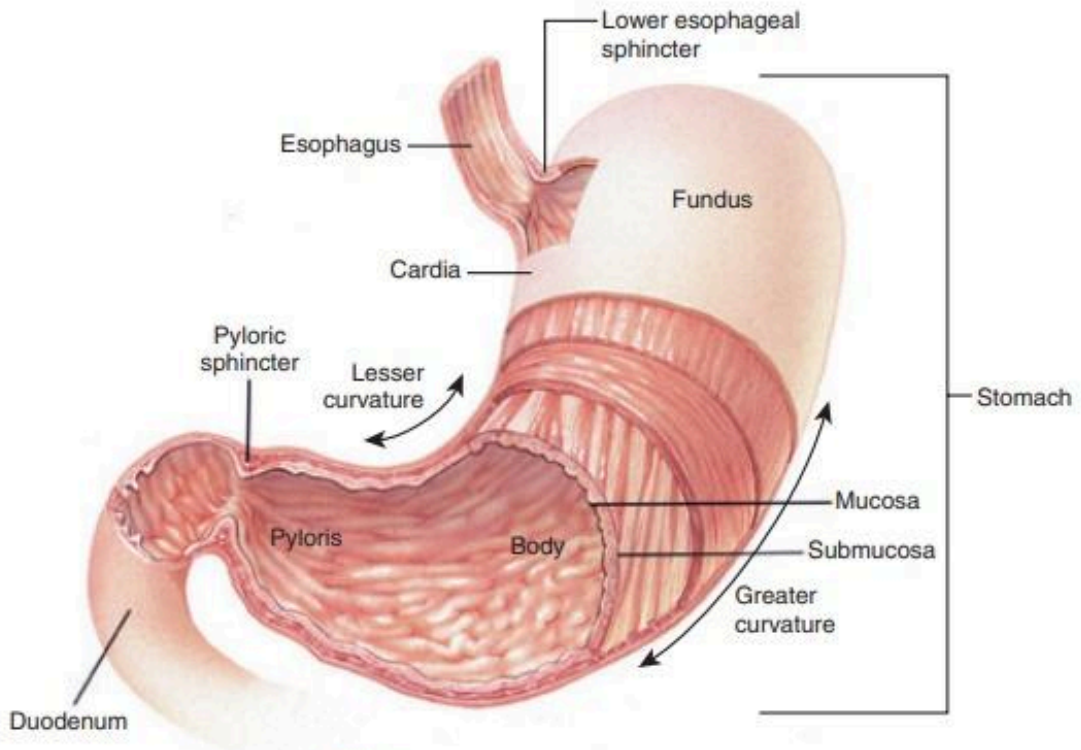


FIGURE The stomach.

🌟 **Q3: Compare and contrast the roles of the small intestine and large intestine in digestion.**

❖ **Answer:**

The small intestine and large intestine are both parts of the alimentary canal but have distinct roles in digestion and absorption.

1. Small Intestine

Structure: The small intestine is the longest part of the digestive system, about 6 meters long, consisting of duodenum, jejunum, and ileum. Its inner wall has villi and microvilli, which greatly increase the surface area for absorption.

Function in Digestion:

a. Chemical Digestion: Enzymes from pancreas (amylase, lipase, trypsin, chymotrypsin) and intestinal juice complete the breakdown of carbohydrates, proteins, and fats. Bile from the liver and gallbladder emulsifies fats for easier digestion.

b. Mechanical Digestion: Segmentation movements mix food with digestive secretions.

c. Absorption: Most nutrients are absorbed here:

- Simple sugars and amino acids enter blood capillaries.
- Fatty acids and glycerol are absorbed into lacteals as chylomicrons.

d. Converts chyme into chyle, an alkaline nutrient-rich fluid.

2. Large Intestine

Structure: Shorter than the small intestine, about 1 meter long. Its includes the caecum, colon, rectum, and anus. Its inner surface lacks villi.

Function in Digestion:

- **Water Absorption:** Absorbs water from undigested food to form solid faeces.
- **Salt and Vitamin Absorption:** Absorbs salts and vitamin K, produced by gut bacteria.
- **Egestion:** Stores faeces in the rectum and eliminates it through the anus.
- **Bacterial Action:** Houses bacteria (e.g., E. coli) that synthesize vitamins and aid in digestion of some fibers.
- Minimal chemical digestion occurs here; most enzymatic digestion is already completed in the small intestine.

Comparison

- **Length:** Small intestine is much longer than large intestine.
- **Surface Area:** Small intestine has villi and microvilli for nutrient absorption; large intestine lacks villi.
- **Primary Function:** Small intestine completes digestion and absorbs nutrients; large intestine absorbs water, salts, vitamins and forms faeces.
- **Movement:** Small intestine uses segmentation for mixing; large intestine primarily uses peristalsis to push faeces.
- **Chemical Digestion:** Predominantly in small intestine; very little occurs in large intestine.

Diagram:

✦ **Summary:**

- **Small intestine:** Digestion and nutrient absorption (carbs, proteins, fats), chyme ⟶ chyle.
- **Large intestine:** Water and salt absorption, vitamin K synthesis, faeces formation, egestion.

Both are part of the alimentary canal but serve complementary roles in completing digestion and maintaining fluid balance.

🌟 Q4: Explain the absorption of food from the small intestine.

❖ **Answer:**

The small intestine is the primary site for absorption of nutrients from digested food. It is about 6 meters long in adults and consists of duodenum, jejunum, and ileum. Its inner surface is highly adapted for absorption due to folds, villi, and microvilli, which greatly increase the surface area.

✦ Mechanism of Absorption

1. Structure Supporting Absorption:

- **Villi:** Finger-like projections on the inner wall of the small intestine. Each villus is covered by a single-layer epithelium and contains blood capillaries and a lacteal (lymphatic vessel).
- **Microvilli:** Tiny projections on the epithelial cells, forming the brush border, further increasing surface area.
- Rich blood supply in villi helps transport absorbed nutrients to the liver via hepatic portal vein.

2. Absorption of Different Nutrients:

Carbohydrates:

- Digested into simple sugars (glucose, fructose, galactose). Absorbed by active transport or facilitated diffusion into epithelial cells and then into blood capillaries.

Proteins:

- Digested into amino acids or small peptides. Absorbed by active transport into epithelial cells, then enter blood capillaries, and transported to the liver via hepatic portal vein.

Fats (lipids):

- Fatty acids and glycerol are absorbed by passive diffusion into epithelial cells. Inside the cells, they combine to form triglycerides, which are coated with proteins to form chylomicrons. Chylomicrons enter the lacteals of villi and are transported through the lymphatic system into the bloodstream.

Vitamins and Minerals:

- Water-soluble vitamins are absorbed into the blood, while fat-soluble vitamins (A, D, E, K) follow the lipid absorption pathway via lacteals. Minerals like calcium and iron are absorbed through active transport.

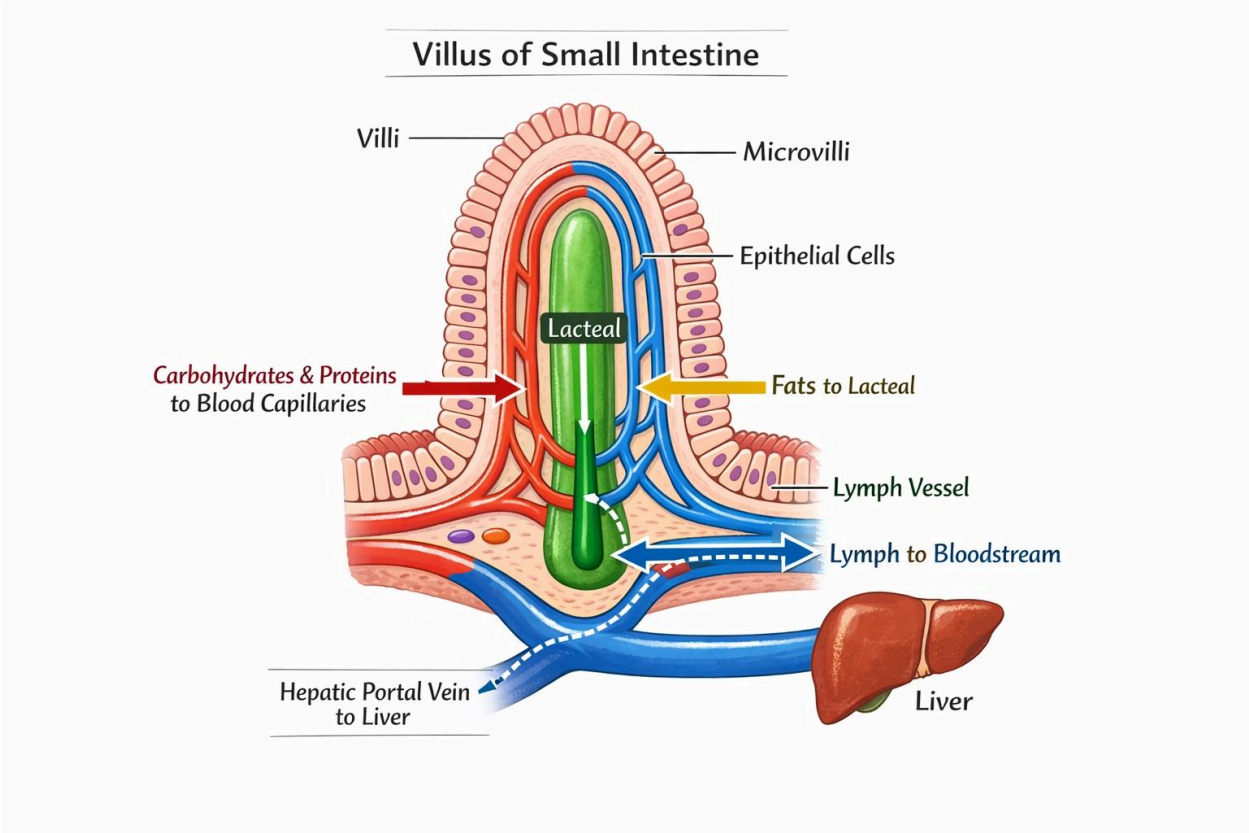
Water:

- Most water absorption occurs in the small intestine through osmosis, following the concentration gradient created by absorbed solutes.

Transport to the Liver:

- Nutrients absorbed into blood capillaries pass through the hepatic portal vein to the liver, where they are processed, stored, or released into circulation as needed.

Diagram:



✦ **Summary:**

- Small intestine has folds, villi, and microvilli to maximize absorption.
- Carbohydrates ⟶ glucose/fructose/galactose ⟶ blood capillaries
- Proteins ⟶ amino acids ⟶ blood capillaries
- Fats ⟶ triglycerides ⟶ chylomicrons ⟶ lacteals ⟶ lymph ⟶ bloodstream
- Water, minerals, and vitamins absorbed along with nutrients.
- Blood carries nutrients to the liver for processing and storage.

🌟 **Q5: Discuss accessory organs (liver, gallbladder, and pancreas) and their contributions in digestion.**

❖ **Answer:**

The accessory digestive organs include the liver, gallbladder, and pancreas. These organs do not form part of the alimentary canal, but they play vital roles in digestion by producing secretions that aid in chemical digestion of food.

1. Liver

Structure and Location: The liver is a large, reddish-brown organ located in the upper right side of the abdominal cavity.

Functions in Digestion:

- **Bile Production:** Liver secretes bile, a greenish alkaline fluid containing bile salts, bile pigments, and cholesterol.
- **Fat Digestion:** Bile emulsifies fats, breaking them into smaller droplets to increase the surface area for lipase action.
- **Nutrient Processing:** Absorbed nutrients from the small intestine are processed in the liver. For example, glucose is converted to glycogen, amino acids are processed, and fats are metabolized.
- **Detoxification:** Liver removes harmful substances from the blood, including drugs and toxins.
- **Clinical Note:** Accumulation of bile pigments can cause jaundice, a yellowing of the skin and eyes.

2. Gallbladder

- Structure and Location: A small sac located under the liver.

Functions in Digestion:

- **Bile Storage:** Stores and concentrates bile produced by the liver.
- **Bile Release:** Releases bile into the duodenum via the bile duct when fats are present in chyme.

Clinical Note: Bile may crystallize to form gallstones, which can block bile flow and affect fat digestion.

3. Pancreas

- Structure and Location: A large gland located behind the stomach, with both exocrine and endocrine portions.

Exocrine Function (Digestive Role):

- Secretes pancreatic juice into the duodenum via the pancreatic duct.

Enzymes in Pancreatic Juice:

1. Pancreatic amylase – digests starch into maltose.
2. Trypsinogen (activated to trypsin) – digests proteins into peptides.
3. Chymotrypsin and carboxypeptidase – further breakdown of proteins into amino acids.
4. Pancreatic lipase – digests fats into fatty acids and glycerol.
5. Nucleases – digest nucleic acids into nucleotides.

Alkaline Nature: Pancreatic juice contains bicarbonate ions to neutralize acidic chyme entering from the stomach.

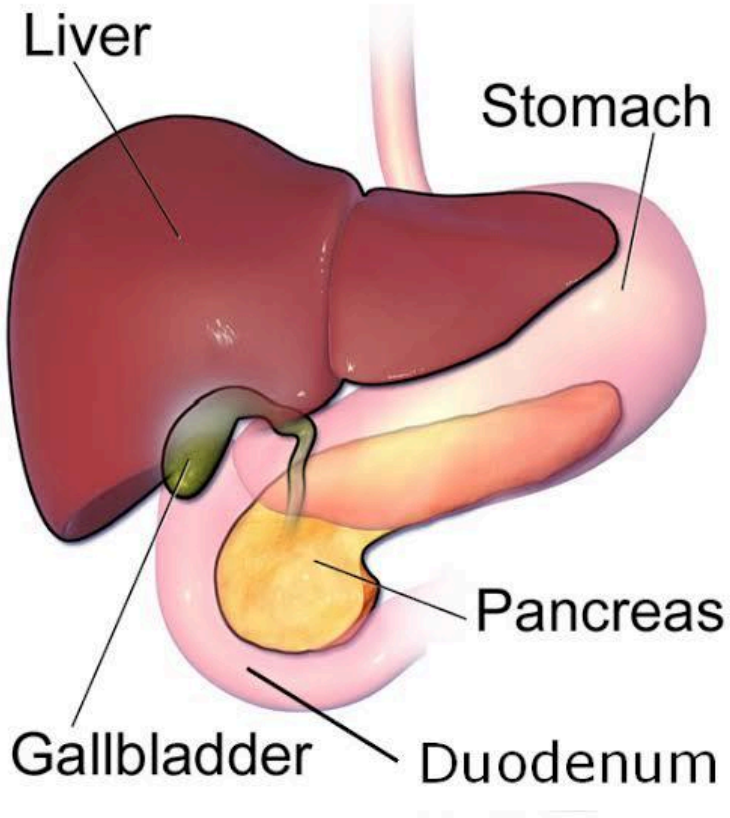
Endocrine Function:

- Secretes insulin and glucagon, which regulate blood glucose levels (not directly involved in digestion but vital for metabolism).

Hormonal Control

- **Secretin:** Released by the duodenum when acidic chyme enters; stimulates pancreas to release bicarbonate-rich pancreatic juice.
- **Cholecystokinin (CCK):** Released in response to fats and proteins in chyme; stimulates pancreas to release digestive enzymes and gallbladder to release bile.

Diagram:



✦ **Summary:**

- **Liver:** Produces bile ⟶ emulsifies fats, processes nutrients, detoxifies.
- **Gallbladder:** Stores and concentrates bile ⟶ releases it when fat is present.
- **Pancreas:** Secretes pancreatic juice (enzymes) ⟶ digests carbs, proteins, fats, nucleic acids; neutralizes stomach acid.
- Hormones secretin and CCK regulate the secretion of these organs.
- Together, these organs ensure efficient chemical digestion and nutrient absorption.

🌟 **Q6: Describe the hormonal and nervous regulation of gastric acid secretion.**

❖ **Answer:**

Gastric acid (HCl) secretion is a well-coordinated process controlled by nervous signals and hormones to ensure proper digestion and to protect the stomach lining from damage. This regulation occurs in three phases: cephalic, gastric, and intestinal.

1. Nervous Regulation

The nervous system regulates gastric acid through re flex actions mainly via the vagus nerve, which connects the stomach to the brain.

i. Cephalic Phase (Before Food Enters the Stomach)

- Triggered by sight, smell, or thought of food.

- The brain (medulla oblongata) sends nerve impulses via the vagus nerve to the gastric glands.
- This stimulates a small release of gastric juice even before the food enters the stomach.
- **Purpose**: Prepares the stomach for digestion.

ii. Gastric Phase (When Food is in the Stomach)

- Triggered by distension (stretching) of the stomach and presence of proteins in the food.
- Stretch receptors in the stomach wall send impulses to the medulla, which further stimulates gastric glands.
- The drop in pH due to the presence of food also triggers acid secretion.
- This phase is responsible for major gastric acid secretion.

iii. Intestinal Phase (When Chyme Enters Small Intestine)

- Sensory nerves in the duodenum detect acidity, fats, and proteins.
- Sends negative feedback to the stomach to reduce gastric acid secretion if the chyme is too acidic.
- Prevents damage to the duodenum and ensures proper neutralization by pancreatic juice.

2. Hormonal Regulation

Hormones coordinate increase and inhibition of gastric acid based on the stomach's needs.

i. Gastrin

- Secreted by G cells in the stomach lining when proteins are present.
- Travels via blood to gastric glands.

Stimulates:

- Parietal cells ⟶ secrete HCl.
- Chief cells ⟶ secrete pepsinogen (activated to pepsin).
- Enhances stomach motility for better mixing of food.
- **Purpose**: Ensures efficient protein digestion.

ii. Somatostatin

- Secreted by D cells in the stomach.
- Inhibits gastrin release when pH becomes too low.
- Reduces HCl secretion to prevent excessive acidity, protecting the stomach lining.

iii. Secretin and Cholecystokinin (CCK)

- Secreted by duodenal cells when acidic chyme enters the small intestine.
- Secretin ⟶ stimulates pancreas to release bicarbonate-rich juice (neutralizes acid).
- CCK ⟶ stimulates pancreas to release digestive enzymes and gallbladder to release bile.
- Both inhibit excessive gastric acid to prevent duodenal damage.

Key Points of Control

1. **Nervous control:** Quick, reflex-based response to food stimuli.

2. **Hormonal control:** Slower, longer-lasting adjustment of acid secretion.
3. **Feedback mechanism:** Ensures stomach does not become too acidic and protects the duodenum.

✦ **Summary:**

Nervous regulation:

- **Cephalic phase:** Sight/smell ⟶ small HCl release via vagus nerve.
- **Gastric phase:** Food in stomach ⟶ major HCl secretion via vagus nerve.
- **Intestinal phase:** Chyme ⟶ feedback reduces HCl secretion.

Hormonal regulation:

- **Gastrin:** Stimulates HCl and pepsinogen ⟶ promotes digestion.
- **Somatostatin:** Inhibits HCl when pH drops ⟶ protects lining.
- **Secretin & CCK:** Reduce HCl, stimulate pancreas and bile ⟶ neutralize acid.

Overall: Nervous and hormonal systems work together to ensure proper digestion, protect stomach lining, and regulate chyme entering the small intestine.

INQUISITIVE QUESTIONS

🌟 **Q1: Why does the small intestine need both peristalsis and segmentation?**

❖ **Answer:**

The small intestine is responsible for the final digestion of food and absorption of nutrients. To perform these tasks efficiently, it uses two types of muscular movements: peristalsis and segmentation.

1. Peristalsis

Definition: A rhythmic wave-like contraction of the smooth muscles of the intestinal walls.

Purpose:

- Moves the chyme forward from the duodenum to the large intestine.
- Ensures that food does not remain stagnant, preventing fermentation or bacterial overgrowth.

Mechanism:

- Circular muscles contract behind the food mass, while longitudinal muscles ahead relax.
- This pushes food forward along the lumen of the intestine.

2. Segmentation

Definition: Localized contractions of circular muscles in the small intestine, creating back-and-forth movements.

Purpose:

- Mixes chyme with digestive juices from pancreas, liver, and intestinal glands.

- Increases contact of food with absorptive surfaces (villi and microvilli).
- Enhances digestion and nutrient absorption.

Mechanism:

- Rings of circular muscles contract and relax alternately, moving the chyme back and forth in one place.

Why Both Are Needed

- **Peristalsis:** Moves food along ⟶ ensures passage to next digestive organ.
- **Segmentation:** Mixes food thoroughly ⟶ ensures maximum digestion and absorption.
- **Together:** They allow the small intestine to digest food efficiently while absorbing nutrients effectively.

✦ **Summary:**

- **Peristalsis:** Forward movement of food ⟶ propels chyme to large intestine.
- **Segmentation:** Back-and-forth movement ⟶ mixes chyme with enzymes ⟶ improves absorption.

Importance: Both movements work together to ensure efficient digestion and absorption in the small intestine.

🌟 **Q2: How does the liver help digestion without using enzymes?**

❖ **Answer:**

The liver is an accessory digestive organ that supports digestion in ways other than producing enzymes. Its main role is related to fat digestion, nutrient processing, and detoxification.

1. Production of Bile

- Bile is a greenish-yellow fluid produced by the liver.

Function in digestion:

- **Emulsifies fats:** Bile breaks large fat droplets into smaller droplets, increasing the surface area for the action of lipase (enzyme from pancreas).
- This process is called emulsification and does not involve any enzymes.

Storage and release: Bile is stored in the gallbladder and released into the duodenum when fatty foods are present.

2. Metabolism and Nutrient Regulation

- The liver stores excess glucose as glycogen, releasing it into blood when needed.
- It stores vitamins (A, D, K, B12) and minerals (iron, copper) for body use.
- Helps convert nutrients into usable forms for the body.
- Although not directly enzymatic digestion, this ensures that absorbed nutrients are processed and ready for metabolism.

3. Detoxification

- The liver removes toxins, drugs, and harmful substances from blood.
- This protects the digestive system and ensures that nutrients are safely absorbed and utilized.

✦ **Summary:**

- **Bile production:** Emulsifies fats → aids lipase activity → fat digestion.
- **Nutrient processing:** Stores and regulates glucose, vitamins, and minerals.
- **Detoxification:** Removes harmful substances → maintains healthy digestion.

Key point: The liver assists digestion without producing enzymes, primarily through bile secretion and nutrient regulation.

🌟 **Q3: Why do we need bile if we already have enzymes for fat digestion?**

❖ **Answer:**

While enzymes like pancreatic lipase can break down fats into fatty acids and glycerol, bile is still essential because fats are insoluble in water. Without bile, lipase cannot work efficiently.

1. Problem with Fat Digestion Without Bile

- Fats clump together in large droplets in the watery environment of the small intestine.
- Pancreatic lipase can only act on surface of fat droplets.

- If fat droplets are large, surface area is very small, so digestion is slow and inefficient.

2. Role of Bile

- Bile contains bile salts which act like detergents.
- They break large fat droplets into smaller droplets, a process called emulsification.
- This increases the surface area for pancreatic lipase to act.
- Result: Fat is digested faster and completely.

✦ **Summary:**

- Fats are insoluble in water, so enzymes alone cannot digest them efficiently.
- Bile emulsifies fats ⟶ forms small droplets ⟶ increases surface area.
- Pancreatic lipase then acts on these droplets ⟶ digestion of fat into fatty acids and glycerol.

Key point: Without bile, fat digestion would be very slow, even if enzymes are present.

🌟 **Q4: How does the pancreas "know when to release its enzymes"?**

❖ **Answer:**

The pancreas is an accessory digestive organ that produces enzymes for the digestion of carbohydrates, proteins, and fats. Its enzyme release is carefully controlled by nervous and hormonal signals.

1. Role of Hormones

When chyme (partially digested food) enters the duodenum from the stomach:

- Acidity of chyme stimulates the duodenal walls to release secretin.
    - **Secretin:** Signals pancreas to release bicarbonate-rich pancreatic juice to neutralize acidity.
- Presence of fats and proteins in chyme stimulates the duodenal walls to release cholecystokinin (CCK).
    - **CCK:** Signals pancreas to release enzyme-rich pancreatic juice.

Key point: The pancreas releases enzymes only when food enters the small intestine, and the type of enzyme released depends on the composition of food.

2. Role of Nervous System

- The sight, smell, or thought of food can activate the vagus nerve.
- This sends signals to the pancreas, preparing it to secrete digestive enzymes in anticipation of food.

✦ **Summary:**

Hormonal control:

- Secretin → bicarbonate secretion → neutralizes acidic chyme.
- CCK → enzyme secretion → digests fats, proteins, and carbohydrates.

Nervous control:

- Vagus nerve stimulates pancreas at sight/smell/thought of food.
- **Result:** Pancreas releases enzymes at the right time and in the right amount for effective digestion.

🌟 Q5: Why are pancreatic secretions alkaline, not acidic?

❖ **Answer:**

The pancreas secretes pancreatic juice that contains enzymes for digestion. Its alkaline nature is crucial for digestion in the small intestine.

1. Reason for Alkalinity

- When chyme enters the duodenum from the stomach, it is acidic due to hydrochloric acid (HCl) from the stomach.
- Pancreatic juice contains bicarbonate ions (HCO_3^-), which neutralize the acidic chyme.
- **pH of pancreatic juice:** Approximately 8 (slightly alkaline).

2. Importance of Alkaline Pancreatic Juice

- **Protects the small intestine:** Acidic chyme can damage the delicate lining of the duodenum and jejunum.
- **Provides optimal pH for enzymes:**
- Pancreatic enzymes like lipase, trypsin, and amylase work best in alkaline conditions.
- Without alkalinity, these enzymes would be ineffective, and digestion would be slow or incomplete.
- **Neutralization:** Helps create an environment suitable for nutrient absorption in the small intestine.

✦ **Summary:**

- Pancreatic juice is alkaline due to bicarbonate ions.
- **Functions:**
- Neutralizes acidic chyme from the stomach.
- Protects the small intestine from damage.
- Provides optimal pH for digestive enzymes.

Key point: Alkalinity ensures efficient digestion and safe absorption of nutrients in the small intestine.