

CHAPTER 24

LECTURE OUTLINE

I. INTRODUCTION

- A. Food contains substances and energy the body needs to construct all cell components. The food must be broken down through digestion to molecular size before it can be absorbed by the digestive system and used by the cells.
- B. The organs that collectively perform these functions compose the digestive system.
- C. The medical professions that study the structures, functions, and disorders of the digestive tract are gastroenterology for the upper end of the system and proctology for the lower end.

II. OVERVIEW OF THE DIGESTIVE SYSTEM

- A. Organs of the digestive system are shown in figure 24.1
- B. The gastrointestinal tract is the tube open at both ends for the transit of food during processing. The functional segments of the GI tract include the mouth, esophagus, stomach, small intestine, and large intestine.
- C. The accessory structures that contribute to the food processing include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.
- D. Digestion includes six basic processes.
 - a. Ingestion is taking food into the mouth (eating).
 - b. Secretion is the release, by cells within the walls of the GI tract and accessory organs, of water, acid, buffers, and enzymes into the lumen of the tract.
 - c. Mixing and propulsion result from the alternating contraction and relaxation of the smooth muscles within the walls of the GI tract.
 - d. Digestion
 - a. Mechanical digestion consists of movements of the GI tract that aid chemical digestion.
 - b. Chemical digestion is a series of catabolic (hydrolysis) reactions that break down large carbohydrate, lipid, and protein food molecules into smaller molecules that are usable by body cells.
 - e. Absorption is the passage of end products of digestion from the GI tract into blood or lymph for distribution to cells.
 - f. Defecation is emptying of the rectum, eliminating indigestible substances from the GI tract.

III. LAYERS OF THE GI TRACT

A. The basic arrangement of layers in the gastrointestinal tract from the inside outward includes the mucosa, submucosa, muscularis, and serosa (visceral peritoneum) (Figure 24.2).

B. The mucosa consists of an epithelium, lamina propria, and muscularis mucosa.

1. The epithelium consists of a protective layer of non-keratinized stratified squamous cells in the mouth, pharynx and esophagus and simple columnar cells for secretion and absorption in the stomach and intestines. Other cells include mucus secreting cells as well as some enteroendocrine cells that secrete hormones that help regulate the digestive process.
2. The lamina propria consists of three components, including loose connective tissue that adheres the epithelium to the lower layers, the system of blood and lymph vessels through which absorbed food is transported, and nerves and sensors.
 - a. The lymph system is part of the mucosa-associated lymph tissues (MALT) that monitor and produce an immune response to pathogens passing with food through the GI tract.
 - b. It is estimated that there are as many immune cells associated with the GI tract as in all the rest of the body.
3. The muscularis mucosa causes local folding of the mucosal layer to increase surface area for digestion and absorption.

C. The submucosa

1. The submucosa consists of areolar connective tissue. It is highly vascular, contains a part of the submucosal plexus (plexus of Meissner), and contains glands and lymphatic tissue.

D. Muscularis

1. The muscularis of the mouth, pharynx, and superior part of the esophagus contains skeletal muscle that produces voluntary swallowing. Skeletal muscle also forms the external anal sphincter.
2. Through the rest of the tract, the muscularis consists of smooth muscle in an inner sheet of circular fibers and an outer sheet of longitudinal fibers.
3. The serosa is the superficial layer of those portions of the GI tract that are suspended in the abdominopelvic cavity.

E. Serosa

1. Inferior to the diaphragm, the serosa is also called the visceral peritoneum.

IV. NEURAL INNERVATION OF THE GI TRACT

A. The Enteric Nervous system

1. The submucosal plexus (plexus of Meissner) is one network of neurons (Figure 24.3)
 - a. It regulates movements of the mucosa, vasoconstriction of blood vessels, and innervates secretory cells of mucosal glands.
2. The myenteric plexus (plexus of Auerbach) consists of fibers from both divisions of the ANS.
 - a. This plexus mostly controls GI tract motility.

B. Autonomic Nervous System

1. In general, stimulation of the parasympathetic nerves that innervate the GI tract causes an increase in GI secretion and motility by increasing the activity of ENS neurons
2. In general, the sympathetic nerves that supply the GI tract cause a decrease in GI secretion and motility by inhibiting the neurons of the ENS

C. Gastrointestinal reflex pathways

1. The gastrointestinal reflexes, made up of the plexuses, regulates GI secretion and motility in response to stimuli within the GI tract.

V. PERITONEUM

A. The peritoneum is the largest serous membrane of the body.

1. The parietal peritoneum lines the wall of the abdominal cavity.
2. The visceral peritoneum covers some of the organs and constitutes their serosa.
3. The potential space between the parietal and visceral portions of the peritoneum is called the peritoneal cavity and contains serous fluid (Figure 24.4).

B. Some organs, such as the kidneys and pancreas, lie on the posterior abdominal wall behind the peritoneum and are called retroperitoneal.

C. The peritoneum contains large folds that weave between the viscera, functioning to support organs and to contain blood vessels, lymphatic vessels, and nerves of the abdominal organs.

D. Extensions of the peritoneum include the mesentery, mesocolon, falciform ligament, lesser omentum, and greater omentum (Figure 24.4).

1. Peritonitis is an acute inflammation of the peritoneum. (Clinical Connection)

VI. MOUTH

A. Introduction

1. The mouth (oral or buccal cavity) is formed by the cheeks, hard and soft palate, lips, and tongue (Figure 24.5).
2. The vestibule of the oral cavity is bounded externally by the cheeks and lips and internally by the gums and teeth.
3. The oral cavity proper is a space that extends from the gums and teeth to the fauces, the opening between the oral cavity and the pharynx or throat.

B. Salivary Glands

1. The major portion of saliva is secreted by the salivary glands, which lie outside the mouth and pour their contents into ducts that empty into the oral cavity; the remainder of saliva comes from buccal glands in the mucous membrane that lines the mouth.
2. There are three pairs of salivary glands: parotid, submandibular (submaxillary), and sublingual glands (Figure 24.6).
3. Saliva lubricates and dissolves food and starts the chemical digestion of carbohydrates. It also functions to keep the mucous membranes of the mouth and throat moist.
4. Chemically, saliva is 99.5% water and 0.5% solutes such as salts, dissolved gases, various organic substances, and enzymes.
5. Salivation is entirely under nervous control.
6. Mumps is an inflammation and enlargement of the parotid salivary glands caused by infection with the mumps virus (myxovirus). Symptoms include fever, malaise, pain, and swelling of one or both glands. If mumps is contracted by a male past puberty, it is possible to experience inflammation of the testes and, occasionally, sterility. (Clinical Connection)

C. Tongue

1. The tongue, together with its associated muscle, forms the floor of the oral cavity. It is composed of skeletal muscle covered with mucous membrane.
2. Extrinsic and intrinsic muscles permit the tongue to be moved to participate in food manipulation for chewing and swallowing and in speech.
3. The lingual frenulum is a fold of mucous membrane that attaches to the midline of the undersurface of the tongue.

4. The upper surface and sides of the tongue are covered with papillae. Some papillae contain taste buds.
5. On the dorsum of the tongue are glands that secrete lingual lipase, which initiates digestion of triglycerides.

D. Teeth

1. The teeth project into the mouth and are adapted for mechanical digestion (Figure 24.7).
2. A typical tooth consists of three principal portions: crown, root, and neck.
3. Teeth are composed primarily of dentin, a calcified connective tissue that gives the tooth its basic shape and rigidity; the dentin of the crown is covered by enamel, the hardest substance in the body, which protects the tooth from the wear of chewing.
4. The dentin of the root is covered by cementum, another bone-like substance, which attaches the root to the periodontal ligament (the fibrous connective tissue lining of the tooth sockets in the mandible and maxillae).
 - a. The dentin encloses the pulp cavity in the crown and the root canals in the root.
5. The branch of dentistry that is concerned with the prevention, diagnosis, and treatment of diseases that affect the pulp, root, periodontal ligament, and alveolar bone is known as endodontics. Orthodontics is a dental branch concerned with the prevention and correction of abnormally aligned teeth. Periodontics is a dental branch concerned with the treatment of abnormal conditions of tissues immediately around the teeth.
6. There are two dentitions, or sets of teeth, in an individual's lifetime: deciduous (primary), milk teeth, or baby teeth; and permanent (secondary) teeth (Figure 24.8).
7. There are four different types of teeth based on shape: incisors (used to cut food), cuspids or canines (used to tear or shred food), premolars or bicuspid (absent in the deciduous dentition and used for crushing and grinding food), and molars (also used for crushing and grinding food).
8. In root canal therapy all traces of pulp tissue are removed from the pulp cavity and root canal of a badly diseased tooth (Clinical Connection).

E. Mechanical and Chemical Digestion in the Mouth

1. Through mastication (chewing), food is mixed with saliva and shaped into a bolus that is easily swallowed.

2. The enzyme salivary amylase converts polysaccharides (starches) to disaccharides (maltose). This is the only chemical digestion that occurs in the mouth.
3. Table 24.1 summarizes digestion in the mouth.

VII. PHARYNX

- A. The pharynx is a funnel-shaped tube that extends from the internal nares to the esophagus posteriorly and the larynx anteriorly (Figure 23.2).
 1. It is composed of skeletal muscle and lined by mucous membrane.
 2. The nasopharynx functions in respiration only, whereas the oropharynx and laryngopharynx have digestive as well as respiratory functions.

VIII. ESOPHAGUS

- A. The esophagus is a collapsible, muscular tube that lies behind the trachea and connects the pharynx to the stomach (Figure 24.1).

B. Histology of the Esophagus

1. The wall of the esophagus contains mucosa, submucosa, and muscularis layers.
2. The outer layer is called the adventitia rather than the serosa due to structural differences (Figure 24.9).

C. Physiology of the Esophagus

1. The esophagus contains an upper and a lower esophageal sphincter.
2. During the esophageal stage of swallowing (Figure 24.10) progressive contractions of the muscularis push the bolus onward. These propulsive contractions are termed peristalsis.
3. Table 24.2 summarizes the digestion related activities of the pharynx and esophagus.
4. Gastroesophageal reflux disease occurs when the lower esophageal sphincter fails to close adequately after food has entered the stomach, resulting in stomach contents refluxing into the inferior portion of the esophagus. HCl from the stomach contents irritates the esophageal wall resulting in heartburn. (Clinical Connection)

IX. DEGLUTITION

- A. Deglutition, or swallowing, moves a bolus from the mouth to the stomach. It is facilitated by saliva and mucus and involves the mouth, pharynx, and esophagus (Figure 24.10).

1. Deglutition consists of a voluntary state (voluntary), pharyngeal stage (involuntary), and esophageal stage (involuntary).
2. Receptors in the oropharynx stimulate the deglutition center in the medulla and the lower pons of the brain stem.

X. STOMACH

A. Introduction

1. The stomach is a J-shaped enlargement of the GI tract that begins at the bottom of the esophagus and ends at the pyloric sphincter (Figure 24.11).
2. It serves as a mixing and holding area for food, begins the digestion of proteins, and continues the digestion of triglycerides, converting a bolus to a liquid called chyme. It can also absorb some substances.

B. Anatomy of the Stomach

1. The gross anatomical subdivisions of the stomach include the cardia, fundus, body, and pylorus (Figure 24.11).
2. When the stomach is empty, the mucosa lies in folds called rugae.
3. Pylorospasm and pyloric stenosis are two abnormalities of the pyloric sphincter that can occur in newborns. Both functionally block or partially block the exit of food from the stomach into the duodenum and must be treated with drugs or surgery (Clinical Connection).

C. Histology of the Stomach

1. The surface of the mucosa is a layer of simple columnar epithelial cells called mucous surface cells (Figure 24.12).
2. Epithelial cells extend down into the lamina propria forming gastric pits and gastric glands.
3. The gastric glands consist of three types of exocrine glands: mucous neck cells (secrete mucus), chief or zymogenic cells (secrete pepsinogen and gastric lipase), and parietal or oxyntic cells (secrete HCl).
4. Gastric glands also contain enteroendocrine cells which are hormone producing cells. G cells secrete the hormone gastrin into the bloodstream.
5. The submucosa is composed of areolar connective tissue.
6. The muscularis has three layers of smooth muscle: longitudinal, circular, and an inner oblique layer.
7. The serosa is a part of the visceral peritoneum.

8. At the lesser curvature, the visceral peritoneum becomes the lesser omentum.
9. At the greater curvature, the visceral peritoneum becomes the greater omentum.

D. Mechanical and Chemical Digestion in the Stomach

1. Mechanical digestion consists of peristaltic movements called mixing waves.
2. Chemical Digestion
 - a. Chemical digestion consists mostly of the conversion of proteins into peptides by pepsin, an enzyme that is most effective in the very acidic environment (pH 2) of the stomach. The acid (HCl) is secreted by the stomach's parietal cells (Figure 24.13).
 - b. Gastric lipase splits certain molecules in butterfat of milk into fatty acids and monoglycerides and has a limited role in the adult stomach.
3. The stomach wall is impermeable to most substances; however, some water, electrolytes, certain drugs (especially aspirin), and alcohol can be absorbed through the stomach lining.
4. Gastric emptying is the periodic release of chyme from the stomach into the duodenum.
5. Most food leaves the stomach 2-6 hours after ingestion. Carbohydrates leave earliest, followed by proteins and then fats.
6. Vomiting is the forcible expulsion of the contents of the upper GI tract (stomach and sometimes duodenum) through the mouth. Prolonged vomiting, especially in infants and elderly people, can be serious because the loss of gastric juice and fluids can lead to disturbances in fluid and acid-base balance. (Clinical Connection)
7. Table 24.3 summarizes the digestive activities of the stomach

XI. PANCREAS

A. Anatomy of the Pancreas

1. The pancreas is divided into a head, body, and tail and is connected to the duodenum via the pancreatic duct (duct of Wirsung) and accessory duct (duct of Santorini) (Figure 24.15).

B. Histology of the Pancreas

1. Pancreatic islets (islets of Langerhans) secrete hormones and acini secrete a mixture of fluid and digestive enzymes called pancreatic juice. (Figure 18.18b,c)

C. Composition and Functions of Pancreatic Juice

1. Pancreatic juice contains enzymes that digest starch (pancreatic amylase), proteins (trypsin, chymotrypsin, and carboxypeptidase), fats (pancreatic lipase), and nucleic acids (ribonuclease and deoxyribonuclease).
2. It also contains sodium bicarbonate which converts the acid stomach contents to a slightly alkaline pH (7.1-8.2), halting stomach pepsin activity and promoting activity of pancreatic enzymes.
3. Pancreatic cancer and pancreatitis have large effects in terms of the function of the pancreas (Clinical Connection)

XII. LIVER AND GALLBLADDER

A. The liver is the heaviest gland in the body and the second largest organ in the body after the skin.

B. Anatomy of the Liver and Gallbladder

1. The liver is divisible into left and right lobes, separated by the falciform ligament. Associated with the right lobe are the caudate and quadrate lobes (Figure 24.14).
2. The gallbladder is a sac located in a depression on the posterior surface of the liver (Figure 24.14).

C. Histology of the Liver and Gallbladder

1. The lobes of the liver are made up of lobules that contain hepatic cells (liver cells or hepatocytes), sinusoids, stellate reticuloendothelial (Kupffer's) cells, and a central vein (Figure 24.15).
2. The mucosa of the gallbladder is simple columnar epithelium arranged in rugae. There is no submucosa. The smooth muscle of the muscularis ejects bile into the cystic duct. The outer layer is the visceral peritoneum. Functions of the gallbladder are to store and concentrate bile until it is needed in the small intestine.

D. Jaundice is a yellowish coloration of the sclera, skin, and mucous membranes due to a buildup of bilirubin. The main categories of jaundice are prehepatic, hepatic, and enterohepatic (Clinical Connection).

E. Blood Supply of the Liver

1. The liver receives a double supply of blood from the hepatic artery and the hepatic portal vein. All blood eventually leaves the liver via the hepatic vein (Figure 24.16).
2. Hepatic cells (hepatocytes) produce bile that is transported by a duct system to the gallbladder for concentration and temporary storage.
3. Liver function tests (Clinical connection)

F. Functions of the Liver and Gallbladder

1. Bile is partially an excretory product (containing components of worn-out red blood cells) and partially a digestive secretion.
2. Bile's contribution to digestion is the emulsification of triglycerides.
3. The liver also functions in carbohydrate, lipid, and protein metabolism; removal of drugs and hormones from the blood; excretion of bilirubin; synthesis of bile salts; storage of vitamins and minerals; phagocytosis; and activation of vitamin D.
4. The fusion of individual crystals of cholesterol is the beginning of 95% of all gallstones. Gallstones can cause obstruction to the outflow of bile in any portion of the duct system. Treatment of gallstones consists of using gallstone-dissolving drugs, lithotripsy, or surgery (Clinical Connection).

XIII. SMALL INTESTINE

A. Introduction

1. The major events of digestion and absorption occur in the small intestine.
2. The small intestine extends from the pyloric sphincter to the ileocecal sphincter.

B. Anatomy of the Small Intestine

1. The small intestine is divided into the duodenum, jejunum, and ileum (Figure 24.18).
2. Projections called circular folds, or plicae circularis, are permanent ridges in the mucosa that enhance absorption by increasing surface area and causing chyme to spiral as it passes through the small intestine (Figure 24.18).

C. Histology of the Small Intestine

1. The mucosa forms fingerlike villi which increase the surface area of the epithelium available for absorption and digestion (Figure 24.19).
 - a. Embedded in the villus is a lacteal (lymphatic capillary) for fat absorption.
 - b. The cells of the mucosal epithelium include absorptive cells, goblet cells, enteroendocrine cells, and Paneth cells (Figure 24.19c).
 - c. The free surface of the absorptive cells feature microvilli, which increase the surface area (Figure 24.19). They form the brush border which also contains several enzymes.
 - d. The mucosa contains many cavities lined by glandular epithelium. These cavities form the intestinal glands (crypts of Lieberkuhn).

2. The submucosa of the duodenum contains duodenal (Brunner's) glands which secrete an alkaline mucus that helps neutralize gastric acid in chyme. The submucosa of the ileum contains aggregated lymphatic nodules (Peyer's patches) (Figure 24.19).

D. Role of Intestinal Juice and Brush Border Enzymes

1. Intestinal juice provides a vehicle for absorption of substances from chyme as they come in contact with the villi.
2. Some intestinal enzymes (brush border enzymes) break down foods inside epithelial cells of the mucosa on the surfaces of their microvilli.
3. Some digestion also occurs in the lumen of the small intestine.

E. Mechanical Digestion in the Small Intestine

1. Segmentation, the major movement of the small intestine, is a localized contraction in areas containing food.
2. Peristalsis propels the chyme onward through the intestinal tract.

F. Chemical Digestion in the Small Intestine

1. Digestion of Carbohydrates

- a. Carbohydrates are broken down into monosaccharides for absorption.
 - 1) Intestinal enzymes break down starches into maltose, maltotriose, and alpha-dextrins (pancreatic amylase); alpha-dextrins into glucose (alphadextrinase); maltose to glucose (maltase); sucrose to glucose and fructose (sucrase); and lactose to glucose and galactose (lactase).
 - 2) In some individuals, there is a failure of the intestinal mucosal cells to produce the enzyme lactase. This results in lactose intolerance, the inability to digest the sugar lactose found in milk and other dairy products. It may be a temporary or long-lasting condition and is characterized by diarrhea, gas, bloating, and abdominal cramps after ingestion of dairy products (Clinical Connection)

2. Digestion of proteins

- a. Proteins are converted to peptides by trypsin and chymotrypsin. Also, enzymes break peptide bonds that attach terminal amino acids to carboxyl ends of peptides (carboxypeptidases) and peptide bonds that attach terminal amino acids to amino ends of peptides (aminopeptidases).
- b. Finally, enzymes split dipeptides to amino acids (dipeptidase).

3. Digestion of lipids

- a. Most lipid digestion, in an adult, occurs in the small intestine.
 - b. Bile salts break the globules of triglycerides (fats) into droplets, a process called emulsification.
 - c. Pancreatic lipase, due to the increase exposed surface area of the droplets, can hydrolyze more triglycerides into fatty acids and monoglycerides.
4. Digestion of Nucleic Acids
 - a. Nucleic acids are broken down into nucleotides for absorption.
 5. A summary of digestive enzymes in terms of source, substrate acted on, and product is presented in Table 24.4.

G. Absorption in the Small Intestine

1. Absorption is the passage of the end products of digestion from the GI tract into blood or lymph and occurs by diffusion, facilitated diffusion, osmosis, and active transport.
2. Absorption of Monosaccharides
 - a. Essentially all carbohydrates are absorbed as monosaccharides.
 - b. They are absorbed into blood capillaries (Figure 24.21a).
3. Absorption of Amino Acids, Dipeptides, and Tripeptides
 - a. Most proteins are absorbed as amino acids by active transport processes.
 - b. They are absorbed into the blood capillaries in the villus (Figure 24.21).
4. Absorption of Lipids and bile salts
 - a. Dietary lipids are all absorbed by simple diffusion.
 - b. Long-chain fatty acids and monoglycerides are absorbed as part of micelles, resynthesized to triglycerides, and formed into protein-coated spherical masses called chylomicrons.
 - 1) Chylomicrons are taken up by the lacteal of a villus.
 - 2) From the lacteal they enter the lymphatic system and then pass into the cardiovascular system, finally reaching the liver or adipose tissue (Figure 24.21a).
 - c. The plasma lipids - fatty acids, triglycerides, cholesterol - are insoluble in water and body fluids.
 - 1) In order to be transported in blood and utilized by body cells, the lipids must be combined with protein transporters called lipoproteins to make them soluble.
 - 2) The combination of lipid and protein is referred to as a lipoprotein.

5. Absorption of Electrolytes

- a. Many of the electrolytes absorbed by the small intestine come from gastrointestinal secretions and some are part of digested foods and liquids.
- b. Active transport mechanisms are primarily used for electrolyte absorption.

6. Absorption of Vitamins

- a. Fat-soluble vitamins (A, D, E, and K) are included along with ingested dietary lipids in micelles and are absorbed by simple diffusion.
- b. Water-soluble vitamins (B and C) are absorbed by simple diffusion.

7. Absorption of Water

- a. Figure 24.21 reviews the fluid input to the GI tract.
 - b. All water absorption in the GI tract occurs by osmosis from the lumen of the intestines through epithelial cells and into blood capillaries.
 - c. The absorption of water depends on the absorption of electrolytes and nutrients to maintain an osmotic balance with the blood.
 - d. Alcohol begins to be absorbed in the stomach. The longer alcohol remains in the stomach, the slower it is absorbed. Blood alcohol levels rise more slowly when fat rich foods are consumed with alcohol (Clinical Connection).
8. Table 24.4 summarizes the digestive and absorptive activities of the small intestine and associated accessory structures.

XIV. LARGE INTESTINE

A. Anatomy of the Large Intestine

1. The large intestine (colon) extends from the ileocecal sphincter to the anus.
2. Its subdivisions include the cecum, colon, rectum, and anal canal (Figure 24.23).
3. Hanging inferior to the cecum is the appendix.
 - a. Inflammation of the appendix is called appendicitis. (Clinical Connection)
 - b. A ruptured appendix can result in gangrene or peritonitis, which can be life-threatening conditions.
4. The colon is divided into the ascending, transverse, descending, and sigmoid portions.

B. Histology of the Large Intestine

1. The mucosa of the large intestine has no villi or permanent circular folds. It does have a simple columnar epithelium with numerous goblet cells (Figure 24.24a).

2. The muscularis contains specialized portions of the longitudinal muscles called taeniae coli, which contract and gather the colon into a series of pouches called haustra (Figure 24.23a).
3. Polyps of the colon are usually slow growing benign growths but are often removed as they may become cancerous (Clinical Connection)

C. Mechanical movements of the large intestine include haustral churning, peristalsis, and mass peristalsis.

D. Chemical Digestion in the Large Intestine

1. The last stages of chemical digestion occur in the large intestine through bacterial, rather than enzymatic, action. Substances are further broken down and some vitamins are synthesized by bacterial action and absorbed by the large intestine.

E. Absorption and Feces Formation in the Large Intestine

1. The large intestine absorbs water, electrolytes, and some vitamins.
2. Feces consist of water, inorganic salts, sloughed-off epithelial cells, bacteria, products of bacterial decomposition, and undigested parts of food.
3. Although most water absorption occurs in the small intestine, the large intestine absorbs enough to make it an important organ in maintaining the body's water balance.
4. The main diagnostic value of the occult blood test is to screen for colorectal cancer (Clinical Connection).

F. Defecation Reflex

1. The elimination of feces from the rectum is called defecation.
2. Defecation is a reflex action aided by voluntary contractions of the diaphragm and abdominal muscles. The external anal sphincter can be voluntarily controlled (except in infants) to allow or postpone defecation.
3. Diarrhea refers to frequent defecation of liquid feces. It is caused by increased motility of the intestine and can lead to dehydration and electrolyte imbalances.
4. Constipation refers to infrequent or difficult defecation and is caused by decreased motility of the intestines, in which feces remain in the colon for prolonged periods of time. It may be alleviated by increasing one's intake of dietary fiber and fluids.
5. Dietary fiber may be classified as insoluble (does not dissolve in water) and soluble (dissolves in water). Both types affect the speed of food passage through the GI tract and may produce a number of benefits in the GI tract as well as elsewhere in the body. There is evidence that insoluble fiber may help protect against colon

cancer and that soluble fiber may help lower blood cholesterol level. (Clinical Connection)

6. Table 24.6 summarizes the digestive activities in the large intestine while Table 24.7 summarizes the organs of the digestive system and their functions.

XV. PHASES OF DIGESTION

A. Digestion occurs in three overlapping phases: cephalic (reflex), gastric, and intestinal.

1. Cephalic Phase
 - a. The cephalic phase consists of reflexes initiated by sensory receptors in the head.
 - b. The cephalic phase stimulates gastric secretion and motility.
2. Gastric Phase
 - a. The gastric phase can be regulated by neural and hormonal mechanisms.
 - b. Neural regulation begins when the stomach walls are distended or when pH increases because proteins have entered the stomach and buffered some of the stomach acid, the stretch receptors and chemoreceptors are activated (Figure 24.25) resulting in waves of peristalsis and continual flow of gastric juice.
 - c. Hormonal negative feedback also regulates gastric secretions during the gastric phase.
 - 1) Chemoreceptors and stretch receptors stimulate the ANS to release acetylcholine which stimulates the release of gastrin by G cells.
 - 2) Gastrin stimulates growth of the gastric glands and secretion of large amounts of gastric juice. It also strengthens contraction of the lower esophageal sphincter, increases motility of the stomach, and relaxes the pyloric and ileocecal sphincters.
3. Intestinal Phase
 - a. The intestinal phase begins when partially digested food enters the small intestine.
 - b. Neural regulation
 - 1) Neural regulation is stimulated by distension of the duodenum.
 - 2) Distension triggers the enterogastric reflex which reduces gastric emptying.
 - c. Hormonal regulation

- 1) Secretin promotes secretion of bicarbonate ions into pancreatic juice and bile. It inhibits secretion of gastric juice and promotes normal growth and maintenance of the pancreas. It enhances the effects of CCK. Overall, it causes buffering of acid in chyme.
 - 2) CCK stimulates secretion of pancreatic juice rich in digestive enzymes and ejection of bile into the duodenum. It also slows gastric emptying.
4. Other Hormones of the Digestive System
- a. There are other hormones secreted by and having effects on the GI tract. They include motilin, substance P, bombesin, vasoactive intestinal polypeptide, gastrin-releasing peptide, and somatostatin.
 - b. Table 24.8 summarizes the activities of the digestive hormones

XVI. DEVELOPMENT OF THE DIGESTIVE SYSTEM

- A. The endoderm of the primitive gut forms the epithelium and glands of most of the gastrointestinal tract (Figure 29.12).
- B. The mesoderm of the primitive gut forms the smooth muscle and connective tissue of the GI tract.

XVII. AGING AND THE DIGESTIVE TRACT

- A. General changes associated with aging of the digestive system include decreasing secretory mechanisms, decreasing motility of the digestive organs, loss of strength and tone of digestive muscular tissue and its supporting structures, changes in neurosecretory feedback, and diminished response to pain and internal sensations.
- B. Specific changes include reduced sensitivity to mouth irritations and sores, loss of taste, periodontal disease, difficulty in swallowing, hiatal hernia, cancer of the esophagus, gastritis, peptic ulcer, gastric cancer, duodenal ulcers, appendicitis, malabsorption, maldigestion, gallbladder problems, cirrhosis, acute pancreatitis, constipation, cancer of the colon or rectum, hemorrhoids, and diverticular disease of the colon.

XVIII. FOCUS ON HOMEOSTASIS: THE DIGESTIVE SYSTEM

- A. Examines the role of the digestive system in maintaining homeostasis.

XIX. DISORDERS: HOMEOSTATIC IMBALANCES

- A. Dental caries, or tooth decay, is started by acid-producing bacteria that reside in dental plaque, act on sugars, and demineralize tooth enamel and dentin with acid.
- B. Periodontal diseases are characterized by inflammation and degeneration of the gingivae (gums), alveolar bone, periodontal ligament, and cementum.
- C. Peptic ulcers are crater-like lesions that develop in the mucous membrane of the GI tract in areas exposed to gastric juice. The most common complication of peptic ulcers is bleeding, which can lead to anemia if blood loss is serious. The three well-defined causes of peptic ulcer disease (PUD) are the bacterium *Helicobacter pylori*; nonsteroidal anti-inflammatory drugs, such as aspirin; and hypersecretion of HCl.
- D. Diverticula are saclike outpouchings of the wall of the colon in places where the muscularis has become weak. The development of diverticula is called diverticulosis. Inflammation within the diverticula, known as diverticulitis, may cause pain, nausea, vomiting, and either constipation or an increased frequency of defecation. High fiber diets help relieve the symptoms.
- E. Tumors, both benign and malignant, may occur in any portion of the GI tract. One of the most common and deadly malignancies is colorectal cancer, second only to lung cancer in males and third after lung and breast cancer in females. Screening for colorectal cancer includes fecal occult blood testing, digital rectal examination, sigmoidoscopy, colonoscopy, and barium enema.
- F. Hepatitis is an inflammation of the liver and can be caused by viruses, drugs, and chemicals, including alcohol.
 1. Hepatitis A (infectious hepatitis) is caused by hepatitis A virus and is spread by fecal contamination. It does not cause lasting liver damage.
 2. Hepatitis B is caused by hepatitis B virus and is spread primarily by sexual contact and contaminated syringes and transfusion equipment. It can produce cirrhosis and possibly cancer of the liver. Vaccines are available to prevent hepatitis B infection.
 3. Hepatitis C is caused by the hepatitis C virus. It is clinically similar to hepatitis B and is often spread by blood transfusions. It can cause cirrhosis and possibly liver cancer.
 4. Hepatitis D is caused by hepatitis D virus. It is transmitted like hepatitis B and, in fact, a person must be coinfecting with hepatitis B before contracting hepatitis D. It results in severe liver damage and has a high fatality rate.
 5. Hepatitis E is caused by hepatitis E virus and is spread like hepatitis A. It is responsible for a very high mortality rate in pregnant women.

G. Anorexia nervosa is a chronic disorder characterized by self-induced weight loss, body-image and other perceptual disturbances, and physiologic changes that result from nutritional depletion. The disorder is found predominantly in young, single females and may be inherited. Individuals may become emaciated and may ultimately die of starvation or one of its complications. Treatment consists of psychotherapy and dietary regulation.

XX. MEDICAL TERMINOLOGY - Alert students to the medical terms associated with the digestive system.