The Digestive System

Objectives

Part 1: Overview of the Digestive System

1. List the organs of the alimentary canal and the accessory digestive organs.
2. Name and define the six digestive processes.
3. Explain the relationship of the digestive organs to the peritoneum.
4. Describe the blood supply to the digestive tract.
5. Identify the four layers of the alimentary canal organs.

Part 2: Functional Anatomy of the Digestive System

6. Describe the anatomy of the mouth, lips, cheeks, palate, tongue, salivary glands, teeth, pharynx, and esophagus.
7. Explain the processes of mastication and deglutition.
8. Discuss the gross and microscopic anatomies of the stomach.
9. List and explain the phases of the regulation of gastric secretion.
10. Examine gastric motility and emptying.
11. Describe the gross and microscopic anatomies of the small intestine.
12. Define the roles of the liver, gall bladder, and pancreas in digestion.
13. Discuss the motility of the small intestine and its requirements for optimal activity.
14. Explain the gross and microscopic anatomies of the large intestine.
15. Describe defecation and the motility of the large intestine.

Part 3: Physiology of Chemical Digestion and Absorption

16. Define chemical digestion and explain the process as it relates to the breakdown of carbohydrates, proteins, lipids, and nucleic acids.
17. Describe the absorption of carbohydrates, proteins, lipids, nucleic acids, vitamins, electrolytes, and water.

Developmental Aspects of the Digestive System

18. Explain the processes that occur during fetal development of the digestive tract.
19. Underscore the changes in the digestive system that occur with age.

Suggested Lecture Outline

I. Part 1: Overview of the Digestive System (pp. 883–889; Figs. 23.1–23.6)

A. Digestive system organs fall into two main groups: the alimentary canal and the accessory organs. (pp. 883–884; Fig. 23.1)

1. Alimentary canal, or the gastrointestinal (GI) tract, is the continuous muscular digestive tube that winds through the body digesting and absorbing foodstuff; its organs include: the mouth, pharynx, esophagus, stomach, small intestine, and large intestine.
2. Accessory digestive organs aid digestion physically and produce secretions that break down foodstuff in the GI tract; the organs involved are the teeth, tongue, gallbladder, salivary glands, liver, and pancreas.

B. Digestive Processes (pp. 884–885; Figs. 23.2–23.3)
1. Ingestion is the simple act of putting food into the mouth.
2. Propulsion moves food through the alimentary canal and includes both swallowing and peristalsis.
3. Mechanical digestion is the physical process of preparing the food for chemical digestion and involves chewing, mixing, churning, and segmentation.
4. Chemical digestion is a series of catabolic steps in which complex food molecules are broken down to their chemical building blocks by enzymes.
5. Absorption is the passage of digested end products from the lumen of the GI tract through the mucosal cells into the blood or lymph.
6. Defecation eliminates indigestible substances from the body via the anus as feces.

C. The digestive system creates an optimal internal environment for its functioning in the lumen of the GI tract, an area that is technically outside of the body. (pp. 885–886; Fig. 23.4)
1. Digestive activities within the GI tract are triggered by mechanical and chemical stimuli.
2. Controls of the digestive activity are both extrinsic and intrinsic (nervous and hormonal).

D. Digestive System Organs: Relationship and Structural Plan (pp. 886–889; Figs. 23.5–23.6)
1. Relationship of Digestive Organs to the Peritoneum
    a. The visceral peritoneum covers the external surfaces of most of the digestive organs, and the parietal peritoneum lines the body wall of the abdominopelvic cavity.
    b. Peritoneal cavity is located between the visceral and parietal peritoneums and is filled with serous fluid.
    c. Mesentery is a double layer of peritoneum that extends to the digestive organs from the body wall. It allows blood vessels, lymphatics, and nerves to reach the digestive organs, and holds the organs in place as well as stores fat.
    d. Retroperitoneal organs are found posterior to the mesentery, lying against the dorsal abdominal wall.
2. The splanchnic circulation serves the digestive system and includes those arteries that branch off the abdominal aorta to serve the digestive organs and the hepatic portal circulation.
3. Histology of the Alimentary Canal
    a. Mucosa is the innermost, moist, epithelial membrane that lines the entire digestive tract. It secretes mucus, digestive enzymes, and hormones; absorbs digestive end products into the blood; and protects against infectious disease.
    b. Submucosa is a moderately dense connective tissue layer containing blood and lymphatic vessels, lymphoid follicles, and nerve fibers.
    c. Muscularis externa typically consists of smooth muscle and is responsible for peristalsis and segmentation.
    d. Serosa, the protective outer layer of the intraperitoneal organs, is the visceral peritoneum.
4. The alimentary canal has its own nerve supply made up of enteric neurons that communicate widely with each other to regulate digestive activity.

II. Part 2: Functional Anatomy of the Digestive System (pp. 889–927; Figs. 23.7–23.32; Tables 23.1–23.3)

A. Mouth, Pharynx, and Esophagus (pp. 889–897; Figs. 23.7–23.12)
   1. The mouth is a stratified squamous epithelial mucosa-lined cavity with boundaries of the lips, cheeks, palate, and tongue.
      a. The lips and cheeks have a core of skeletal muscle covered externally by skin that helps to keep food between the teeth when we chew and plays a small role in speech.
      b. The palate forms the roof of the mouth and has two parts: the hard palate anteriorly and the soft palate posteriorly.
      c. The tongue is made of interlacing bundles of skeletal muscle and is used to reposition food when chewing, mix food with saliva, initiate swallowing, and help form consonants for speech.
      d. Salivary glands produce saliva, which cleanses the mouth, dissolves food chemicals for taste, moistens food, and contains chemicals that begin the breakdown of starches.
      e. The teeth tear and grind food, breaking it into smaller pieces.
   2. The pharynx (oropharynx and laryngopharynx) provides a common passageway for food, fluids, and air.
   3. The esophagus provides a passageway for food and fluids from the laryngopharynx to the stomach where it joins at the cardiac orifice.

B. Digestive Processes Occurring in the Mouth, Pharynx, and Esophagus (pp. 897–902; Figs. 23.13–23.15)
   1. Mastication, or chewing, begins the mechanical breakdown of food and mixes the food with saliva.
   2. Deglutition, or swallowing, is a complicated process that involves two major phases.
      a. The buccal phase is voluntary and occurs in the mouth where the bolus is forced into the oropharynx.
      b. The pharyngeal-esophageal phase is involuntary and occurs when food is squeezed through the pharynx and into the esophagus.

C. The stomach is a temporary storage tank where the chemical breakdown of proteins is initiated and food is converted to chyme. (pp. 902–908; Figs. 23.16–23.19; Table 23.1)
   1. The adult stomach varies from 15–25 cm long, but its diameter and volume vary depending on the amount of food it contains.
      a. The major regions of the stomach include the cardiac region, fundus, body, and the pyloric region.
      b. The convex lateral surface of the stomach is its greater curvature, and its convex medial surface is its lesser curvature.
      c. Extending from the curvatures are the lesser omentum and the greater omentum, which help to tie the stomach to other digestive organs and the body wall.
   2. Microscopic Anatomy
      a. The surface epithelium of the stomach mucosa is a simple columnar epithelium composed of goblet cells, which produce a protective two-layer coat of alkaline mucus.
      b. The gastric glands of the stomach produce gastric juice, which may be composed of a combination of mucus, hydrochloric acid, intrinsic factor, pepsinogen, and a variety of hormones.
   3. Digestive Processes Occurring in the Stomach

a. Gastric secretion is controlled by both neural and hormonal mechanisms and acts in three distinct phases: the cephalic phase, the gastric phase, and the intestinal phase.
b. The reflex-mediated relaxation of the stomach muscle and the plasticity of the visceral smooth muscle allow the stomach to accommodate food and maintain internal pressure.
c. The interstitial cells of Cajal establish the stomach's basic electrical rhythm of peristaltic waves.
d. The rate at which the stomach empties is determined by both the contents of the stomach and the processing that is occurring in the small intestine.

D. Small Intestine and Associated Structures (pp. 908–918; Figs. 23.20–23.27)
1. The small intestine is the site of the completion of digestion and absorption of nutrients.
a. It extends from the pyloric sphincter to the ileocecal valve where it joins the large intestine. It has three subdivisions: the duodenum, the jejunum, and the ileum.
b. It is highly adapted for absorption with three microscopic modifications: plicae circulares, villi, and microvilli.
c. The intestinal crypts, or the crypts of Lieberkühn, secrete intestinal juice that serves as a carrier fluid for absorbing nutrients from chyme.
2. The liver and gallbladder are accessory organs associated with the small intestine.
a. The liver is the largest gland in the body and has four lobes.
b. The liver is composed of liver lobules, which are made of plates of liver cells (hepatocytes).
c. The digestive function of the liver is to produce bile, which is a fat emulsifier.
d. Bile is a yellow-green, alkaline solution containing bile salts, bile pigments (primarily bilirubin), cholesterol, neutral fats, phospholipids, and a variety of electrolytes.
e. The gallbladder stores and concentrates bile that is not needed immediately for digestion.
f. Bile does not usually enter the small intestine until the gallbladder contracts when stimulated by cholecystokinin.
3. The pancreas is an accessory gland that is retroperitoneal.
a. Pancreatic juice consists mainly of water and contains enzymes that break down all categories of foodstuffs and electrolytes.
b. Secretion of pancreatic juice is regulated by local hormones and the parasympathetic nervous system.

E. Digestive Processes Occurring in the Small Intestine (pp. 919–922; Fig. 23.28; Tables 23.2–23.3)
1. Food takes 3 to 6 hours to complete its digestive path through the small intestine, the site of virtually all nutrient absorption.
2. Most substances required for chemical digestion within the small intestine are imported from the pancreas and the liver.
3. Optimal digestive activity in the small intestine depends on a slow, measured delivery of chyme from the stomach.
4. Segmentation is the most common motion of the small intestine.

F. The large intestine absorbs water from indigestible food residues and eliminates them as feces. (pp. 922–927; Figs. 23.29–23.32)
1. The large intestine exhibits three unique features: teniae coli, haustra, and epiploic appendages, and has the following subdivisions: cecum, appendix, colon, rectum, and anal canal.

2. The mucosa of the large intestine is thick and has crypts with a large number of mucus-producing goblet cells.
3. Bacteria entering the colon via the small intestine and anus colonize the colon and ferment some of the indigestible carbohydrates.
4. Digestive Processes Occurring in the Large Intestine
    a. The movements seen in the large intestine include haustral contractions and mass movements.
    b. Feces forced into the rectum by mass movements stretch the rectal wall and initiate the defecation reflex.

III. Part 3: Physiology of Chemical Digestion and Absorption (pp. 927–933; Figs. 23.33–23.36)

A. Chemical digestion is a catabolic process in which large food molecules are broken down to chemical building blocks (monomers), which are small enough to be absorbed by the GI tract lining. (pp. 927–931; Figs. 23.33–23.35)
    1. Chemical digestion is accomplished by enzymes, secreted by intrinsic and accessory glands of the alimentary canal, used in hydrolysis reactions.
    2. Carbohydrates
        a. Monosaccharides are simple sugars that are absorbed immediately (glucose, galactose, and fructose).
        b. Disaccharides are composed of two monosaccharides bonded together (maltose, lactose, and sucrose).
        c. The digestible polysaccharide found in the diet is starch; other polysaccharides, such as cellulose, are not able to be broken down by humans.
        d. Chemical digestion of carbohydrates begins in the mouth where salivary amylase breaks large polysaccharides into smaller fragments.
    3. Proteins digested into amino acids in the GI tract include not only dietary proteins but also enzyme proteins secreted into the GI tract lumen.
        a. Pepsin, secreted by the chief cells, begins the chemical digestion of proteins in the stomach.
        b. Rennin is produced in infants and breaks down milk proteins.
        c. Pancreatic enzymes, such as trypsin and chymotrypsin, further break down proteins in the small intestine.
        d. The brush border enzymes carboxypeptidase, aminopeptidase, and dipeptidase work on freeing single amino acids in the small intestine.
    4. The small intestine is the sole site for lipid digestion.
        a. Lipases are secreted by the pancreas and are the enzymes that digest fats after they have been pretreated with bile.
    5. Nucleic acids (both DNA and RNA) are hydrolyzed to their nucleotide monomers by pancreatic nucleases present in pancreatic juice.

B. Absorption occurs along the entire length of the small intestine, and most of it is completed before the chyme reaches the ileum. (pp. 931–933; Fig. 23.36)
    1. Absorption of Specific Nutrients
        a. Glucose and galactose are transported into the epithelial cells by common protein carriers and are then moved by facilitated diffusion into the capillary blood.

b. Several types of carriers transport the different amino acids before entering the capillary blood by diffusion.
c. Monoglycerides and free fatty acids of lipid digestion become associated with bile salts and lecithin to form micelles, which are necessary for lipid absorption.
d. Pentose sugars, nitrogenous bases, and phosphate ions are transported actively across the epithelium by special transport carriers in the villus epithelium.
e. The small intestine absorbs dietary vitamins, while the large intestine absorbs vitamins B and K.
f. Electrolytes are actively absorbed along the entire length of the small intestine, except for calcium and iron which are absorbed in the duodenum.
g. Water is the most abundant substance in chyme and 95% of it is absorbed in the small intestine by osmosis.

2. Malabsorption of nutrients can result from anything that interferes with the delivery of bile or pancreatic juices, as well as factors that damage the intestinal mucosa.

IV. Developmental Aspects of the Digestive System (pp. 933–937; Fig. 23.37)

A. Embryonic Development (pp. 933, 936; Fig. 23.37)
1. The epithelial lining of the developing alimentary canal forms from the endoderm with the rest of the wall arising from the mesoderm.
2. The anteriormost endoderm touches the depressed area of the surface ectoderm where the membranes fuse to form the oral membrane and ultimately the mouth.
3. The end of the hindgut fuses with an ectodermal depression, called the proctodeum, to form the cloacal membrane and ultimately the anus.
4. By week 8 the alimentary canal is a continuous tube stretching from the mouth to the anus.

B. Aging (pp. 936–937)
1. GI tract motility declines, digestive juice production decreases, absorption is less efficient, and peristalsis slows resulting in less frequent bowel movements and often constipation.
2. Diverticulosis, fecal incontinence, and cancer of the GI tract are fairly common problems in the elderly.

Cross References

Additional information on topics covered in Chapter 23 can be found in the chapters listed below.

1. Chapter 1: Serous membranes
2. Chapter 2: Enzyme function; acids and bases; carbohydrates, lipids, proteins, and nucleic acids
3. Chapter 3: Microvilli; membrane transport
4. Chapter 4: Simple columnar epithelium; areolar connective tissue; serous and mucous glands
5. Chapter 9: Smooth muscle
6. Chapter 10: Mastication and tongue movement
7. Chapter 12: Brain stem centers
8. Chapter 13: Receptors; reflex activity; nerve plexuses
9. Chapter 14: Sympathetic and parasympathetic controls
10. Chapter 15: Papillae and taste buds
11. Chapter 16: Hormones
12. Chapter 17: Pernicious anemia

13. Chapter 20: Lymphatic tissue; lacteals; palatine tonsils
14. Chapter 21: Macrophages
15. Chapter 24: Hepatic metabolism and detoxification; role of chylomicrons in lipid metabolism; bile formation; cholesterol and lipid transport in the blood
16. Chapter 26: Electrolyte balance

Laboratory Correlations

1. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Cat and Fetal Pig Versions.* Eighth Edition Updates. Benjamin Cummings, 2006.

   Exercise 38: Anatomy of the Digestive System

   Exercise 39: Chemical and Physical Processes of Digestion
2. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Main Version.* Seventh Edition Update. Benjamin Cummings, 2006.

   Exercise 38: Anatomy of the Digestive System

   Exercise 39: Chemical and Physical Processes of Digestion

Histology Slides for the Life Sciences

Available through Benjamin Cummings, an imprint of Pearson Education, Inc. To order, contact your local Benjamin Cummings sales representative.

Slide 56 Esophagus Wall.
Slide 57 Stomach Gastric Pits and Glands, Fundic Portion.
Slide 58 Submaxillary Gland.
Slide 59 Wall of Duodenum, Small Intestine.
Slide 60 Wall of Large Intestine, Colon.
Slide 61 Intestinal Glands, Jejunum.
Slide 62 Liver Lobule, Pig Liver.
Slide 63 Liver Lobule Central Vein, Monkey Liver Cell with Glycogen.
Slide 64 Pancreatic Islet, Pancreas.
Slide 65 Detailed Structure of the Gastric Glands and Pits.
Slide 66 Gastroesophageal Junction of Simple Columnar Epithelium (Stomach) and Stratified Squamous Epithelium (Esophagus).
Slide 67 Sublingual Salivary Glands.
Slide 68 Pancreas Tissue—Exocrine and Endocrine Areas Clearly Visible.

Lecture Hints

1. Emphasize that the digestive system is not only the alimentary (gastrointestinal) canal but all organs and tissues that aid in the process of digestion.
2. Point out that the gastrointestinal tract is formed of the same basic four layers through its length, but that each area is modified for the specific task involved.
3. Digestion is the process of breaking large particles into small particles. Emphasize that the overall function of the digestive system is the mechanical and chemical breakdown of ingested substances followed by the absorption of those substances and elimination of undigestible materials.

4. Most students have difficulty with the serous coverings of the abdominal viscera. Use diagrams and photographs of actual tissue to reinforce descriptions of the relatively complex folded nature of these membranes.
5. Spend some time with the hepatic portal system. This is another example of blood entering a capillary bed, feeding into a vein, then into another capillary bed before being returned to general circulation.
6. When discussing the histology of the tract, ask the class: "What is the logical epithelial choice for the mouth? For the esophagus?" Point out that the choice of columnar epithelium for the mucosal layer of the gastrointestinal tract is ideally suited to its function.
7. Emphasize that the esophagus is not covered by serosa, but instead has an adventitia as its outermost coat.
8. Emphasize that the lower esophageal sphincter (gastroesophageal) is not a true sphincter.
9. As a point of interest, mention that heartburn is actually acid reflux into the lower portion of the esophagus.
10. Point out the modification of the muscularis externa in the stomach as it relates to the function of the stomach.
11. Have students note the difference between the way the mucosa in the stomach has a relatively low surface area structure as compared to the small intestine. Ask the students why this is so.
12. Intrinsic factor is a stomach secretion necessary for vitamin B_{12} absorption; however, actual absorption of this vitamin does not occur in the stomach, but much later in the large intestine.
13. As each cell of the stomach mucosa is described, relate the logical function of each type to the overall function of the stomach.
14. Mention that the three areas of the small intestine are distinguishable histologically by examination of the mucosal structure.
15. Use diagrams or black line masters to demonstrate the three structural modifications of the small intestine that greatly increase the surface area for absorption.
16. When introducing the digestive function of the small intestine, lead into the topic by asking the class: "What functions must occur as chyme enters the initial part of the small intestine?" Using carefully led questioning, the class should respond: acid neutralization, further digestion of carbohydrates and proteins, and initiation of lipid digestion.
17. Students have difficulty with the pathways of flow in the liver lobule. Use two-dimensional cross sections of a lobule and indicate the directions of blood flow and bile flow. Stress the difference between the hepatic portal vein and the hepatic vein.
18. Ask the class why the hepatic artery is necessary, since the liver is already supplied by the portal vein. They should be able to respond that portal blood is "used" blood from the digestive tract.
19. Emphasize that the pancreas is a dual function/structure gland, endocrine and exocrine.
20. *Taenia coli* are best explained by using a cross-sectional diagram followed by a longitudinal section.
21. Emphasize that the amount of time the contents of the large intestine are in contact with the mucosa determines fecal water content. Too little time in the large intestine means a watery stool, and too much time results in constipation.
22. Point out the logical names of digestive enzymes: the prefix usually indicates the substrate, and the suffix "-ase" means enzyme. An exception, trypsin, was named before universal acceptance of the "-ase" convention.
23. Spend time on fat digestion and absorption, from emulsification to movement through the bloodstream. Point out that carbohydrates and proteins take a different (vascular) path to the liver than do the lipids.

Activities/Demonstrations

1. Audio-visual materials listed under Multimedia in the Classroom and Lab.
2. Have students calculate their total caloric intake over a 24-hour period by using a simple caloric guide available in any drugstore. Have students analyze their diet with attention to what improvements could (and should) be made in their eating habits.
3. Demonstrate the emulsification action of bile: first mix oil and water together and allow the layers to separate out. Then add bile salts and shake vigorously. Point out that the layer of oil has been dispersed into hundreds of tiny fat spheres by the action of the bile salts.
4. Use a torso model and/or dissected animal model to exhibit digestive organs.
5. Use gallstones obtained from a surgeon to exhibit as you discuss the liver and gallbladder.
6. Use a long balloon, not quite fully blown up, to demonstrate peristalsis.
7. Use a human skull or dentition models to demonstrate the different tooth shapes, types, and numbers.
8. Demonstrate molecular models of carbohydrate, fat, and protein.

Critical Thinking/Discussion Topics

1. Discuss symptoms, treatment, and prognosis of a hiatal hernia.
2. Explain why it is important to chew food properly.
3. Explore the importance of the liver.
4. Discuss the cause, treatment, and prevention of ulcers.
5. Talk about why it is necessary for someone with ulcer-like symptoms to consult a physician rather than to just use antacids.
6. Discuss the reasons why elderly individuals should be checked for colorectal cancer.
7. Examine the reasons for treatment and prognosis of a colostomy.
8. If a high-salt meal is ingested, why is a large amount of water not lost in the feces?
9. Discuss how people on low-carbohydrate diets have relatively constant glucose levels.

Library Research Topics

1. Research the causes and treatment of ulcers.
2. Study the benefits of fiber in the diet.
3. Research liver transplants in terms of rationale for the transplant, procedure, and prognosis.
4. Explore inherited metabolic disorders.
5. Research the congenital disorders that affect a newborn’s ability to survive in the first days after birth.
6. Investigate the latest causes and treatments of hepatitis. What are the consequences of liver inflammation/infection?
7. What are malabsorption syndromes? Their causes? Their treatments?
8. Study the different types of motility disorders associated with the digestive tract. Include possible secondary complications and suggested treatments.
9. What are the common cancers of the digestive system? Are cancers limited to the gastrointestinal tract? Are they limited to the accessory structures?

Multimedia in the Classroom and Lab

Online Resources for Students

www.anatomyandphysiology.com www.myaandp.com

The following shows the organization of the Chapter Guide page in both the Anatomy & Physiology Place and MyA&P™. The Chapter Guide organizes all the chapter-specific online media resources for Chapter 23 in one convenient location, with e-book links to each section of the textbook. Please note that both sites also give you access to other general A&P resources, like InterActive Physiology®*, PhysioEx 6.0™, Anatomy 360°, Flashcards, a Glossary, a Histology Tutorial, and much more.*

Objectives

PART ONE: OVERVIEW OF THE DIGESTIVE SYSTEM (PP. 883–889)

InterActive Physiology®: Orientation

Art Labeling Activity: Alimentary Canal and Related Accessory Organs (Fig. 23.1, p. 883)

PART TWO: FUNCTIONAL ANATOMY OF THE DIGESTIVE SYSTEM (PP. 889–927)

InterActive Physiology®: Anatomy Review

Art Labeling Activity: Anatomy of the Stomach (Fig. 23.14, p. 899)

Art Labeling Activity: Microscopic Anatomy of the Stomach (Fig. 23.15, p. 901)

Art Labeling Activity: Gross Anatomy of the Large Intestine (Fig. 23.29, p. 923)

Memory: Digestive System Associated Structures

Memory: The Digestive System

PART THREE: PHYSIOLOGY OF CHEMICAL DIGESTION AND ABSORPTION (PP. 927–933)

InterActive Physiology®: Control of the Digestive System

InterActive Physiology®: Motility

InterActive Physiology®: Secretion

InterActive Physiology®: Digestion and Absorption

PhysioEx: Chemical and Physical Processes of Digestion

Case Study: Iron Deficiency Anemia

Section 23.4 Developmental Aspects of the Digestive System (pp. 933, 936–937)

Chapter Summary

Self-Study Quizzes

Art Labeling Quiz

Matching Quiz

Multiple-Choice Quiz (Level I)

Multiple-Choice Quiz (Level II)

True-False Quiz

Crossword Puzzles

Crossword Puzzle 23.1

Crossword Puzzle 23.2

Media

See Guide to Audio-Visual Resources in Appendix A for key to AV distributors.

Slides

1. *Digestive Tract Set* (CBS). Contains tissue samples from all major organs of the digestive tract.
2. *Human Organs and Glands of Digestion Set* (CBS). Represents all organs and glands in the digestive tract.

Video

1. *Breakdown* (FHS; 28 min., 1984). From the award-winning *The Living Body* series, this video investigates the digestive consequences of eating a meal, following the food through the entire alimentary canal.
2. *Digestion* (FHS; 20 min., 1995). From the award-winning *The New Living Body* series, this video provides a thorough introduction to the structures and functions of the digestive tract.
3. *The Digestive System: Down the Hatch!* (KV; 20 min., 2001). From the four-part series *Amazing Adventures Inside the Human Body*. This video explores the mechanical and chemical processes of digestion that turn food into nutrients and vitamins that the body can absorb.
4. *Digestive System: Your Personal Power Plant* (FHS/IM; 25 min., 2000). From *The Human Body: Systems at Work* series, this program examines the processes by which the digestive system acts as a power plant for the body by turning food into energy.
5. *The Food Machine* (NIMCO; 25 min., 1994). This video, from *The Body Atlas* series, follows the path of food through the alimentary canal and explains how the body separates useful substances from wastes.
6. *Gastrointestinal Disorders* (IM; 50 min., 1997). This video details diagnostic procedures and presents information about numerous GI diseases.
7. *The Human Digestive System Videotape* (BC; 33 min., 1998). This video provides an excellent overview of the human digestive system.
8. *Passage of Food Through the Digestive Tract* (WNS; 8 min.). A concise video that introduces the student to the digestive system. Students are able to relate each part of the digestive tract to the digestion of food through the use of X-ray motion photography.

Software

1. *A.D.A.M.® InterActive Anatomy® 4.0* (see p. 9 of this guide for full listing).
2. *A.D.A.M.® MediaPro* (see p. 9 of this guide for full listing).
3. *A.D.A.M.® Anatomy Practice* (see p. 86 of this guide for full listing).
4. *Bodyworks* (see p. 9 of this guide for full listing).
5. *The Human Digestive System* (IM; Win/Mac). Accesses endoscopic pictures and lab experiments to show the human digestive system at work.
6. *InterActive Physiology® 9-System Suite CD-ROM*† (BC; Win/Mac). The Digestive System module walks students through animations that clearly and simply explain every part of the human digestive process, from basic anatomy to complete digestion and absorption. Like the rest of the CD, students learn at their own pace by pausing and/or replaying animations when needed, and test their knowledge with the worksheets and quizzes available at the end of the module.
7. *The Ultimate Human Body* (see p. 9 for full listing).

Lecture Enhancement Material

To view thumbnails of all of the illustrations for Chapter 23, see Appendix B.

Transparencies Index/Media Manager

Figure 23.1 Alimentary canal and related accessory digestive organs.

Figure 23.2 Gastrointestinal tract activities.

Answers to End-of-Chapter Questions

Multiple Choice and Matching Question answers appear in Appendix G of the main text.

Short Answer Essay Questions

18. A drawing of the organs of the alimentary tube and labels can be found on page 883, Fig. 23.1.
19. The digestive system does contain local nerve plexuses known as the local (enteric) nervous system or the gut brain. This is essentially composed of nerve plexuses in the wall of the alimentary canal that extend the entire length of the GI tract. These plexuses respond to local stimuli in the GI tract by initiating both short and long reflexes. The gut brain solely mediates the short reflexes. Long reflexes are initiated by both external and local stimuli, and involve both the gut brain and the ANS. (Sympathetic nerves inhibit GI tract activity, whereas parasympathetic nerves, primarily the vagus nerve, stimulate it.) (pp. 885–886)
20. The basic alimentary canal wall structure consists of four tunics: the mucosa, submucosa, muscularis, and serosa. The mucosa consists of a surface epithelium underlain by a small amount of connective tissue called the lamina propria and a scanty amount of smooth muscle fibers, the muscularis mucosae. Typically, the epithelium of the mucosa is a simple columnar epithelium rich in mucus-secreting goblet cells and other types of glands. The mucus protects certain digestive organs from being digested themselves by the enzymes working within their cavities and eases the passage of food along the tract. In some digestive organs the mucosa contains both enzyme-secreting and hormone-secreting cells. The lamina propria, consisting of areolar connective tissue and containing lymph nodules, is important in the defense against bacteria and other pathogens. In the small intestine, the muscularis mucosae throw the mucosal tunic into a series of small folds that vastly increases its surface area for secretion and absorption.

    The submucosa is areolar connective tissue containing blood vessels, lymphatic vessels, nerve endings, and epithelial glands. Its vascular network supplies surrounding tissues and carries away absorbed nutrients. Its nerve plexus is part of the enteric nerve supply of the gastrointestinal tube.

    The muscularis externa mixes and propels food along the digestive tract. This muscular tunic usually has an inner circular layer and an outer longitudinal layer of smooth muscle cells, although there are variations in this pattern.

    The serosa is formed of areolar connective tissue covered with mesothelium, a single layer of squamous epithelial cells. It is the protective outermost layer and the visceral peritoneum. (pp. 887–888)
21. The mesentery is a double peritoneal fold that suspends the small intestine from the posterior abdominal wall. The mesocolon is a special dorsal mesentery that secures the transverse colon to the parietal peritoneum of the posterior abdominal wall. The greater omentum is also a double peritoneal sheet that covers the coils of the small intestine and wraps the transverse portion of the large intestine. (pp. 886, 900)
22. The six functional activities of the digestive system are ingestion, propulsion, mechanical digestion, chemical digestion, absorption, and defecation. (pp. 884–885)
23. The boundaries of the oral cavity include the lips, cheeks, tongue, palate, and oropharynx. The epithelium is stratified squamous epithelium because the walls have to withstand considerable abrasion. (pp. 889–900)
24. a. The normal number of permanent teeth is 32; deciduous teeth, 20.
    b. Enamel covers the crown; cementum, the root.
    c. Dentin makes up the bulk of the tooth.
    d. Pulp is found in the central cavity in the tooth. Soft tissue structures (connective tissue, blood vessels, and nerve fibers) compose pulp. (pp. 893–895)
25. The two phases of swallowing are as follows:
    a. Buccal (voluntary) phase of swallowing: organs involved—tongue, soft palate; activities—tongue compacts food into a bolus, forces the bolus into the oropharynx via tongue contractions. The soft palate rises to close off the superior nasopharynx. (pp. 897–898)

b. Pharyngeal-esophageal (involuntary) phase: organs involved—pharynx and esophagus; activities—motor impulses sent from the swallowing center to their muscles, which contract to send the food to the esophagus by peristalsis. Arrival of food/peristaltic wave at the gastroesophageal sphincter causes it to open. (p. 898)

26. The parietal cells secrete hydrochloric acid and intrinsic factor. Chief cells produce pepsinogen. Mucous neck cells produce mucus that helps shield the stomach wall from damage by gastric juices. Enteroendocrine cells secrete hormones into the lamina propria. (pp. 900–901)
27. Gastric secretion is controlled by both neural and hormonal mechanisms. The stimulation of gastric secretion involves three distinct phases: the cephalic, gastric, and intestinal phases.

    The cephalic phase occurs before food enters the stomach and is triggered by the sight, aroma, taste, or thought of food. Input is relayed to the hypothalamus, which stimulates the vagal nuclei of the medulla oblongata, causing motor impulses to be sent via vagal nerve fibers to the stomach. This reflex may be dampened during depression or loss of appetite.

    The gastric phase is initiated by neural and hormonal mechanisms once food reaches the stomach. Stomach distension activates stretch receptors and initiates reflexes that transmit impulses to the medulla and then back to the stomach, leading to acetylcholine release. Acetylcholine stimulates the output of gastric juice. During this phase, the hormone gastrin is more important in gastric juice secretion than neural influences. Chemical stimuli provided by foods directly activate gastrin-secreting cells. Gastrin stimulates the gastric glands to spew out even more gastric juice. Gastrin secretions are inhibited by high acidity.

    The intestinal phase is set into motion when partially digested food begins to fill the duodenum. This filling stimulates intestinal mucosal cells to release a hormone (intestinal gastrin) that encourages the gastric glands to continue their secretory activity briefly; but as more food enters the small intestine, the enterogastric reflex is initiated, which inhibits gastric secretion and food entry into the duodenum to prevent the small intestine from being overwhelmed. Additionally, intestinal hormones (enterogastrones) inhibit gastric activity. (pp. 902–905)
28. a. The cystic and common hepatic ducts fuse to form the bile duct, which fuses with the pancreatic ducts just before entering the duodenum. (p. 912)
    b. The point of fusion of the common bile duct and pancreatic duct is called the hepatopancreatic ampulla. (p. 908)
29. The absence of bile (which causes fat emulsification) and/or pancreatic juice (which contains essentially the only important source of lipase) causes fat absorption to be so slow as to allow most of the fat to be passed into the large intestine. (p. 932)
30. The Kupffer cells function to remove debris such as bacteria from the blood. The hepatocytes function to produce bile, in addition to their many metabolic activities. (p. 912)
31. a. Brush border enzymes are intestinal digestive enzymes; these are part of the plasma membrane of the microvilli of the intestinal absorptive cells. (p. 910)
    b. Chylomicrons are fatty droplets consisting of triglycerides combined with small amounts of phospholipids, cholesterol, and free fatty acids, and coated with proteins. They are formed within the absorptive cells and enter the lacteals. (p. 932)
32. Common inflammatory conditions include appendicitis in adolescents, ulcers, and gallbladder problems in middle-age adults, and constipation in old age. (p. 937)
33. The effects of aging on digestive system activity include declining mobility, reduced production of digestive juice, less efficient absorption, and slowing of peristalsis. (p. 937)

Critical Thinking and Clinical Application Questions

1. If the agent promotes increased bowel motility without providing for increased bulk, diverticulosis is a possibility, because the rigor of the colonic contractions increases when the volume of residues is small. This increases the pressure on the colon wall, promoting the formation of diverticula. If the product irritates the intestinal mucosa, diarrhea will occur. Intestinal contents will be moved rapidly through both the small and large intestines, leaving inadequate time for absorption of water, which can result in dehydration and electrolyte imbalance. (pp. 926–927)
2. This patient has the classical symptoms of a gallbladder attack in which a gallstone has lodged in the cystic duct. The pain is discontinuous and colicky because it reflects the rhythm of peristaltic contractions (contract-relax-contract-relax, etc.). The stone can be removed surgically or by sound or laser treatment. If it is not removed, bile will back up into the liver, and jaundice will result. (p. 917)
3. The baby's blood would indicate acidosis due to the intestinal juice passing through the large intestine with little or no time for reabsorption of water and substances such as bicarbonate ions dissolved in water by the large intestine. (p. 927)
4. a. Most gastric ulcers are found to be caused by infection with *Helicobacter pylori*. This drug regimen successfully eradicates the infection.
   b. Possible consequences of nontreatment could be surgical removal of the existing ulcer due to internal bleeding, or the occurrence of multiple ulcers. (p. 902)
5. An endoscope is an instrument used to visually inspect any cavity of the body and is composed of an illuminated fiber optic tube with a lens. The polyps seen were removed immediately because most colorectal cancers arise from initially benign polyps. Presently, colon cancer is the second largest cause of cancer death in males in the U.S. (p. 937)
6. Along with the risk of dehydration, severe diarrhea can result in loss of potassium, which could lead to an electrolyte imbalance that affects his neuromuscular function. His severe weakness may be a symptom of this. (p. 927)

Suggested Readings

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