The Digestive System Outline

PART 1: OVERVIEW OF THE DIGESTIVE SYSTEM

A. Digestive system organs fall into two main groups: the alimentary canal and the accessory organs. (pp. 857–858; Fig. 23.1)
   1. The alimentary canal is the continuous muscular tube that includes the mouth, pharynx, esophagus, stomach, small intestine, and large intestine, and functions to digest and absorb food.
   2. Accessory digestive organs are the teeth, tongue, and salivary glands, located in the mouth, and the gallbladder, liver, and pancreas, connected to the alimentary canal by a series of ducts, and aid in mechanical breakdown and produce specialized secretions to aid digestion of food.

23.1 What major processes occur during digestive system activity? (pp. 858–859; Figs. 23.2–23.3)

A. The processing of food involves six essential activities (pp. 858–859; Figs. 23.2–23.3):
   1. Ingestion takes food into the GI tract.
   2. Propulsion, including swallowing and peristalsis, moves food through the GI tract.
   3. Mechanical breakdown involves increasing surface area for digestion, and mixing with digestive secretions.
   4. Digestion occurs as enzymes catabolize food to its chemical components.
   5. Absorption is the movement of digested end products from the lumen of the GI tract into the blood or lymph.
   6. Eliminates indigestible substances via the anus.

23.2 The GI tract has four layers and is usually surrounded by peritoneum (pp. 859–862; Figs. 23.4–23.5)

A. Relationship of the Digestive Organs to the Peritoneum (pp. 859–860; Fig. 23.4)
   1. 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.
   2. The peritoneal cavity is located between the visceral and parietal peritoneums and is filled with serous fluid.
   3. 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; holds the organs in place; and stores fat.
   4. Retroperitoneal organs are found posterior to the mesentery, lying against the dorsal abdominal wall.

B. Histology of the Alimentary Canal (pp. 860–861; Fig. 23.5)
   1. Mucosa is the innermost, moist, epithelial membrane that lines the entire digestive tract, and functions to provide secretions to the GI lumen, absorbs digestive end products, and protect against infectious disease.
   2. Submucosa is a moderately dense connective tissue layer containing blood and lymphatic vessels, lymphoid follicles, and nerve fibers.

3. Muscularis externa typically consists of an inner layer of circular and an outer layer of longitudinal smooth muscle and is responsible for peristalsis and segmentation.
4. Serosa, the protective outer layer of the intraperitoneal organs, is the visceral peritoneum.

C. The splanchnic circulation includes those arteries that branch off the abdominal aorta to serve the digestive organs, and the hepatic portal circulation to the liver. (p. 862)

23.3 The GI tract has its own nervous system called the enteric nervous system (pp. 862–863; Fig. 23.6)

A. The alimentary canal has its own nerve supply made up of enteric neurons that constitute the bulk of two major intrinsic nerve plexuses in the alimentary canal: the submucosal plexus. (pp. 862–863; Fig. 23.6)
1. The enteric nervous system participates in both short and long reflexes: Short reflexes are mediated entirely by enteric neurons, but long reflexes also involve CNS integration centers and extrinsic autonomic nerves.

B. Three concepts govern regulation of digestive activity: A variety of chemical and mechanical stimuli promote digestive activity; smooth muscle and glands are the GI effectors; neurons and hormones control digestive activity. (p. 863)

PART 2: FUNCTIONAL ANATOMY OF THE DIGESTIVE SYSTEM (pp. 856–892; Figs. 23.7–23.31; Tables 23.1–23.3)

23.4 Ingestion occurs only at the mouth (pp. 864–869; Figs. 23.7–23.11)

A. The mouth is a stratified squamous epithelial mucosa-lined cavity with boundaries of the lips, cheeks, palate, and tongue. (pp. 864–865; Fig. 23.8)
1. 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.
2. The palate forms the roof of the mouth and has two parts: the bony hard palate that aids in manipulation of food, and the soft palate that rises during swallowing to close the nasopharynx.

B. The tongue is made of skeletal muscle and is used to reposition food when chewing, mix food with saliva, initiate swallowing, and aid in speech production: Papillae on its surface house taste buds. (p. 865; Fig. 23.9)

C. Major and minor salivary glands produce saliva, and are composed of two types of cells: serous cells that produce a watery secretion, and mucous cells that produce mucus. (pp. 865–867; Fig. 23.10)
1. Saliva is mostly water, but contains electrolytes, salivary amylase and lingual lipase enzymes, mucins, lysozyme, and IgA antibodies, along with a small amount of metabolic waste.

D. The teeth tear and grind food, breaking it into smaller pieces. (pp. 867–869; Figs. 23.11–23.12)
1. The primary dentition, also called deciduous, or baby, teeth consists of 20 teeth that are lost to make way for the permanent dentition; permanent dentition consists of 32 teeth, including the wisdom teeth, or third molars.
2. Teeth are classified by their shapes and functions: Incisors are used for cutting, canines tear or pierce, and premolars and molars are used for grinding.

3. Each tooth has two regions: the enamel covered crown extending above the gingiva, or gum, and the root, which is embedded in the jawbone.
4. Cement, a calcified connective tissue, anchors the root to the periodontal ligaments, which hold the tooth in the bony socket of the jaw.
5. Dentin, a bone-like material, underlies the enamel and surrounds the pulp cavity, containing blood and nerve supply.
6. Mastication, or chewing, begins the mechanical breakdown of food and mixes the food with saliva.

23.5 The pharynx and esophagus move food from the mouth to the stomach (pp. 869–872)

A. The pharynx (oropharynx and laryngopharynx) provides a common passageway for food, fluids, and air: Muscular contraction within the wall propels food into the esophagus. (pp. 869–870)

B. The esophagus provides a passageway for food and fluids from the laryngopharynx to the stomach, where it joins at the cardial orifice. (pp. 870–871; Fig. 23.13)

C. Deglutition, or swallowing, is a complicated process that involves two major phases. (p. 871–872; Fig. 23.14)

1. The buccal phase is voluntary and occurs in the mouth where the bolus is forced into the oropharynx.
2. The pharyngeal-esophageal phase is involuntary and occurs when food is squeezed through the pharynx and into the esophagus.

23.6 The stomach temporarily stores food and begins protein digestion (pp. 872–881; Figs. 23.14–23.20; Tables 23.1–23.2)

A. An empty stomach has a volume of about 50 ml, but can distend to a capacity of 4 L: When empty, the walls fall into folds, called rugae. (pp. 873–874; Fig. 23.15)

1. The major regions of the stomach include the cardial part, fundus, body, and the pyloric part.
2. The convex lateral surface of the stomach is its greater curvature, and its convex medial surface is its lesser curvature.
3. 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.

B. Microscopic Anatomy (pp. 874–877; Figs. 23.16–23.17; Table 23.1)

1. 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.
2. 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.

C. Digestive Processes in the Stomach (p. 877)

1. Gastric acid denatures proteins, in preparation for enzymes to begin digestion.
2. Alcohol and aspirin are absorbed across the stomach mucosa.
3. Intrinsic factor, used to prepare vitamin B_{12} for absorption in the intestine, is secreted here.

D. Regulation of Gastric Secretion (pp. 877–879; Fig. 23.19; Table 23.1)

1. 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.

E. Gastric acid secretion occurs when HCl is formed by parietal cells: H^+ is secreted into the stomach lumen by proton pumps as HCO_3^- is pumped into the blood. (p. 879; Fig. 23.20)

F. Regulation of Gastric Motility and Emptying (pp. 879–881; Figs. 23.21–23.22)

1. 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.
2. The enteric pacemaker cells establish the stomach's basic electrical rhythm of peristaltic waves.
3. 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.

23.7 The liver secretes bile; the pancreas secretes digestive enzymes (pp. 881–888; Figs. 23.23–23.27)

A. The Liver (pp. 882–886; Figs. 23.23–23.24)

1. The liver is divided into four lobes: Right and left lobes are separated by the falciform ligament, which anchors it to the diaphragm, and it is enclosed by a visceral peritoneum.
2. The liver is composed of liver lobules, which are made of plates of liver cells (hepatocytes) that surround a central vein and meet at portal triads, each consisting of a hepatic artery, and hepatic portal vein, and a bile duct.
3. Hepatocytes secrete bile, process blood-borne nutrients, store fat-soluble vitamins, and play important roles in detoxification.

B. The gallbladder stores and concentrates bile that is not needed immediately for digestion, and concentrates it, by absorbing water and ions. (p. 886)

C. The pancreas exocrine function of the pancreas involves secretion of pancreatic juice, containing enzymes and bicarbonate, into the small intestine. (pp. 886–887; Figs. 23.25–23.26)

D. Bile and Pancreatic Secretion into the Small Intestine (pp. 887–888; Fig. 23.27)

1. The bile duct from the liver, and the pancreatic duct join at the duodenal wall and deliver bile and pancreatic juice to the intestine.
2. Hormones cholecystokinin and secretin and neural stimuli control secretion of bile and pancreatic juice.

23.8 The small intestine is the major site for digestion and absorption (pp. 888–894; Figs. 23.28–23.30; Tables 23.2–23.3)

A. Gross Anatomy (p. 889; Figs. 23.28–23.29)

1. The small intestine has three divisions, the duodenum, that begins at the pyloric sphincter, the jejunum, and the ileum, that ends at the ileocecal valve.
2. Blood from the intestine drains into the hepatic portal system, where it is routed to the liver.

B. Microscopic Anatomy (pp. 889–890; Figs. 23.29–23.30)

1. The wall of the small intestine has deep circular folds; the mucosal lining is rich in finger-like villi and microvilli to increase surface area for absorption.
2. The mucosa mostly consists of enterocytes, the primary absorptive cells, but is studded with tubular glands, the intestinal crypts, that contain several types of cells that produce mucus, hormones, and antimicrobial agents.

C. Intestinal juice is secreted in response to acidic chyme, and contains mostly water and mucus. (p. 891)

D. Digestive Processes in the Small Intestine (pp. 891–894; Tables 23.2–23.3)

1. Most substances required for digestion within the small intestine—bile, digestive enzymes, and bicarbonate—are imported from the pancreas and the liver.
2. To ensure proper mixing with digestive secretions, and to protect from excessive water loss to the intestinal lumen, feedback mechanisms carefully control the rate of gastric emptying.
3. Following a meal, segmentation and some peristalsis work together to mix chyme and propel it through the intestine: Between meals, migrating motor complexes move remnants toward the large intestine.
4. The ileocecal valve relaxes to allow chyme to enter the cecum in response to the gastroileal reflex, and gastrin secretion.

23.9 The large intestine absorbs water and eliminates feces (pp. 894–899; Figs. 23.31–23.33; Table 23.2)

A. The large intestine absorbs water from indigestible food residues and eliminates the latter as feces. (pp. 894–898; Figs. 23.31–23.32)

1. The large intestine exhibits three unique features: teniae coli, haustra, and epiploic appendages, and has a number of 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, synthesize B complex vitamins and vitamin K, and influence the behavior of the immune system.

B. Digestive Processes in the Large Intestine (pp. 898–899; Fig. 23.33)

1. The movements seen in the large intestine include haustral contractions and mass movements that aid in mixing residues to facilitate water absorption.
2. Feces forced into the rectum by mass movements stretch the rectal wall and initiate the defecation reflex.

PART 3: PHYSIOLOGY OF DIGESTION AND ABSORPTION (pp. 892–901; Figs. 23.32–23.36)

23.10 Digestion hydrolyzes food into nutrients that are absorbed across the gut epithelium (p. 900; Figs. 23.32–23.34)

A. Mechanism of Digestion: Enzymatic Hydrolysis (p. 900)

1. Most digestion occurs in the small intestine, and is accomplished by enzymes secreted to the lumen that hydrolyze larger molecules into monomers.

B. Absorption of molecules in the intestine involves entering epithelial cells across the apical membrane, in the lumen, and then across the basolateral face to the interstitial fluid, where they diffuse into capillaries or lacteals. (p. 900)

23.11 How is each type of nutrient processed? (pp. 900–906; Figs. 23.34–23.37)

A. Carbohydrates (pp. 900–902; Figs. 23.34–23.35)
   1. Carbohydrate digestion begins in the mouth as salivary amylase splits starch into oligosaccharides.
   2. In the intestine, pancreatic amylase breaks down starch and glycogen into oligosaccharides and disaccharides.
   3. Brush border enzymes break oligo- and disaccharides into monosaccharides.
   4. Monosaccharides are cotransported across the apical membrane of the absorptive epithelial cell.
   5. Monosaccharides exit across the basolateral membrane by facilitated diffusion.

B. Proteins digested into amino acids in the GI tract include not only dietary proteins but also enzyme proteins secreted into the GI tract lumen. (pp. 902–903; Figs. 23.34, 23.36)
   1. Pepsin, secreted by the chief cells, begins the digestion of proteins in the stomach.
   2. In the small intestine, pancreatic proteases break down proteins and protein fragments into smaller pieces and some individual amino acids.
   3. Brush border enzymes break oligo and dipeptides into amino acids.
   4. Amino acids are cotransported across the apical membrane of the absorptive epithelial cell.
   5. Amino acids exit across the basolateral membrane via facilitated diffusion.

C. Lipids (pp. 904–905; Figs. 23.34, 23.37)
   1. The small intestine is the primary site for lipid digestion: The first step is emulsification with bile salts.
   2. Pancreatic lipases break down fats to monoglycerides and free fatty acids.
   3. Monoglycerides and fatty acids combine with bile salts and lecithin to form micelles: At the plasma membrane, fatty acids and monoglycerides diffuse into epithelial cells of the mucosa.
   4. Within the epithelial cells, monoglycerides and fatty acids are converted back to triglycerides, and then combined with lecithin, cholesterol, and other lipids, to form chylomicrons, which are exocytosed to the interstitial space, and taken into lacteals for transport.

D. Nucleic acids (both DNA and RNA) are hydrolyzed to their nucleotide monomers by pancreatic nucleases present in pancreatic juice. (p. 905; Fig. 23.34)

E. Absorption of Vitamins, Electrolytes, and Water (pp. 905–906)
   1. The small intestine absorbs dietary vitamins, while the large intestine absorbs vitamins B and K.
   2. Electrolytes are actively absorbed along the entire length of the small intestine, except for calcium and iron, which are absorbed in the duodenum.

3. Water is the most abundant substance in chyme and 95% of it is absorbed in the small intestine by osmosis.

Developmental Aspects of the Digestive System (pp. 906–907; Fig. 23.36)

A. Embryonic Development (pp. 906–907; Fig. 23.3)

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 5, the alimentary canal is a continuous tube stretching from the mouth to the anus.

B. The digestive system after birth (p. 907)

1. A newborn infant has two reflexive behaviors: a rooting reflex, that enables the baby to find the nipple, and a sucking reflex, that allows the infant to hold on to the nipple and swallow.
2. The stomach of an infant is small, and peristalsis is inefficient: Infants must nurse frequently, and vomiting may occur.

C. Aging and the Digestive System (p. 907)

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.