DIGESTIVE SYSTEM

The digestive system is made up of the digestive tract—a series of hollow organs joined in a long, twisting tube from the mouth to the anus and other organs that help the body break down food into forms that can be absorbed and used by body cells. Foods can be broken down into molecules that are small enough to enter body cells through the process known as Digestion (dis= apart; gerere=carry).

The Digestive system is made up of the gastrointestinal (GI) tract or alimentary canal and accessory digestive organs.

- **GI tract**

- It is a continuous tube that extends from the mouth to the anus through the thoracic and abdominopelvic cavities.
- It includes:
  - Mouth
  - Most of pharynx
  - Esophagus
  - Small intestines
  - Large intestines
- Length: 5-7 meters
- The wall of the GI tract has 4-layered arrangement of tissues:
  - Mucosa or the inner lining of the GI tract is composed of:
    - Layer of Epithelium in direct contact with the contents of the GI tract
    - Lamina propria- layer of connective tissue
    - Muscularis mucosae- thin layer of smooth muscle
  - Submucosa consist of areolar tissue that binds the mucosa to the muscularis
  - Muscularis
  - Serosa- serous membrane composed of areolar CT and simple squamous epithelium.

- **Accessory digestive organs**
- It includes:
  - Teeth
  - Tongue
  - Salivary glands
  - Liver
  - Gallbladder
  - Pancreas

Digestive System performs 6 basic processes

1. Ingestion
2. Secretion
3. Mixing and propulsion
4. Digestion
5. Absorption
6. Defecation

MOUTH

- Also referred as oral or buccal

- The human mouth has many functions, including the formation of speech and aiding in breathing, but the three main digestive purposes the mouth has are:
  - the intake of food
- the beginning of mechanical digestion
- swallowing

SALIVARY GLANDS

- It is a gland that releases a secretion called saliva into the oral cavity.
- It is composed of 3 pair of salivary glands:
  - Parotid Gland
    - location: Inferior and anterior to the ears, b/w the skin and masseter muscle.
    - secretes saliva to the oral cavity via parotid duct
    - secretes a watery liquid containing salivary amylase
  - Submandibular gland
    - location: Floor of the mouth, medial and partially inferior to the body of the mandible.
    - secretes saliva to the mouth via submandibular ducts
    - secretes a fluid that contains amylase but is thickened with mucous
  - Sublingual gland
    - location: Beneath the tongue and superior to the submandibular gland
    - secretes saliva to the mouth via lesser sublingual ducts
    - secretes a much thicker fluid that contributes only a small amount of salivary amylase.

- Composition of saliva:
  - 99.5% water
  - 0.5% solutes
    - Sodium
    - Chloride - activates salivary amylase
    - Bicarbonate and Phosphate - buffer acidic foods that enter the mouth

- Salivary glands help remove waste molecules from the body which accounts to the presence of urea and uric acid in saliva.

- Salivation is the secretion of saliva that is controlled by the autonomic NS.

- amount of saliva secreted daily: average of 1000-1500mL

TONGUE
- It is an accessory digestive organ composed of skeletal muscle covered with mucous membrane.
- It is the chief organ of taste, and aids in mastication, swallowing, and speech.

**TEETH**

- It is also known as dentes.
- Are accessory digestive organs located in sockets of the alveolar process of the mandible and maxillae.
- The teeth are the hardest substances in the human body. Besides being essential for chewing, the teeth play an important role in speech.
- A typical tooth has 3 major external regions:
- Crown - visible portion above the level of the gums
- Roots - embedded in the sockets
- Neck - constricted junction of the crown and root near the gumline

Mechanical and Chemical digestion in mouth

PHARYNX

- A funnel-shaped tube that extends from the internal nares to the esophagus posteriorly and to the larynx anteriorly.
- It has 3 parts
  - Nasopharynx - respiration
  - Oropharynx - digestion and respiration
  - Laryngopharynx - digestion and respiration

ESOPHAGUS

- It is a collapsible muscular tube
- Length: 25cm
- Location: posterior to the trachea
- It begins at the inferior end of the laryngopharynx and passes through the mediastinum anterior to the vertebral column and ends in the superior portion of the stomach.

DEGLUTION
- The movement of food from the mouth into the stomach is achieved by the act of swallowing or deglutition.
- It is facilitated by the secretion of saliva and mucus and involves the mouth, pharynx and esophagus
- Swallowing occurs in 3 stages:
  - Voluntary stage- bolus passes into the oropharynx
  - Pharyngeal stage- involuntary passage of the bolus through the pharynx into the esophagus
  - Esophageal stage- involuntary passage of the bolus through the esophagus into the stomach

**STOMACH**

- It is a J-shaped enlargement of the GI tract directly inferior to the diaphragm in the epigastric, umbilical, and left hypochondriac regions of the abdomen.
- It connects the esophagus to the duodenum
- It serves as the mixing chamber and holding reservoir
- Secretes gastric juice when HCl (kills bacteria and denatures protein), pepsin (begins digestion of proteins), intrinsic factors ( aids absorption of vit B12) and gastric lipase (aids triglyceride digestion).
- Secretes gastrin in bloods
- Summary of Digestive activities in the stomach

<table>
<thead>
<tr>
<th>Cell Types</th>
<th>Substance Secreted</th>
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<tbody>
<tr>
<td>Mucous neck cell</td>
<td>Mucus (protects lining)</td>
</tr>
<tr>
<td>Parietal cells</td>
<td>Bicarbonate</td>
</tr>
<tr>
<td>Enterochromaffin-like</td>
<td>Gastric acid (HCl)</td>
</tr>
<tr>
<td>Chief cells</td>
<td>Intrinsic factor (Ca++ absorption)</td>
</tr>
<tr>
<td>D cells</td>
<td>Histamine (stimulates acid)</td>
</tr>
<tr>
<td>G cells</td>
<td>Pepsin(ogen)</td>
</tr>
<tr>
<td></td>
<td>Gastric lipase</td>
</tr>
<tr>
<td></td>
<td>Somatostatin (inhibits acid)</td>
</tr>
<tr>
<td></td>
<td>Gastrin (stimulates acid)</td>
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</tbody>
</table>
**Pancreas**

- 12-15 cm long and 2.5 cm thick
- lies posterior to the greater curvature of the stomach
- consists of a head, body and tail
- pancreatic secretion pass from secreting cells in the pancreas into small ducts that ultimately unite to form two larger ducts that convey the secretions into the small intestines

- Pancreatic duct (duct of Wirsung) – larger of the two ducts; joins the common bile duct from the liver and gall bladder and enters the duodenum as a common duct called hepatopancreatic ampulla (ampulla of Vater)
- Accessory duct (duct of Santorini) – smaller of the two ducts; leads from the pancreas and empties into the duodenum

- made up of small clusters of glandular epithelial cells:
  - about 99% are arranged in clusters called acini and constitute the exocrine portion of the organ
    - Pancreatic juice – mixture of fluids and digestive enzymes secreted by the cells within the acini. A colorless liquid consisting mostly of water, some salts sodium bicarbonate and several enzymes. The sodium bicarbonate gives pancreatic juice a slightly alkaline pH (7.1-8.2) that buffers acidic gastric juices in chyme, stops the action of pepsin from the stomach, and creates the proper pH for the action of digestive enzymes in the small intestine.
      - Enzymes in the pancreatic juice:
        - Pancreatic amylase-carbohydrate-digesting enzyme
        - Trypsin-protein-digesting enzyme
        - Chymotrypsin-protein-digesting enzyme
        - Carboxypeptidase-protein-digesting enzyme
        - Elastase-protein-digesting enzyme
        - Pancreatic Lipase-principal digesting enzyme
        - Ribonuclease-nucleic acid-digesting enzyme
        - Deoxyribonuclease-nucleic acid-digesting enzyme
  - the remaining 1% of the cells are organized into clusters called pancreatic islets (islets of Langerhans), the endocrine portion of the pancreas. These cells secrete:
    - glucagon, insulin, somatostatin and pancreatic polypeptide
- heaviest gland of the body, 1.4 kg in an average adult
- inferior to the diaphragm and occupies most of the right hypochondriac and part of the epigastric regions of the abdominopelvic cavity
- divided into two principal lobes: a large right lobe and a smaller left lobe – by the falciform ligament
- lobes of the liver are made up of many functional units called lobules which consists of specialized epithelial cells, called hepatocytes, arranged in irregular, branching, interconnected plates around a central vein.
  - Bile – secreted by the hepatocytes. Enters the bile canaliculi, which are narrow intercellular canals that empty into small bile ductules. The ductules pass bile into the bile ducts that merge and form the larger right and left hepatic ducts, which unite and exit the liver as the common hepatic duct. The common hepatic duct joins the cystic duct from the gall bladder to form the common bile duct. The bile enters the cystic duct and is temporarily stored in the gall bladder.
  - Bile is partially an excretory product and partially a digestive secretion. Bile salts, which are sodium salts and potassium salts of bile acids, play a role in emulsification, the breakdown of large lipid globules into a suspension of droplets, and in absorption of lipids following their digestion
  - Conjugated bilirubin – principal bile pigment. The phagocytosis of aged RBCs liberates iron, globulin and bilirubin. The iron and globulin are recycled, and some of the bilirubin is converted to conjugated bilirubin. One of conjugated bilirubin’s breakdown products – stercobilin – gives feces their normal color

- functions of the liver:
  - Secretion of bile – needed for absorption of dietary fats
  - Carbohydrate metabolism
  - Lipid metabolism
  - Protein metabolism
  - Processing of drugs and hormones
  - Excretion of bilirubin
  - Synthesis of bile salts
  - Phagocytosis
  - Activation of Vitamin D
- the liver has larger, endothelium-lined spaces called sinusoids, through which blood passes. Also present in the sinusoids are fixed phagocytes called stellate reticuloendothelial (Kupffer’s) cells, which destroy worn-out leukocytes, RBCs, bacteria and other foreign matter.
**GALLBLADDERS**

- pear-shaped sac that is located in the depression of the posterior surface of the liver
- 7-10 cm long and typically hangs from the anterior inferior margin of the liver
  - parts of the gallbladder: the fundus—projects downward beyond the inferior border of the liver, the body—the central portion, and the neck—the tapered portion
  - the mucosa of the gallbladder consists of simple columnar epithelium
- the gall bladder functions to store and concentrate bile (up to tenfold) until it is needed in the small intestine

**SMALL INTESTINE**

- Duodenum
- Duodenjejunal flexure
- Jejunum
- Ileocecal valve
- Ileum
- begins at the pyloric sphincter of the stomach, coils through the central and inferior part of the abdominal cavity, and eventually opens into the large intestines.
- averages 2.5 cm in diameter, 3m in length
- the small intestines is divided into three regions:
  - Duodenum-shortest region, is retroperitoneal, about 25 cm long
  - Jejunum- 1m long
  - Ileum-longest region, about 2m long, joins the large intestine at the ileocal sphincter
- the mucosa forms a series of fingerlike projections, villi. The epithelium of the mucosa consists of simple columnar epithelium that contains absorptive cells, goblet cells, enteroendocrine cells, and Paneth cells. Cells lining the crevices of the mucosa form the intestinal glands (Crypts of Lieberkühn) and secrete intestinal juice. Paneth cells secrete lysozyme, a bactericidal enzyme, and is capable of phagocytosis.
- two types of movements of the small intestine:
  - Segmentations-localized, mixing type of contraction that occurs in portions of intestine distended by a large volume of chime. Segmentations mix chime with the digestive juices and bring the particles of the food into the mucosa for absorption.
  - Migrating Motility Complex (MMC)-a type of peristalsis that begins in the lower portion of the stomach and pushes chime forward along a short stretch of small intestine before dying out.

**LARGE INTESTINE**

- about 1.5m long and 6.5 cm in diameter
- extends from the ileum to the anus and is attached to the posterior abdominal wall by its mesocolon, which is a double layer of peritoneum
- the opening from the ileum into the large intestine is guarded by a fold of mucous membrane called ileocal sphincter, which allows materials from the small intestine to pass into the large intestine
- four principal regions of the large intestine:
  - Cecum-blind pouch, about 6cm long, connected to the cecum is the appendix or vermiform appendix
  - Colon-divided into ascending, transverse, descending and sigmoid portions
  - Rectum-the last 20cm of the GI tract
  - Anal canal-the terminal 2-3cm of the rectum
# DIGESTIVE ENZYMES

<table>
<thead>
<tr>
<th>ENZYME</th>
<th>SOURCE</th>
<th>SUBSTRATES</th>
<th>PRODUCTS</th>
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</thead>
<tbody>
<tr>
<td><strong>SALIVA</strong></td>
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</tr>
<tr>
<td>Salivary Amylase</td>
<td>Salivary glands.</td>
<td>Starches (polysaccharides).</td>
<td>Maltose (disaccharide)</td>
</tr>
<tr>
<td>Lingual Amylase</td>
<td>Lingual glands in the tongue.</td>
<td>Triglycerides (fats and oils) and other lipids.</td>
<td>Fatty acids and diglycerides.</td>
</tr>
<tr>
<td><strong>GASTRIC JUICE</strong></td>
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<tr>
<td>Gastric Lipase</td>
<td>Stomach chief cells.</td>
<td>Triglycerides (fats and oils).</td>
<td>Fatty acids and monoglycerides.</td>
</tr>
<tr>
<td><strong>PANCREATIC JUICE</strong></td>
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</tr>
<tr>
<td>Pancreatic Amylase</td>
<td>Pancreatic acinar cells.</td>
<td>Starches (polysaccharides).</td>
<td>Maltose (disaccharide), maltotriose (trisaccharide) and α-dextrins</td>
</tr>
<tr>
<td>Carboxypeptidase</td>
<td>Pancreatic acinar cells.</td>
<td>Amino acid at carboxyl end peptides.</td>
<td>Amino acids and peptides.</td>
</tr>
<tr>
<td>Pancreatic lipase</td>
<td>Pancreatic acinar cells.</td>
<td>Triglycerides that have been emulsified by bile salts.</td>
<td>Fatty acids and monoglycerides.</td>
</tr>
<tr>
<td>* Deoxyribonuclease</td>
<td>Pancreatic acinar cells.</td>
<td>Nucleotides.</td>
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<tr>
<td><strong>BRUSH BORDER</strong></td>
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<tr>
<td>α-Dextrinase</td>
<td>Small Intestine.</td>
<td>α-Dextrins.</td>
<td>Glucose.</td>
</tr>
<tr>
<td>* Dipeptidase</td>
<td>Small Intestine.</td>
<td>Dipeptides.</td>
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<td>ORGANS AND FUNCTIONS</td>
<td>FUNCTIONS</td>
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</tr>
</tbody>
</table>
| **Tongue** | ● Maneuvers food for mastification.  
● Shapes food into a bolus.  
● Maneuvers food for deglutition.  
● Detects taste and touch sensations.  
● Initiates digestion of triglycerides. |
| **Salivary Glands** | ● Produce saliva, which softens and dissolves foods.  
● Cleanses mouth and teeth.  
● Initiates the digestion of starch. |
| **Teeth** | ● Cut, tear, and pulverize food (to reduce solids to smaller particles for swallowing). |
| **Pharynx** | ● Receives a bolus from the oral cavity and passes it into the esophagus. |
| **Esophagus** | ● Receives a bolus from the pharynx and moves it into the stomach. (Relaxation of the upper esophageal sphincter and secretion of mucus is required.) |
| **Stomach** | ● Mixing waves macerate food.  
● Mixes food with secretions of gastric glands.  
● Reduces food to chyme.  
● Gastric juice activates pepsin and kills many microbes in food.  
● Serves as a reservoir for food before releasing it. |
| **Pancreas** | ● Pancreatic juice buffers acidic gastric juice in chyme.  
● Stops the action of pepsin from the stomach  
● Contains enzymes that digest carbohydrates, proteins, triglycerides, and nucleic acids. |
| **Liver** | ● Produces bile, which is need for the emulsification and absorption of lipids in the small intestine. |
| **Gallbladder** | ● Stores and concentrates bile.  
● Releases bile into the small intestine. |
| **Small Intestine** | ● Segmentations mix chyme with digestive juices.  
● Migrating motility complexes propel chyme toward the ileocecal sphincter.  
● Circular folds, villi, and microvilli increase surface area for absorption.  
● Site where about 90% of nutrients and water is absorbed. |
| **Large Intestine** | ● Haustral churning  
● Peristalsis  
● Absorption of some water, ions, and vitamins  
● Defecation |
Digestive diseases

Digestive diseases are numerous and can affect any part of the digestive system. They can be grouped into the following five broad categories.

Diseases of the esophagus and stomach

- Gastroesophageal reflux disease (GORD). GORD is the result of a malfunctioning lower esophageal sphincter (LES), the ring of muscle at the end of the esophagus that acts like a valve opening into the stomach. GORD prevents its proper closure and stomach contents return (reflux) to the esophagus, causing a burning sensation in the chest or throat (heartburn)
- Gastroparesis. Also called delayed gastric emptying, gastroparesis causes slow digestion and emptying, vomiting, nausea, and bloating
- Peptic ulcer. A sore in the mucosal lining of the esophagus (esophageal ulcer) or stomach (gastric ulcer)

Diseases of the liver, pancreas, and gallbladder

- Budd-Chiari syndrome. A rare liver disease in which the veins that drain blood from the liver are blocked or narrowed
- Cholecystitis. Infection of the gallbladder
- Cirrhosis. A life-threatening disease that scars liver tissue and damages its cells. It severely affects liver function, preventing it from removing toxins like alcohol and drugs from the blood.
- Hepatitis. Inflammation of the liver that can result in permanent liver damage. Non-alcoholic fatty liver disease (NAFLD). Fatty inflammation of the liver related to insulin resistance, obesity, type II diabetes and high blood pressure.
- Pancreatitis. Irritation of the pancreas that can alter its structure and its function
- Primary biliary cirrhosis (PBC). A liver disease that slowly destroys the bile ducts in the liver, thus preventing the release of bile.
- Primary sclerosing cholangitis (PSC). Irritation, scarring, and narrowing of the liver bile ducts. The accumulation of bile in the liver damages liver cells.

Diseases of the small and large intestines

- Appendicitis. Inflammation of the appendix, the small, finger-like structure attached to the first part of the large intestine.
- Celiac disease. Disease that damages the small intestine in people who cannot tolerate gluten, a protein found in wheat, rye, and barley.
- Crohn’s disease. Inflammatory disease that usually occurs in the last section of the small intestine (ileum), causing swelling in the intestines. It can also occur in the large intestine.
- Diverticulosis. Small pouches (diverticula) that push outward through weak spots in the large intestine.
- Diverticulitis. Infection or rupture of the diverticula.
- Duodenal ulcers. Ulcers associated with alcoholism, chronic lung and kidney disease, and thyroid disorders.
- Dysentery. Inflammation of the intestine with severe diarrhea and intestinal bleeding, resulting from eating food or water containing a parasite called Entamoeba histolytica or Shigella bacteria.
- Giardiasis. Infection of the intestine by the parasite Giardia intestinalis. The parasite is one of the most common causes of waterborne disease in the United States and can be found in both drinking and recreational water.
- Infectious diarrhea resulting from bacterial or viral infections. Bacterial diarrhea is most commonly caused by Campylobacter jejuni, Salmonella, Shigella, Escherichia coli O157:H7. Rotavirus is the commonest cause of viral diarrhea in the United States. Other viruses causing diarrhea include Norwalk virus, and cytomegalovirus.
- Irritable bowel syndrome (IBS). IBS (also called spastic colon, or irritable colon) is a condition in which the colon muscle contracts more readily than it should.
- Lactose intolerance. The inability to digest significant amounts of lactose, the major sugar found in milk, due to a shortage of lactase, the enzyme produced by the cells lining the small intestine. Lactase breaks down milk sugar into two simpler forms of sugar which are then absorbed into the bloodstream. If not present, lactose is not broken down.
- Ulcerative colitis. Inflammation of the inner lining of the colon, characterized by open sores that appear in its mucous membrane.

Diseases of the anus

- Hemorrhoids. Commonly known as piles, hemorrhoids are characterized by swollen blood vessels that line the anal opening.
- Anal fissures. Splits or cracks in the lining of the anus resulting from the passage of very hard or watery stools.
- Perianal abscesses. These can occur when the tiny anal glands that open on the inside of the anus become blocked and infected by bacteria. When pus develops, an abscess forms.
Causes and symptoms

Causes

The causes of some digestive diseases are well-known, especially for those resulting from viral (hepatitis, CMV), bacterial (diarrhea) or parasitic (gardiasis) infections, because the microorganisms can be clearly identified. Most peptic ulcers are also caused by a type of bacteria called Helicobacter pylori that weakens the protective mucus lining of the gut. As for the non-infectious diseases, medical researchers have only recently started to understand their numerous causes. For example, stomach ulcers can also result from the use of anti-inflammatory medications such as aspirin, ibuprofen, or naproxen. Similarly, it is also known that 80% of gallstones consist of hardened cholesterol and form when bile contains too much cholesterol, too much bilirubin, or not enough bile salts. It is also known that chronic alcoholism and hepatitis C are the most common causes of cirrhosis of the liver. As for diverticulitis, strong evidence suggests that it result mainly from a low-fiber diet. Gastroparesis is most often caused by diabetes, smooth muscle disorders and nervous system diseases while pancreatitis most often results from gallstones or alcohol abuse. Lactose intolerance is directly linked to a shortage of the enzyme lactase.

Increasingly however, researchers and physicians are realizing that one of the most common causes of digestive diseases is that people do not have healthy eating habits, and are also not aware of the many sources of food contamination. Besides bacterial or parasite infections, it is now understood that the digestive system can also be damaged by poor diets, prescription drugs, and food additives, especially antibiotics.

Symptoms

Since there are many types of digestive diseases, symptoms can accordingly vary widely, depending on the organ that is affected. Telltale signs are blood in the stool, changes in bowel habits, and weight loss. Additionally, physicians look for symptoms that may include one or more of the following:

- Acute abdominal pain. A sharp pain in the lower right abdomen is one of the symptoms of colitis or Crohn’s disease. A stomach that is very tender to the touch is indicative of diverticulitis or pancreatitis or an ulcer. Acute pain is also a symptom of gallstones.
- Ongoing abdominal pain. Depending on where the pain occurs, it will point to a specific digestive disease. For instance, if the pain goes away after taking antiacid medication, it points to a peptic ulcer. If it starts in the upper middle or upper right abdomen, and occurs after eating greasy or fatty foods, it is indicative of gallstones or infection of the gallbladder. If it occurs after eating milk products, it suggests lactose intolerance. Celiac disease is also accompanied by recurring abdominal pain.
- Bloating. Abdominal bloating is a symptom of lactose intolerance, Celiac disease, IBS, and diverticulosis.
- Changes in bowel movements. Yellow and greasy stools that float are indicative of impaired pancreas function or celiac disease. Excess gas and loose, foul-smelling stools are a symptom of gardiasis or various bowel infections. Alternating loose and hard bowel movements are indicative of IBS.
- Bloody stools. Blood in the stools is one of the symptoms of Crohn’s disease, colitis, dysentery and hemorrhoids.
- Dark urine. Dark urine, accompanied by a yellowing of the skin or the eyes is indicative of hepatitis.
- Diarrhea. Watery bowel movements that occur many times throughout the day. If not bacterial or viral, diarrhea can be indicative of celiac disease, Crohn’s disease, gardiasis, or colitis.
- Fever. Fever accompanies several digestive diseases, in particular infectious diarrhea, dysentery, appendicitis, and colitis.

Key Terms

- **Abdominal cavity**—The hollow part of the body that extends from the chest to the groin.
- **Anus**—The terminal opening of the digestive tract.
- **Ascites**—Abnormal accumulation of fluid in the abdominal cavity.
- **Bacteria**—Microscopic, single-celled organisms found in air, water, soil, and food. Only a few actually cause disease in humans.
- **Bile**—Fluid made by the liver and stored in the gallbladder. Bile helps break down fats and gets rid of wastes in the body.
- **Bile ducts**—Tubes that carry bile from the liver to the gallbladder for storage and to the small intestine for use in digestion.
- **Cecum**—The pouch-like start of the large intestine that links it to the small intestine.
- **Colon**—Part of the large intestine, located in the abdominal cavity.
- **Colon polyps**—Extra tissue that grows in the colon.
- **Diverticula**—Small pouches in the muscular wall of the large intestine.
- **Duodenum**—The first section of the small intestine, extending from the stomach to the jejunum, the next section of the small intestine.
- **Esophagus**—Muscular tube through which food passes from the pharynx to the stomach.
- **Feces**—Waste product of digestion formed in the large intestine. About 75% of its mass is water, the remainder is protein, fat, undigested roughage, dried digestive juices, dead cells, and bacteria.
- **Ileum**—The last section of the small intestine located between the jejunum and the large intestine.
- **Insulin**—Hormone secreted by the pancreas that regulates carbohydrate metabolism in the body. It regulates the liver's ability to store or release glucose.
- **Insulin resistance**—Condition in which normal amounts of insulin are inadequate.
- **Jejunum**—The section of the small intestine located between the duodenum and the ileum.
- **Large intestine**—The terminal part of the digestive system, site of water recycling, nutrient absorption, and waste processing located in the abdominal cavity. It consists of the caecum, the colon, and the rectum.
- **Lower esophageal sphincter (LES)**—Ring of muscle at the bottom of the esophagus that acts like a valve between the esophagus and stomach.
- **Mucosa**—Lining of the digestive tract. In the mouth, stomach, and small intestine, the mucosa contains glands that produce juices to digest food.
- **Pancreas**—The pancreas is a flat, glandular organ lying below the stomach. It secretes the hormones insulin and glucagon that control blood sugar levels and also secretes pancreatic enzymes in the small intestine for the breakdown of fats and proteins.
- **Pharynx**—Part of the neck and throat that connects the mouth to the esophagus.
- **Rectum**—Short, muscular tube that forms the lowest portion of the large intestine and connects it to the anus.
- **Small intestine**—The part of the digestive tract located between the stomach and the large intestine. It consists of the duodenum, the jejunum, and the ileum.
- **Villi intestinales**—Microscopic hair-like structures covered with epithelial cells measuring 1–1.5 mm that line the mucous inner membrane of the small intestine.

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