PowerPoint® Lecture Slide Presentation
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The Digestive System and Body Metabolism

14 PART C

Accessory Digestive Organs

- Teeth
- Salivary glands
- Pancreas
- Liver
- Gallbladder

Teeth

- Function is to masticate (chew) food
- Humans have two sets of teeth
  - Deciduous (baby or “milk”) teeth
  - 20 teeth are fully formed by age two

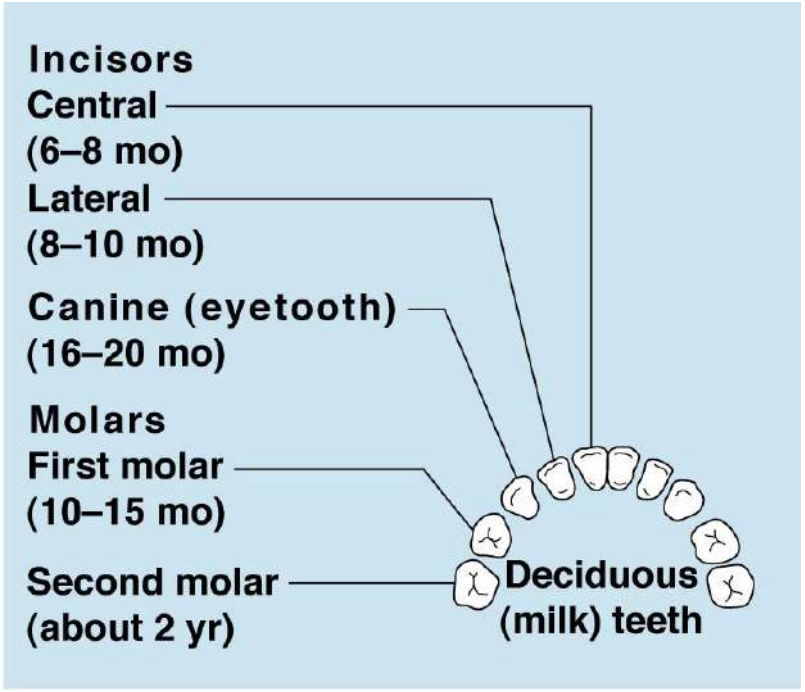
Teeth

- Permanent teeth
  - Replace deciduous teeth between the ages of 6 and 12
  - A full set is 32 teeth, but some people do not have wisdom teeth (third molars)
  - If they do emerge, the wisdom teeth appear between ages of 17 and 25

Classification of Teeth

- Incisors—cutting
- Canines—tearing or piercing
- Premolars—grinding
- Molars—grinding

Human Deciduous and Permanent Teeth



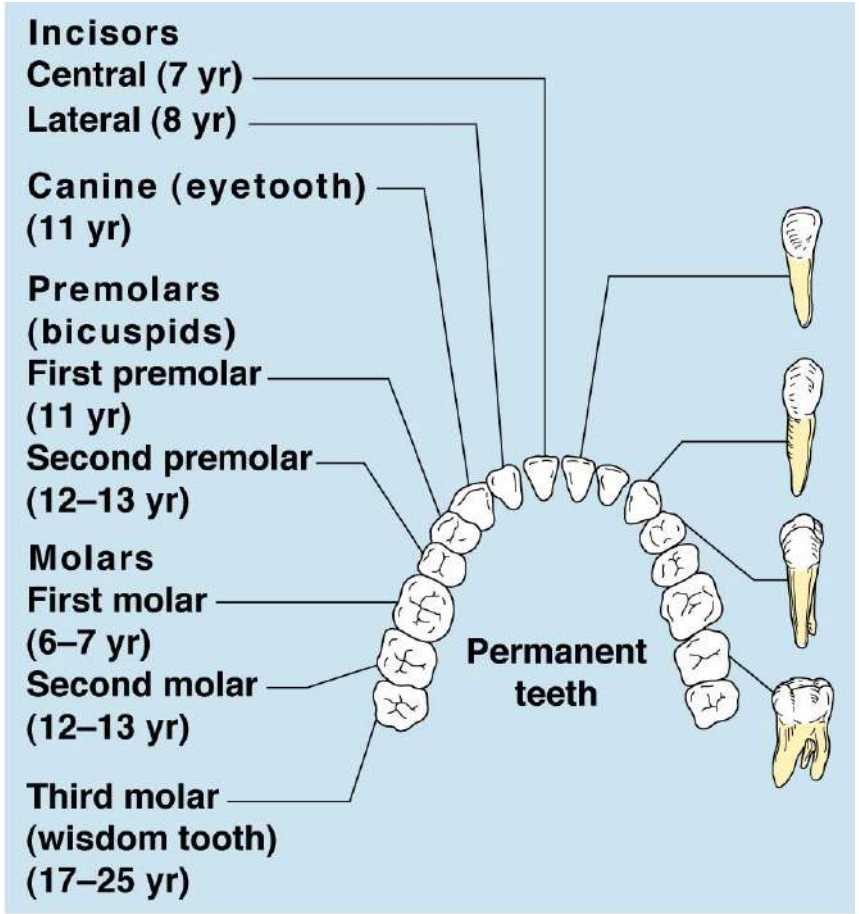


Figure 14.9

Regions of a Tooth

- Crown—exposed part
  - Enamel—hardest substance in the body
  - Dentin—found deep to the enamel and forms the bulk of the tooth
  - Pulp cavity—contains connective tissue, blood vessels, and nerve fibers
  - Root canal—where the pulp cavity extends into the root

Regions of a Tooth

- **Neck**
  - Region in contact with the gum
  - Connects crown to root
- **Root**
  - **Cementum—covers outer surface and attaches the tooth to the periodontal membrane**

Regions of a Tooth

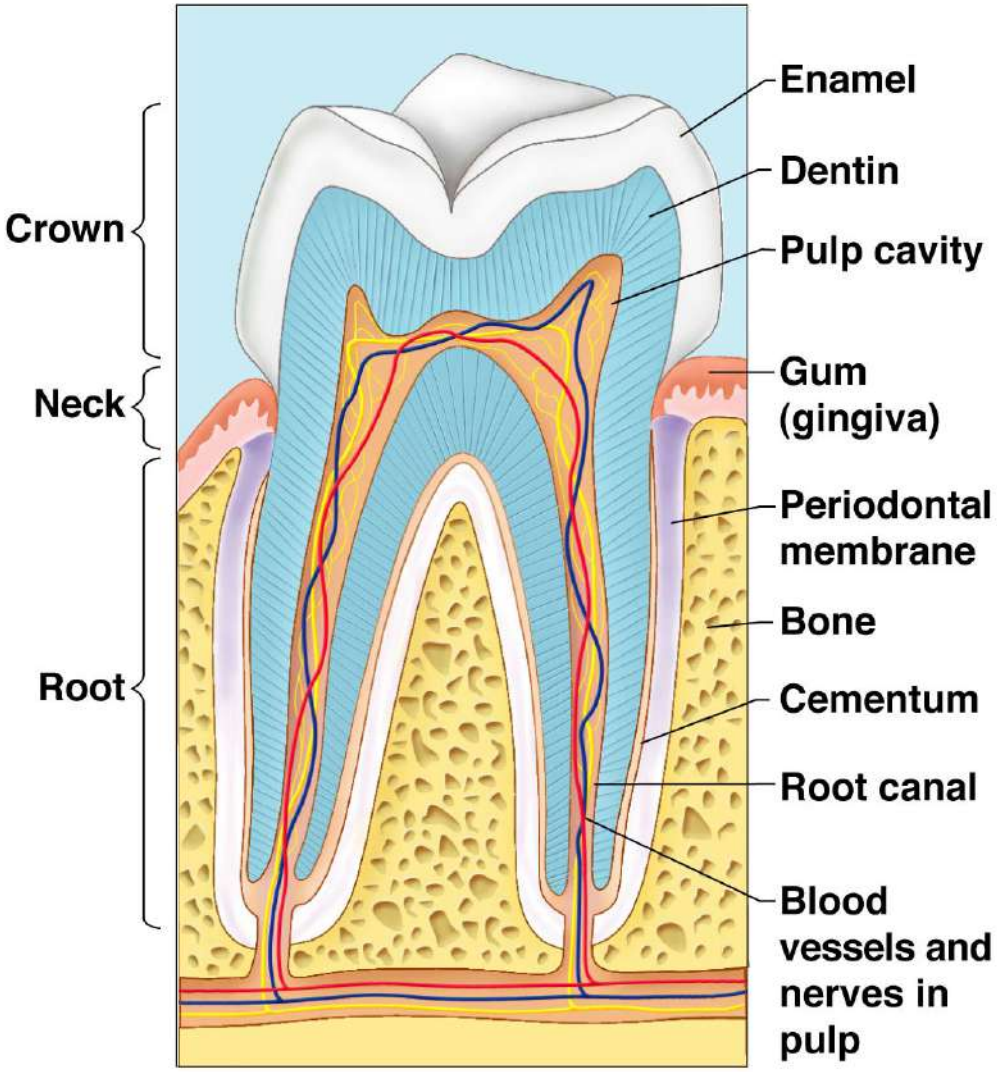


Figure 14.10

Salivary Glands

- Three pairs of salivary glands empty secretions into the mouth
  - Parotid glands
  - Submandibular glands
  - Sublingual glands

Salivary Glands

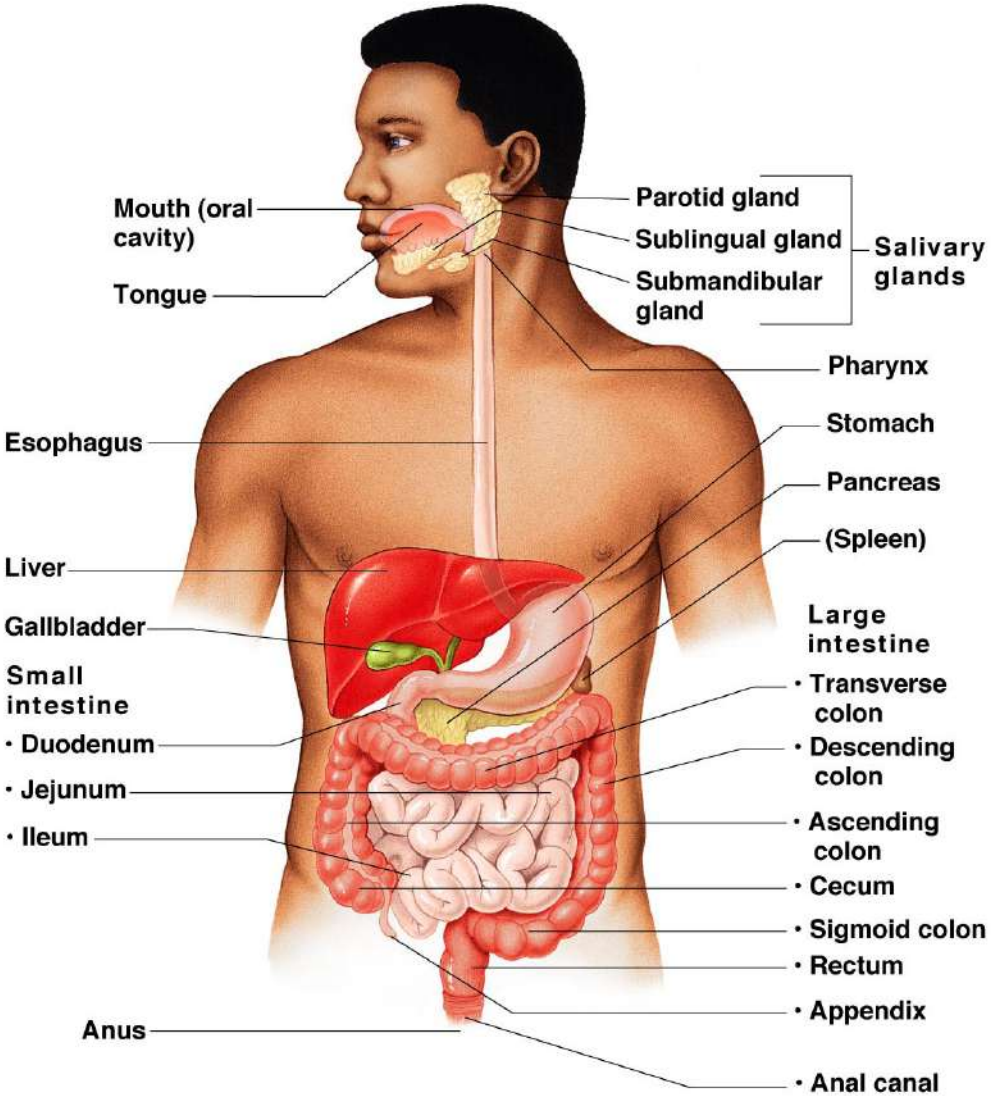


Figure 14.1

Saliva

- Mixture of mucus and serous fluids
- Helps to form a food bolus
- Contains salivary amylase to begin starch digestion
- Dissolves chemicals so they can be tasted

Pancreas

- Found posterior to the parietal peritoneum
- Extends across the abdomen from spleen to duodenum

Pancreas

- Produces a wide spectrum of digestive enzymes that break down all categories of food
- Enzymes are secreted into the duodenum
- Alkaline fluid introduced with enzymes neutralizes acidic chyme coming from stomach
- Hormones produced by the pancreas
  - Insulin
  - Glucagon

Pancreas

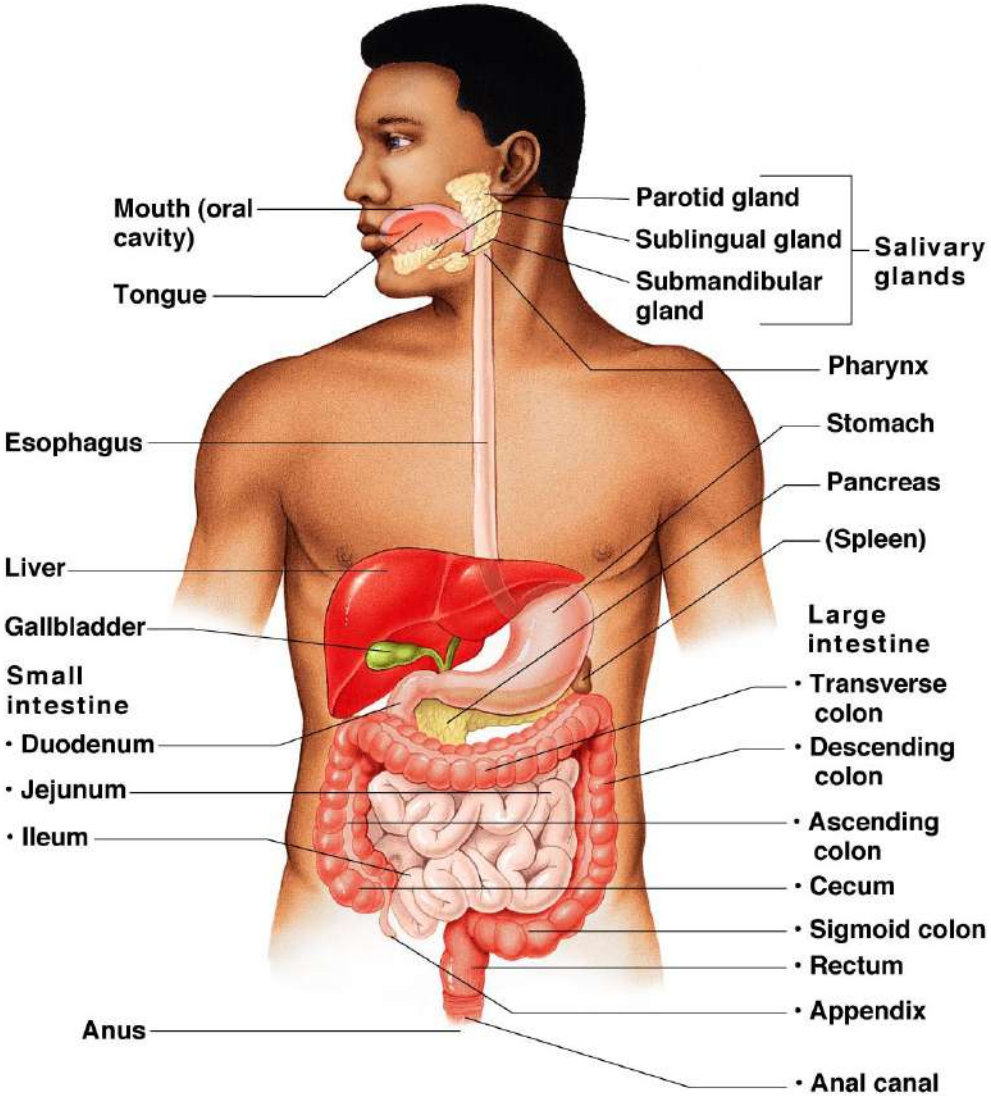


Figure 14.1

Pancreas

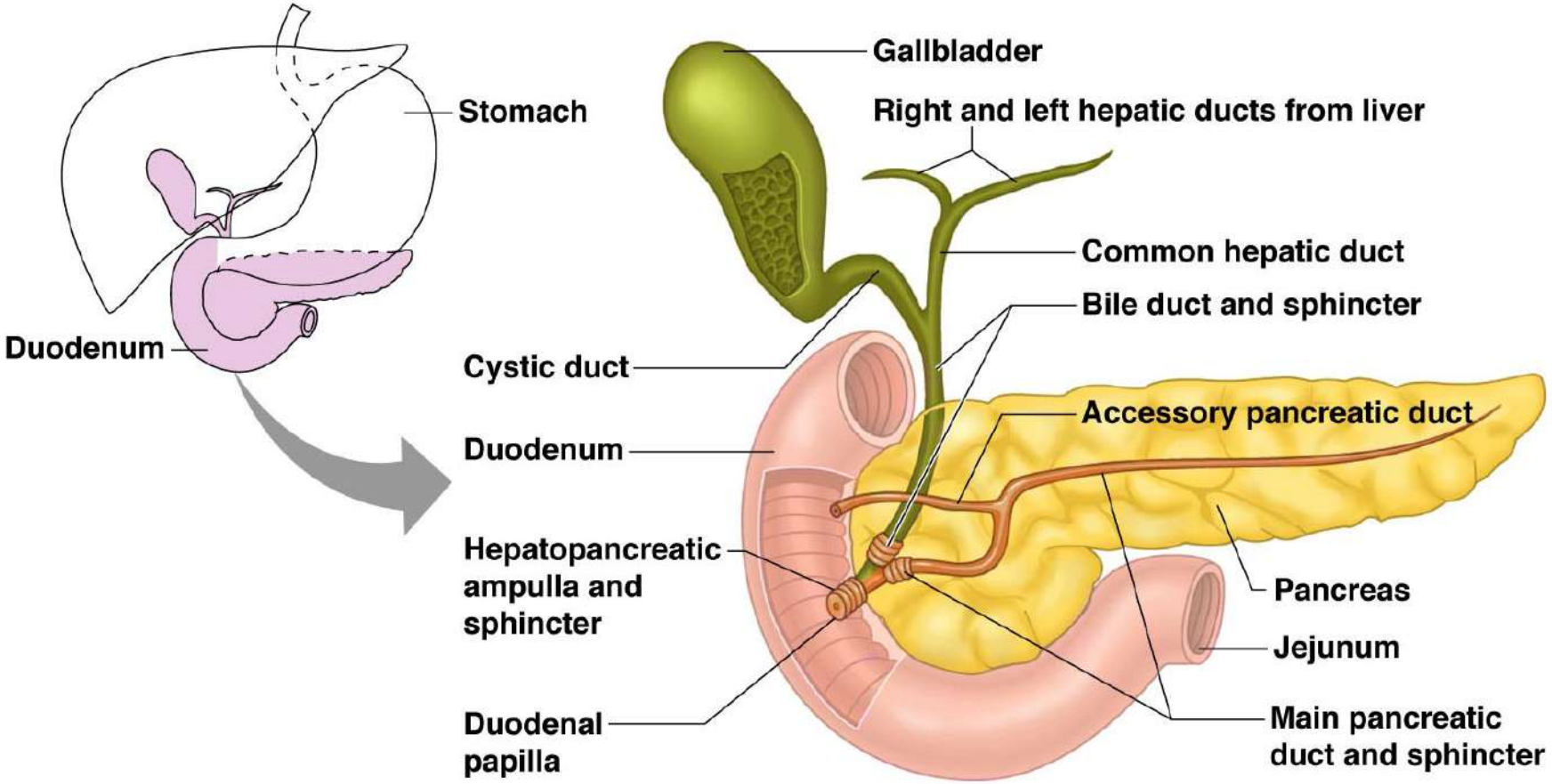


Figure 14.6

Liver

- Largest gland in the body
- Located on the right side of the body under the diaphragm
- Consists of four lobes suspended from the diaphragm and abdominal wall by the falciform ligament
- Connected to the gallbladder via the common hepatic duct

Liver

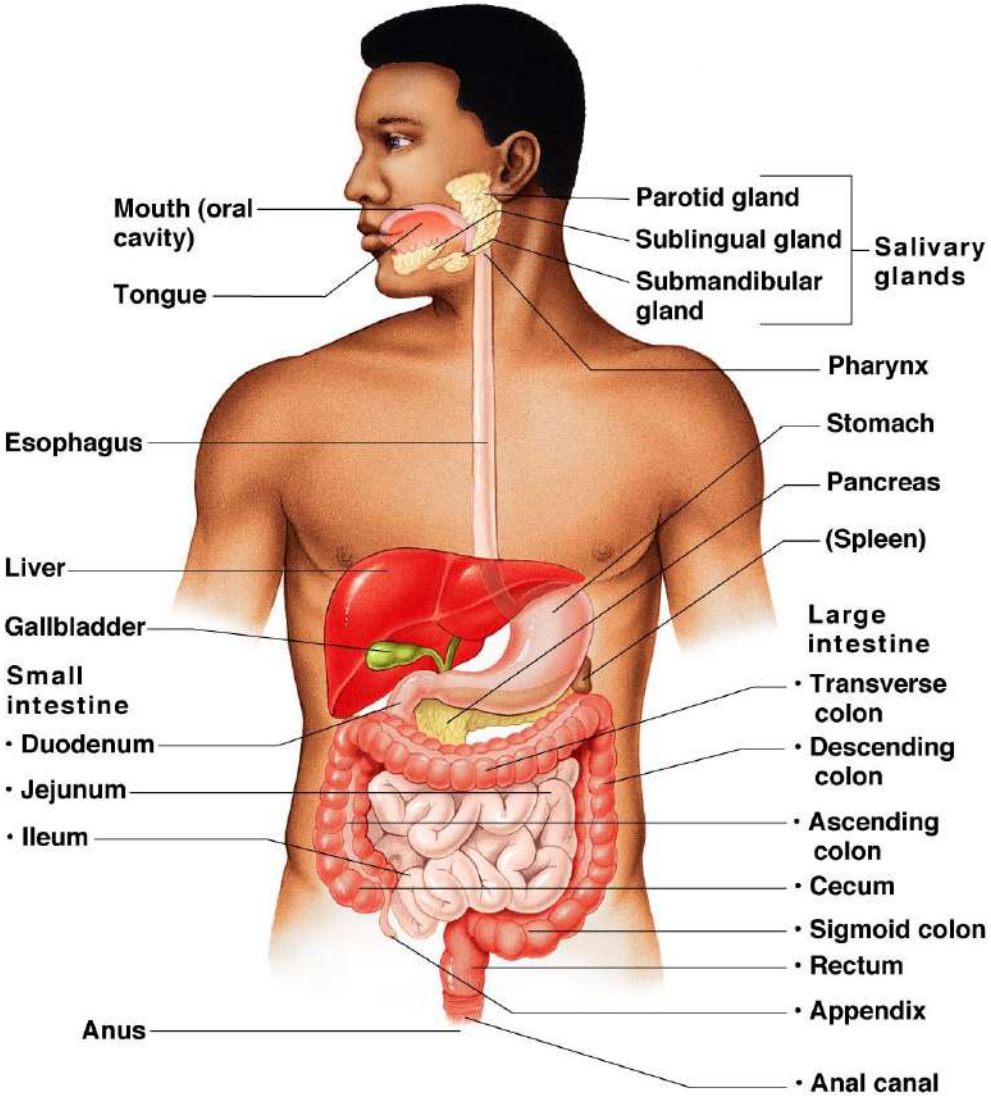


Figure 14.1

Liver

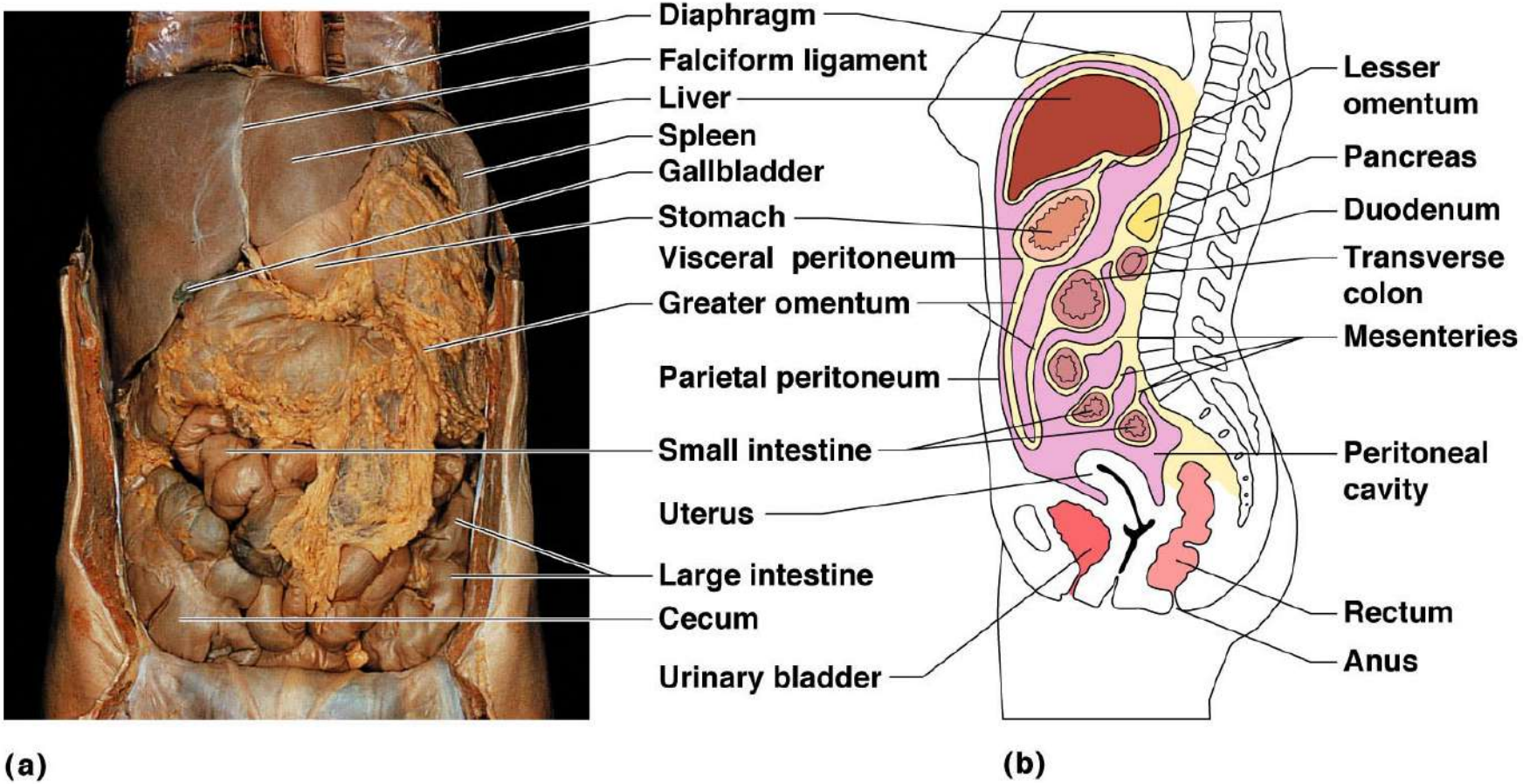


Figure 14.5

Bile

- Produced by cells in the liver
- Composition is
  - Bile salts
  - Bile pigments (mostly bilirubin from the breakdown of hemoglobin)
  - Cholesterol
  - Phospholipids
  - Electrolytes

Bile

- Function—emulsify fats by physically breaking large fat globules into smaller ones

Gallbladder

- Sac found in hollow fossa of liver
- When no digestion is occurring, bile backs up the cystic duct for storage in the gallbladder
- When digestion of fatty food is occurring, bile is introduced into the duodenum from the gallbladder
- Gallstones are crystallized cholesterol which can cause blockages

Gallbladder

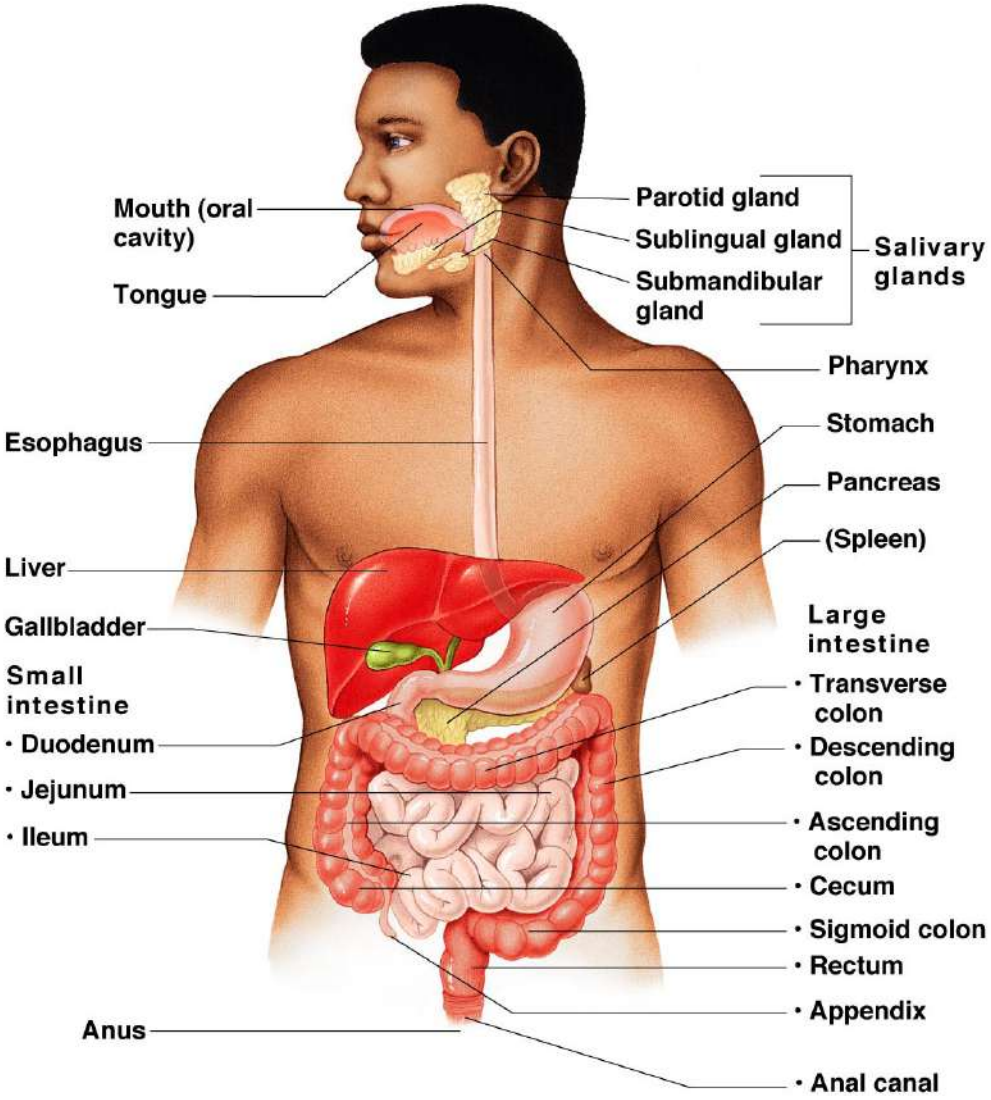


Figure 14.1

Gallbladder

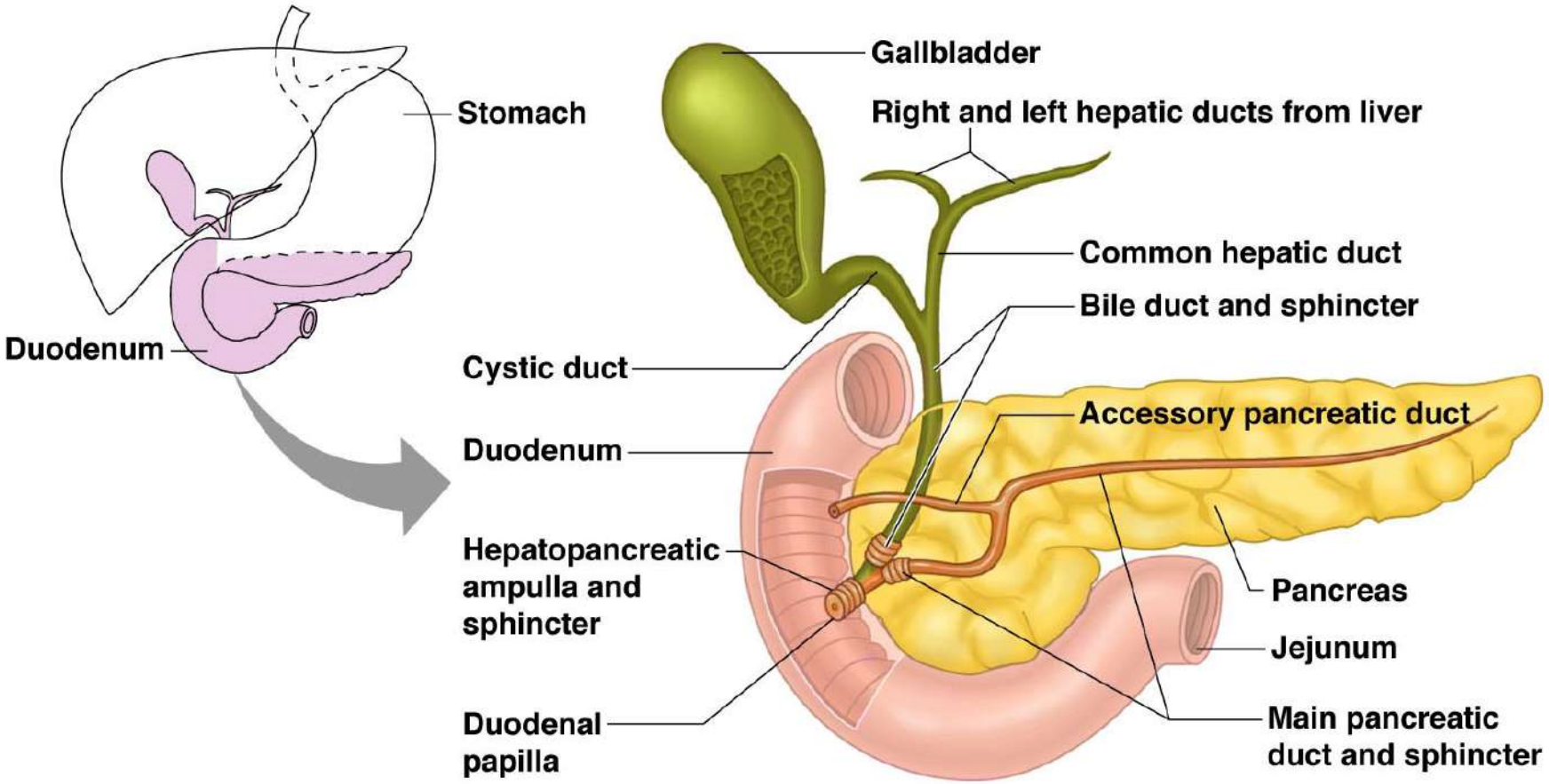


Figure 14.6

Functions of the Digestive System

- **Ingestion—getting food into the mouth**
- **Propulsion—moving foods from one region of the digestive system to another**
  - Peristalsis—alternating waves of contraction and relaxation that squeezes food along the GI tract
  - Segmentation—moving materials back and forth to aid with mixing in the small intestine

Functions of the Digestive System

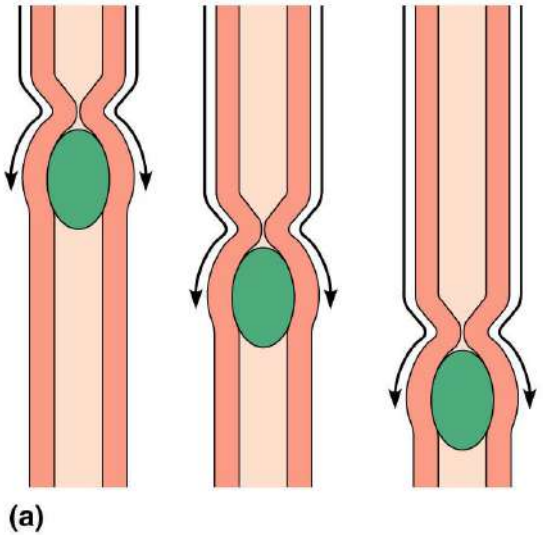


Figure 14.12

Functions of the Digestive System

- Food breakdown as *mechanical* digestion
  - **Examples:**
    - Mixing food in the mouth by the tongue
    - Churning food in the stomach
    - Segmentation in the small intestine
  - Mechanical digestion prepares food for further degradation by enzymes

Functions of the Digestive System

- Food breakdown as *chemical* digestion
  - Enzymes break down food molecules into their building blocks
  - Each major food group uses different enzymes
    - Carbohydrates are broken to simple sugars
    - Proteins are broken to amino acids
    - Fats are broken to fatty acids and alcohols

Functions of the Digestive System

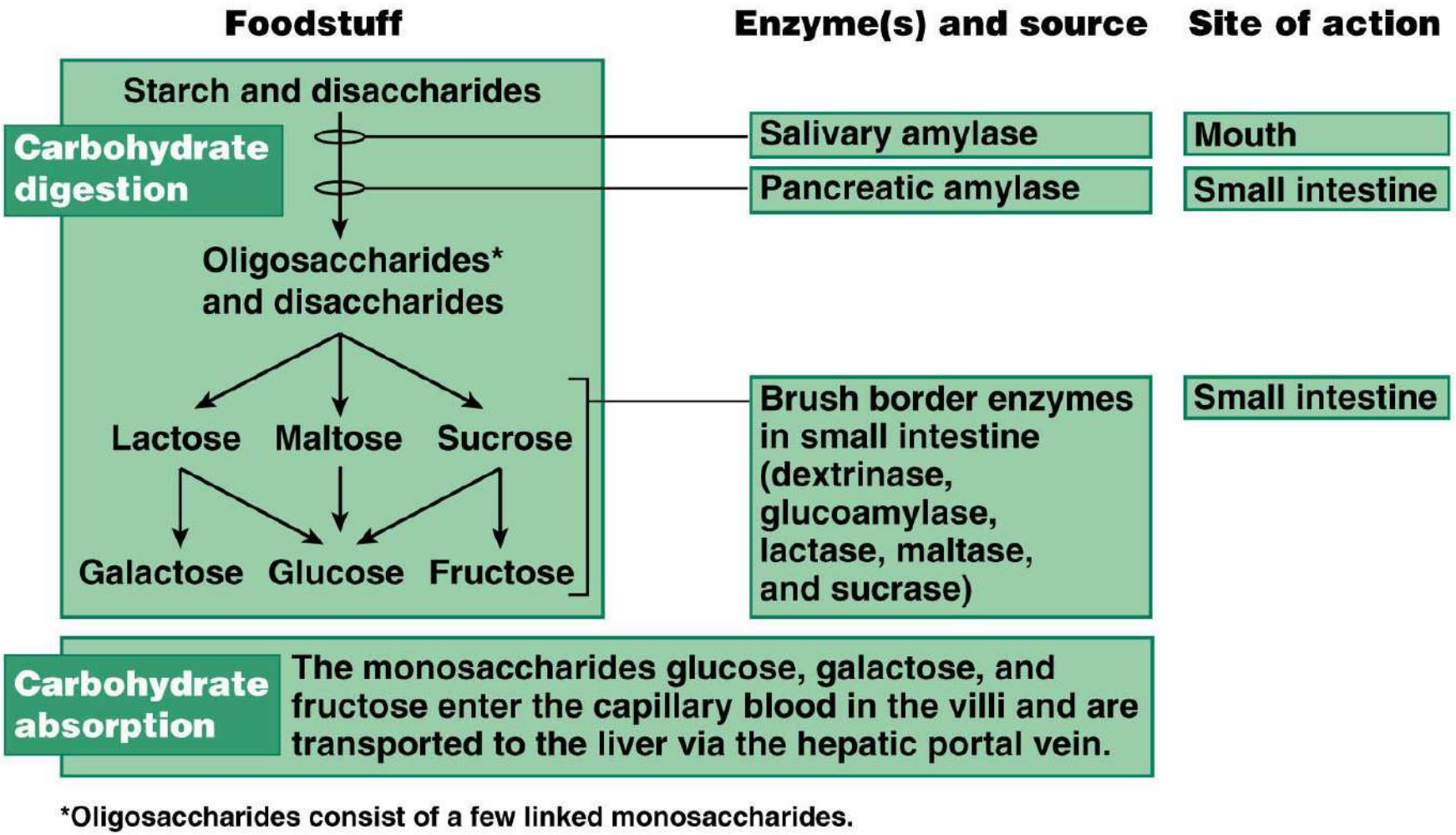


Figure 14.13 (1 of 3)

Functions of the Digestive System

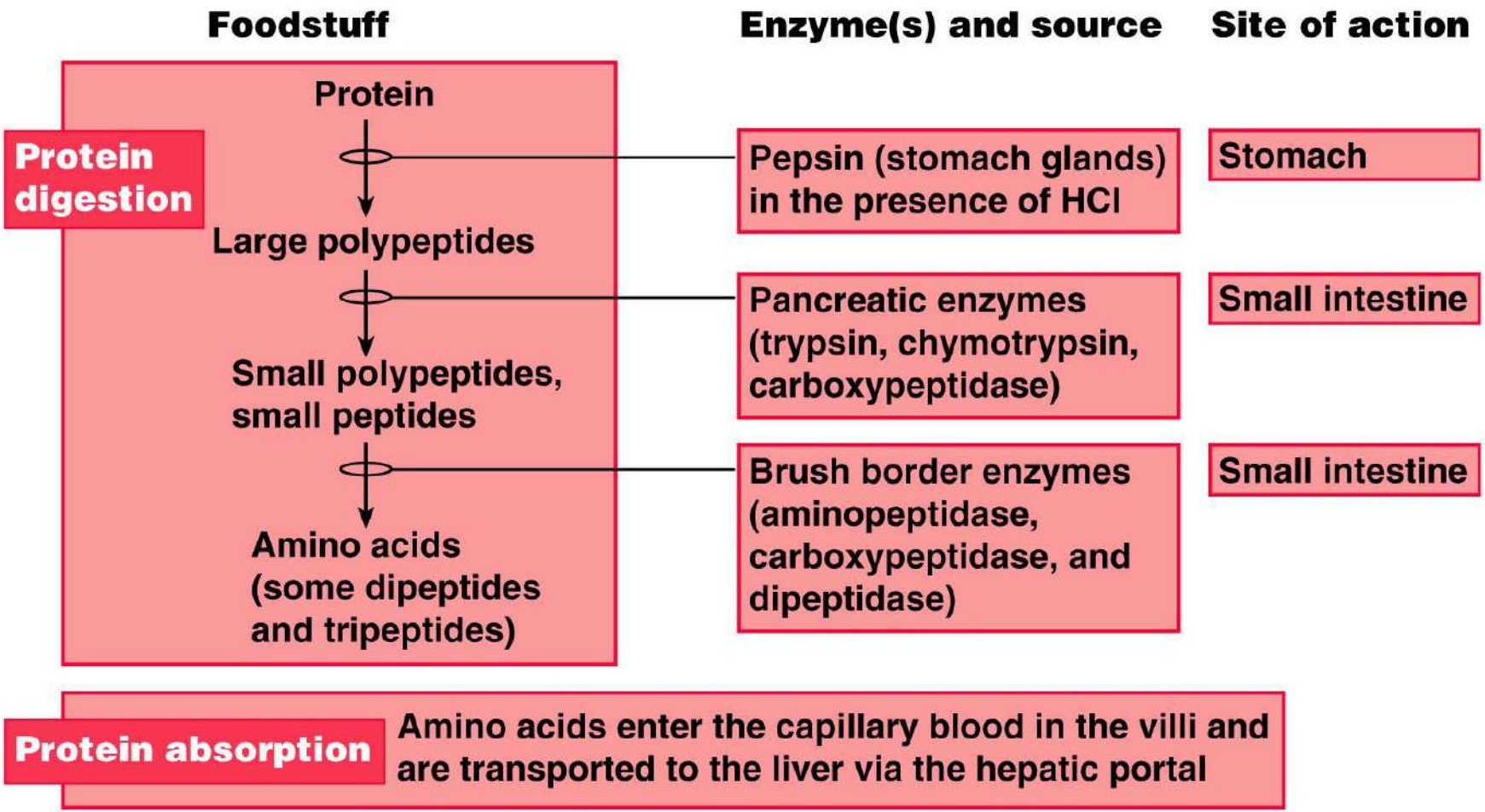


Figure 14.13 (2 of 3)

Functions of the Digestive System

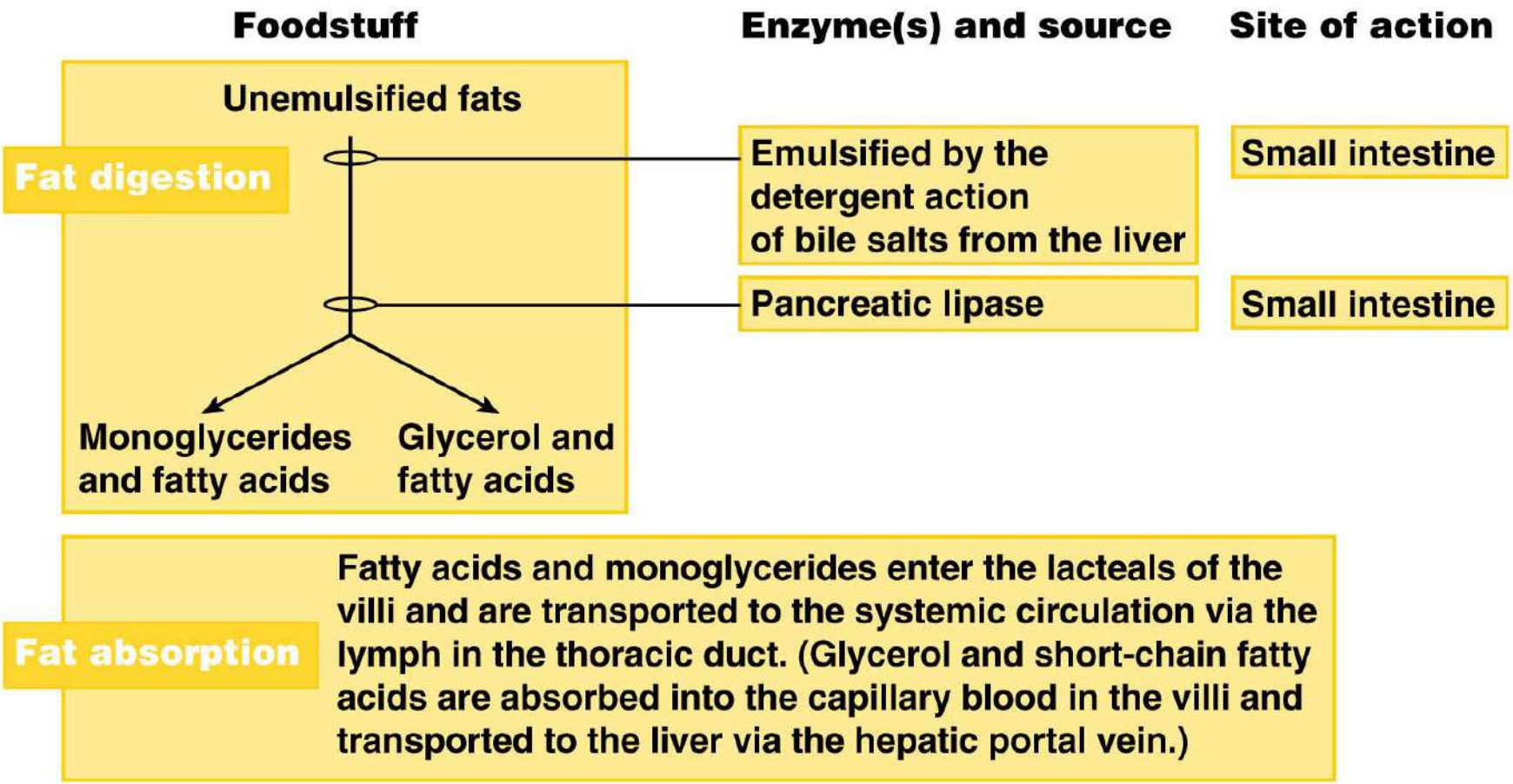


Figure 14.13 (3 of 3)

Functions of the Digestive System

- **Absorption**
  - End products of digestion are absorbed in the blood or lymph
  - Food must enter mucosal cells and then into blood or lymph capillaries
- **Defecation**
  - **Elimination of indigestible substances from the GI tract in the form of feces**

Functions of the Digestive System

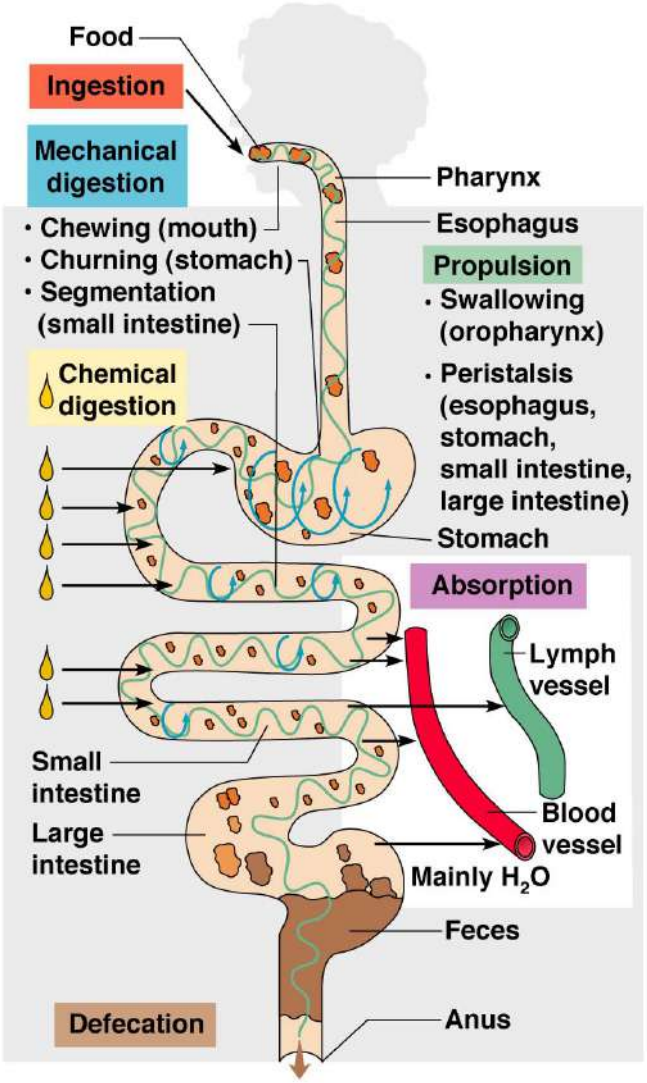


Figure 14.11

Control of Digestive Activity

- Mostly controlled by reflexes via the parasympathetic division
- Chemical and mechanical receptors are located in organ walls that trigger reflexes

Control of Digestive Activity

- **Stimuli include**
  - Stretch of the organ
  - pH of the contents
  - Presence of breakdown products
- **Reflexes include**
  - **Activation or inhibition of glandular secretions**
  - **Smooth muscle activity**

Digestive Activities of the Mouth

- **Mechanical breakdown**
  - Food is physically broken down by chewing
- **Chemical digestion**
  - **Food is mixed with saliva**
  - **Starch is broken down into maltose by salivary amylase**

Activities of the Pharynx and Esophagus

- These organs have no digestive function
- Serve as passageways to the stomach

Deglutition (Swallowing)

- Buccal phase
  - Voluntary
  - Occurs in the mouth
  - Food is formed into a bolus
  - The bolus is forced into the pharynx by the tongue

Deglutition (Swallowing)

- Pharyngeal-esophageal phase
  - Involuntary transport of the bolus
  - All passageways except to the stomach are blocked
    - Tongue blocks off the mouth
    - Soft palate (uvula) blocks the nasopharynx
    - Epiglottis blocks the larynx

Deglutition (Swallowing)

- Pharyngeal-esophogeal phase (continued)
  - Peristalsis moves the bolus toward the stomach
  - The cardioesophageal sphincter is opened when food presses against it

Deglutition (Swallowing)

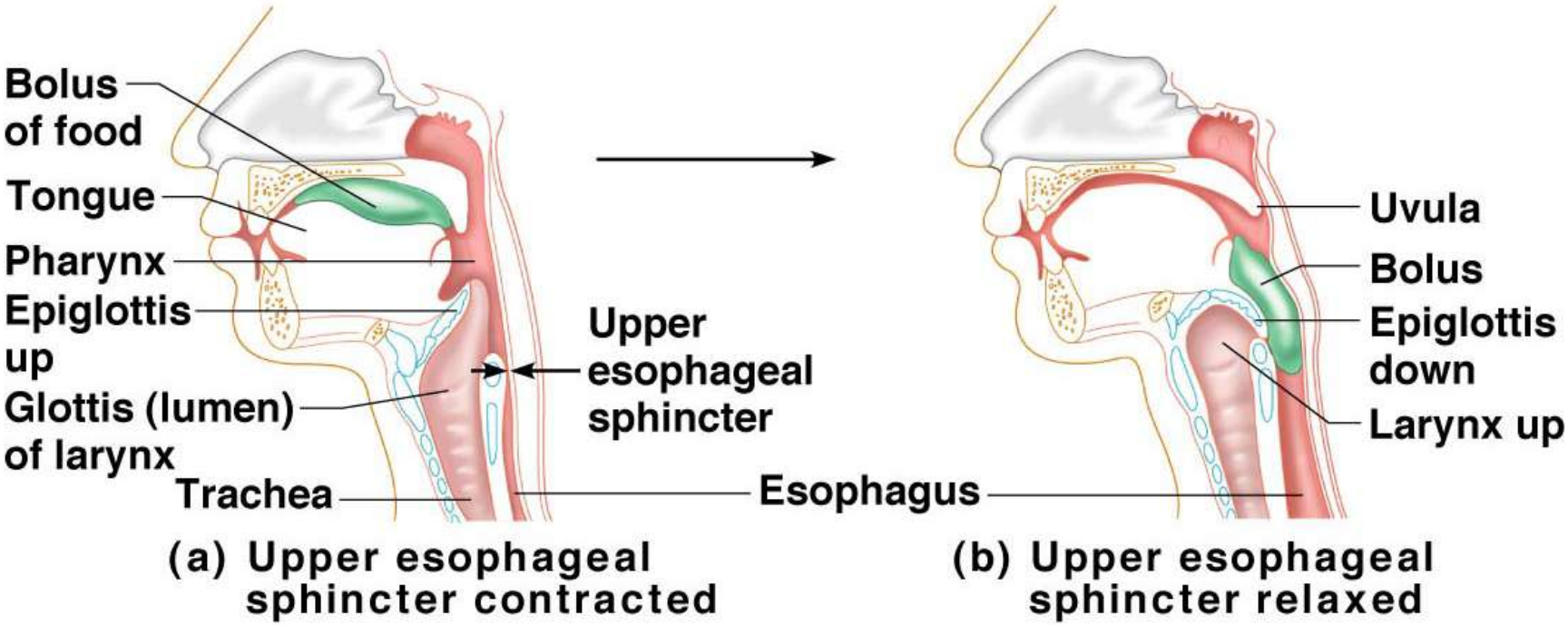
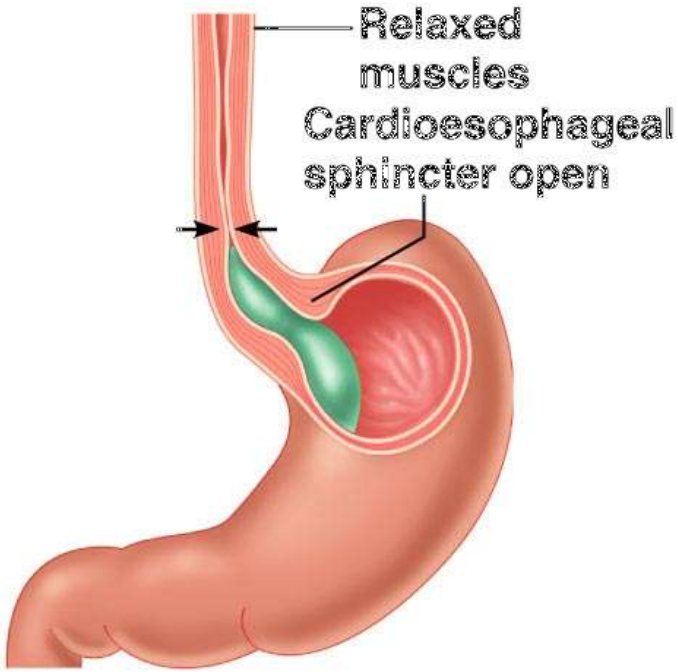
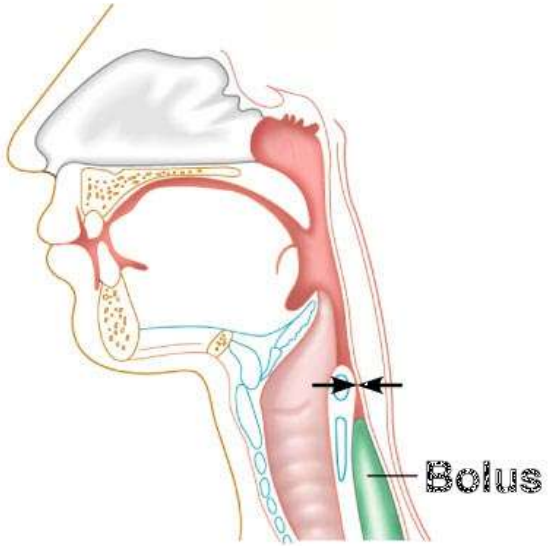


Figure 14.14a–b

Deglutition (Swallowing)



(d) Cardioesophageal sphincter relaxed



(c) Upper esophageal sphincter contracted

Figure 14.14c–d

Food Breakdown in the Stomach

- Gastric juice is regulated by neural and hormonal factors
- Presence of food or rising pH causes the release of the hormone gastrin
- Gastrin causes stomach glands to produce
  - Protein-digesting enzymes
  - Mucus
  - Hydrochloric acid

Food Breakdown in the Stomach

- Hydrochloric acid makes the stomach contents very acidic
- Acidic pH
  - Activates pepsinogen to pepsin for protein digestion
  - Provides a hostile environment for microorganisms

Digestion and Absorption in the Stomach

- **Protein digestion enzymes**
  - Pepsin—an active protein-digesting enzyme
  - Rennin—works on digesting milk protein in infants, not adults
- **Alcohol and aspirin are the only items absorbed in the stomach**

Propulsion in the Stomach

- Food must first be well mixed
- Rippling peristalsis occurs in the lower stomach
- The pylorus meters out chyme into the small intestine (30 mL at a time)
- The stomach empties in 4–6 hours

Propulsion in the Stomach

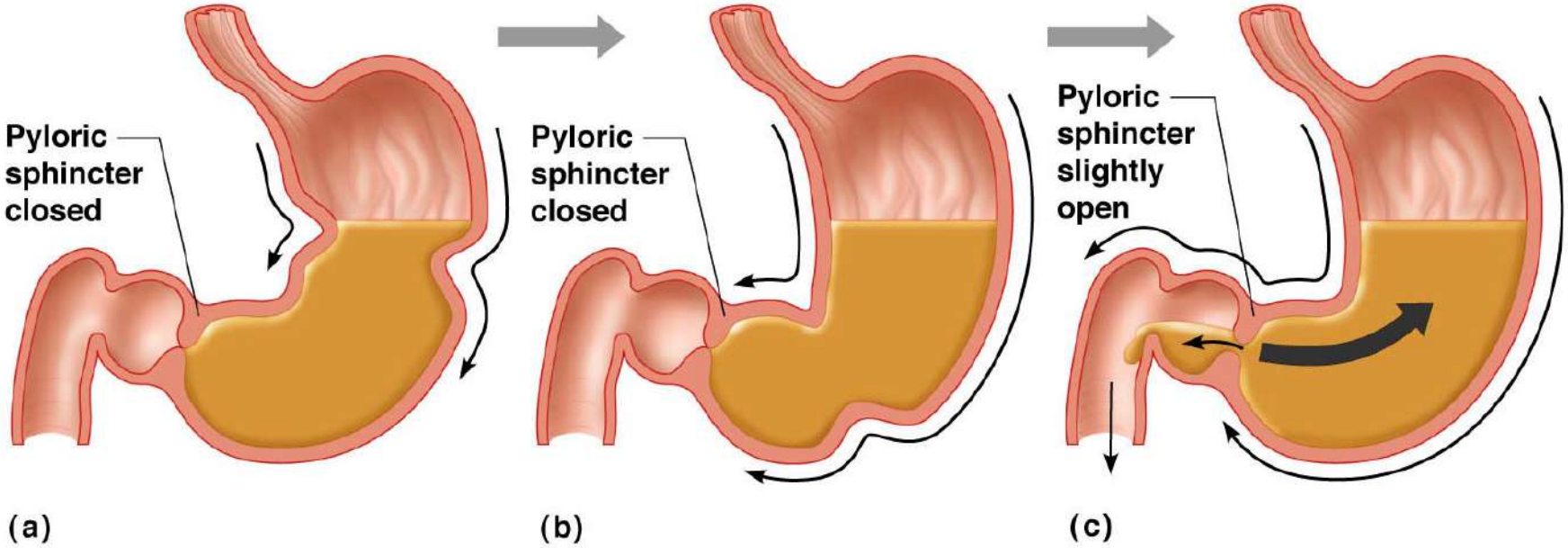


Figure 14.15a–c

Digestion in the Small Intestine

- Enzymes from the brush border function to
  - Break double sugars into simple sugars
  - Complete some protein digestion

Digestion in the Small Intestine

- **Pancreatic enzymes play the major digestive function**
  - Help complete digestion of starch (pancreatic amylase)
  - Carry out about half of all protein digestion
  - Digest fats using lipases from the pancreas
  - Digest nucleic acids using nucleases
- **Alkaline content neutralizes acidic chyme**

Regulation of Pancreatic Juice Secretion

- Release of pancreatic juice into the duodenum is stimulated by
  - Vagus nerve
  - Local hormones
    - Secretin
    - Cholecystokinin (CCK)
- Hormones travel the blood to stimulate the pancreas to release enzyme- and bicarbonate-rich product

Regulation of Pancreatic Juice Secretion

- Secretin causes the liver to increase bile output
- CCK causes the gallbladder to release stored bile
  - Bile is necessary for fat absorption and absorption of fat-soluble vitamins (K, D, A)

Regulation of Pancreatic Juice Secretion

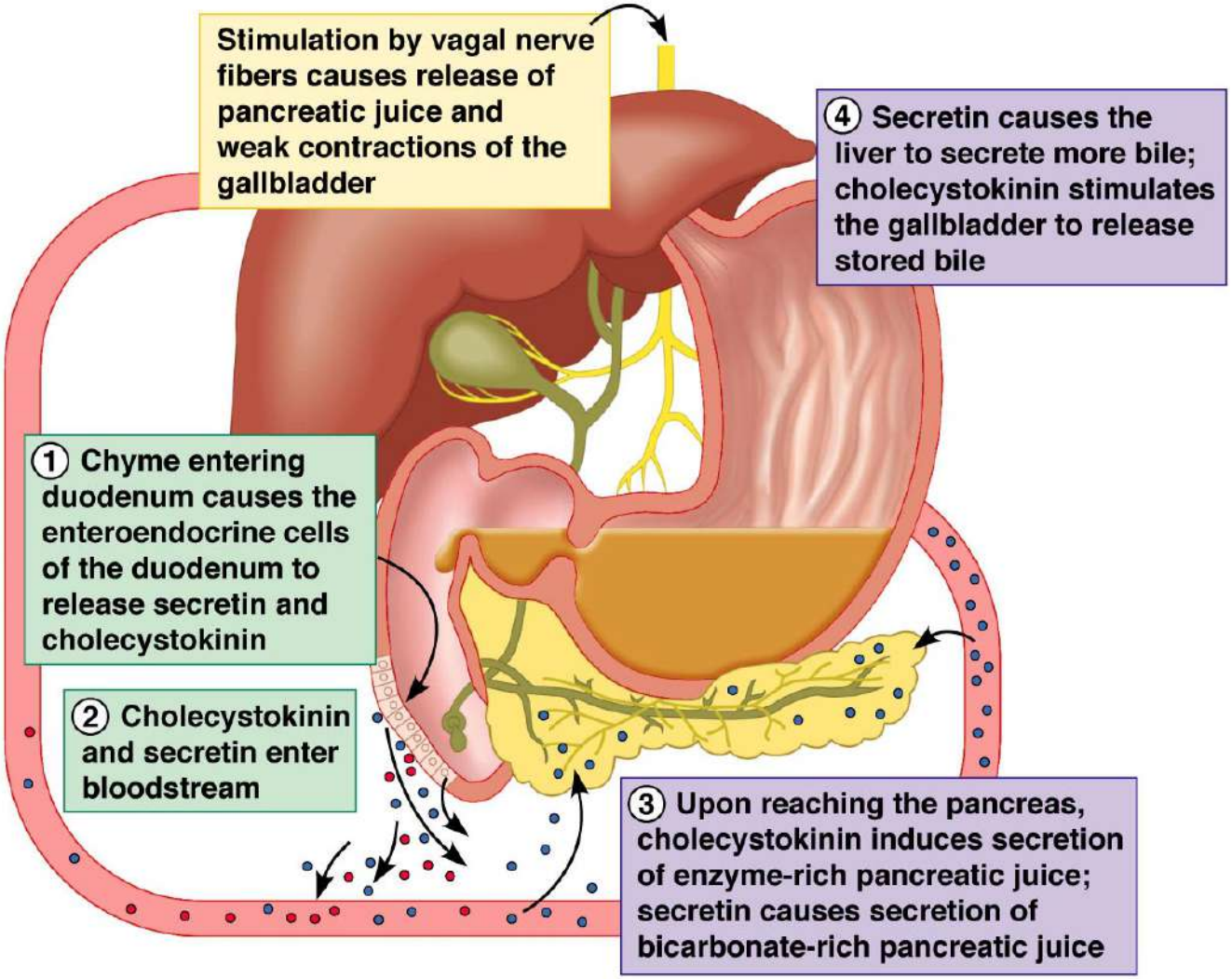


Figure 14.16

Hormones and Hormonelike Products that Act in Digestion

TABLE 14.1 Hormones and Hormonelike Products That Act in Digestion

Hormone	Source	Stimulus for secretion	Action
Gastrin	Stomach	Food in stomach (chemical stimulus); ACH released by nerve fibers	• Stimulates release of gastric juice • Stimulates stomach emptying
Intestinal gastrin	Duodenum	Acidic food in stomach	• Stimulates gastric secretion and emptying
Histamine	Stomach	Food in stomach	• Activates parietal cells to secrete hydrochloric acid.
Somatostatin	Stomach and duodenum	Food in stomach; stimulated by sympathetic nerve fibers	• Inhibits secretion of gastric juice and pancreatic juice • Inhibits emptying of stomach and gallbladder.

Table 14.1 (1 of 2)

Hormones and Hormonelike Products that Act in Digestion

TABLE 14.1 Hormones and Hormonelike Products That Act in Digestion *(continued)*

Hormone	Source	Stimulus for secretion	Action
Secretin	Duodenum	Acidic chyme and partially digested foods in duodenum	• Increases output of pancreatic juice rich in bicarbonate ions • Increases bile output by liver • Inhibits gastric mobility and gastric gland secretion.
Cholecystokinin (CCK)	Duodenum	Fatty chyme and partially digested proteins in duodenum	• Increases output of enzyme-rich pancreatic juice • Stimulates gallbladder to expel stored bile • Relaxes sphincter of duodenal papilla to allow bile and pancreatic juice to enter the duodenum.
Gastric inhibitory peptide (GIP)	Duodenum	Fatty chyme in duodenum	• Inhibits secretion of gastric juice.

Table 14.1 (2 of 2)

Absorption in the Small Intestine

- **Water is absorbed along the length of the small intestine**
- **End products of digestion**
  - Most substances are absorbed by active transport through cell membranes
  - Lipids are absorbed by diffusion
- **Substances are transported to the liver by the hepatic portal vein or lymph**

Propulsion in the Small Intestine

- Peristalsis is the major means of moving food
- Segmental movements
  - Mix chyme with digestive juices
  - Aid in propelling food

Segmentation

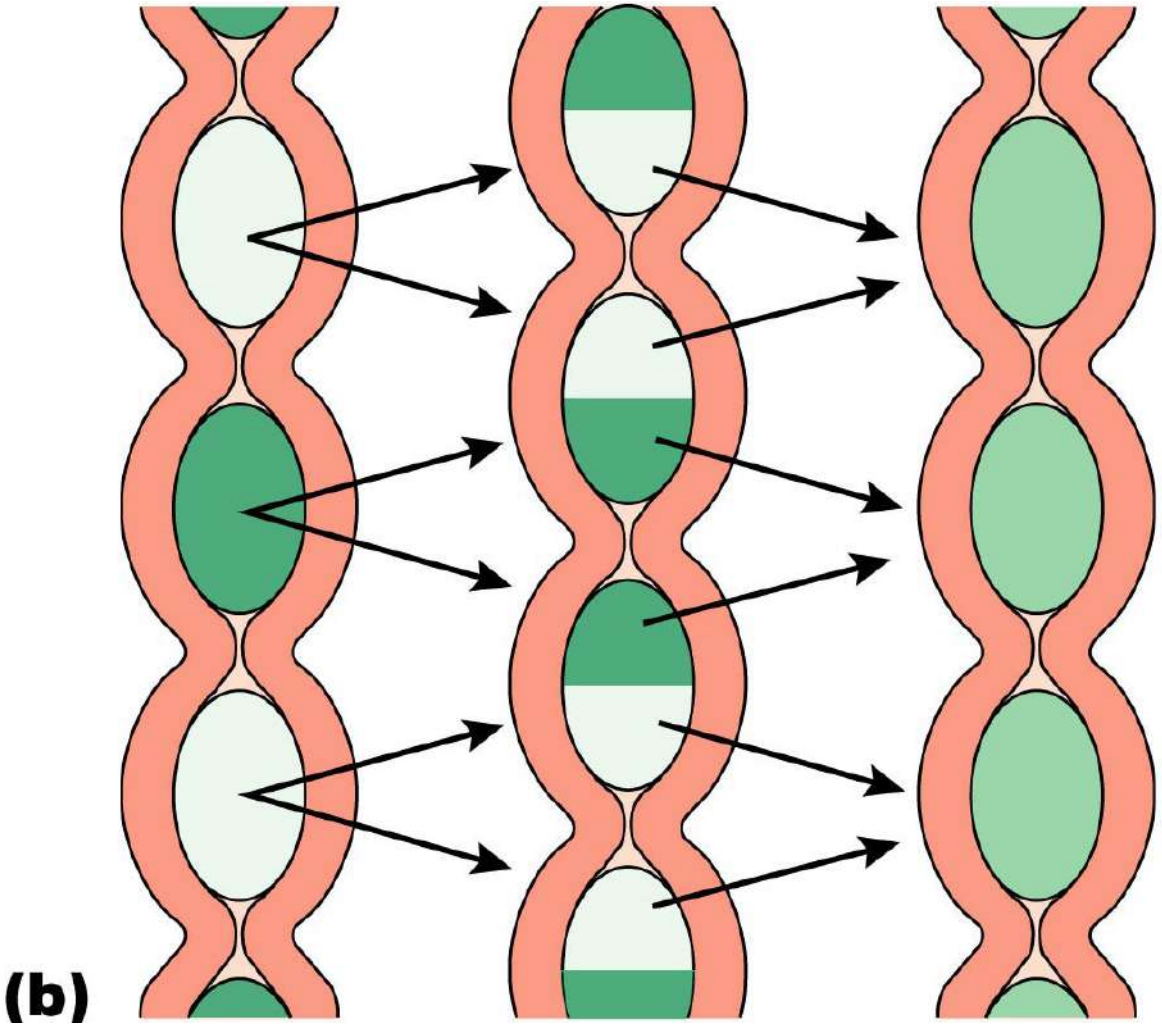


Figure 14.12b

Food Breakdown and Absorption in the Large Intestine

- **No digestive enzymes are produced**
- **Resident bacteria digest remaining nutrients**
  - Produce some vitamin K and B
  - Release gases
- **Water and vitamins K and B are absorbed**
- **Remaining materials are eliminated via feces**

Food Breakdown and Absorption in the Large Intestine

- Feces contains
  - Undigested food residues
  - Mucus
  - Bacteria
  - Water

Propulsion in the Large Intestine

- **Sluggish peristalsis**
- **Mass movements**
  - Slow, powerful movements
  - Occur three to four times per day
- **Presence of feces in the rectum causes a defecation reflex**
  - **Internal anal sphincter is relaxed**
  - **Defecation occurs with relaxation of the voluntary (external) anal sphincter**

Nutrition

- **Nutrient—substance used by the body for growth, maintenance, and repair**
- **Major nutrients**
  - Carbohydrates
  - Lipids
  - Proteins
  - Water
- **Minor nutrients**
  - **Vitamins**
  - **Minerals**

Five Basic Food Groups and Some of Their Major Nutrients

TABLE 14.2 Five Basic Food Groups and Some of Their Major Nutrients

Group	Example foods	Major nutrients supplied in significant amounts: By all in group	By only some in group
Fruits 	Apples, bananas, dates, oranges tomatoes	Carbohydrate Water	Vitamins: A, C, folic acid Minerals: iron, potassium Fiber
Vegetables 	Broccoli, cabbage, green beans, lettuce, potatoes	Carbohydrate Water	Vitamins: A, C, E, K, and B vitamins except B_{12} Minerals: calcium, magnesium, iodine, manganese, phosphorus Fiber
Grain products (preferably whole grain; otherwise, enriched or fortified) 	Breads, rolls, bagels; cereals, dry and cooked; pasta; rice, other grains; tortillas, pancakes, waffles; crackers; popcorn	Carbohydrate Protein Vitamins: thiamin (B_1), niacin	Water Fiber Minerals: iron, magnesium, selenium

Source: Christian, Janet, and Janet Greger. *Nutrition for Living,* 3rd ed. San Francisco, CA: Benjamin Cummings, 1991.

Table 14.2 (1 of 2)

Five Basic Food Groups and Some of Their Major Nutrients

TABLE 14.2 Five Basic Food Groups and Some of Their Major Nutrients *(continued)*

Group	Example foods	Major nutrients supplied in significant amounts: By all in group	By only some in group
Milk products 	Milk, yogurt; cheese; ice cream, ice milk, frozen yogurt	Protein Fat Vitamins: riboflavin, B_{12} Minerals: calcium, phosphorus Water	Carbohydrate Vitamins: A, D
Meats and meat alternatives 	Meat, fish, poultry; eggs; seeds; nuts, nut butters; soybeans, tofu; other legumes (peas and beans)	Protein Vitamins: niacin, B_6 Minerals: iron, zinc	Carbohydrate Fat Vitamins: B_{12}, thiamin (B_1) Water Fiber

Source: Christian, Janet, and Janet Greger. *Nutrition for Living,* 3rd ed. San Francisco, CA: Benjamin Cummings, 1991.

Table 14.2 (2 of 2)

USDA Food Guide Pyramid

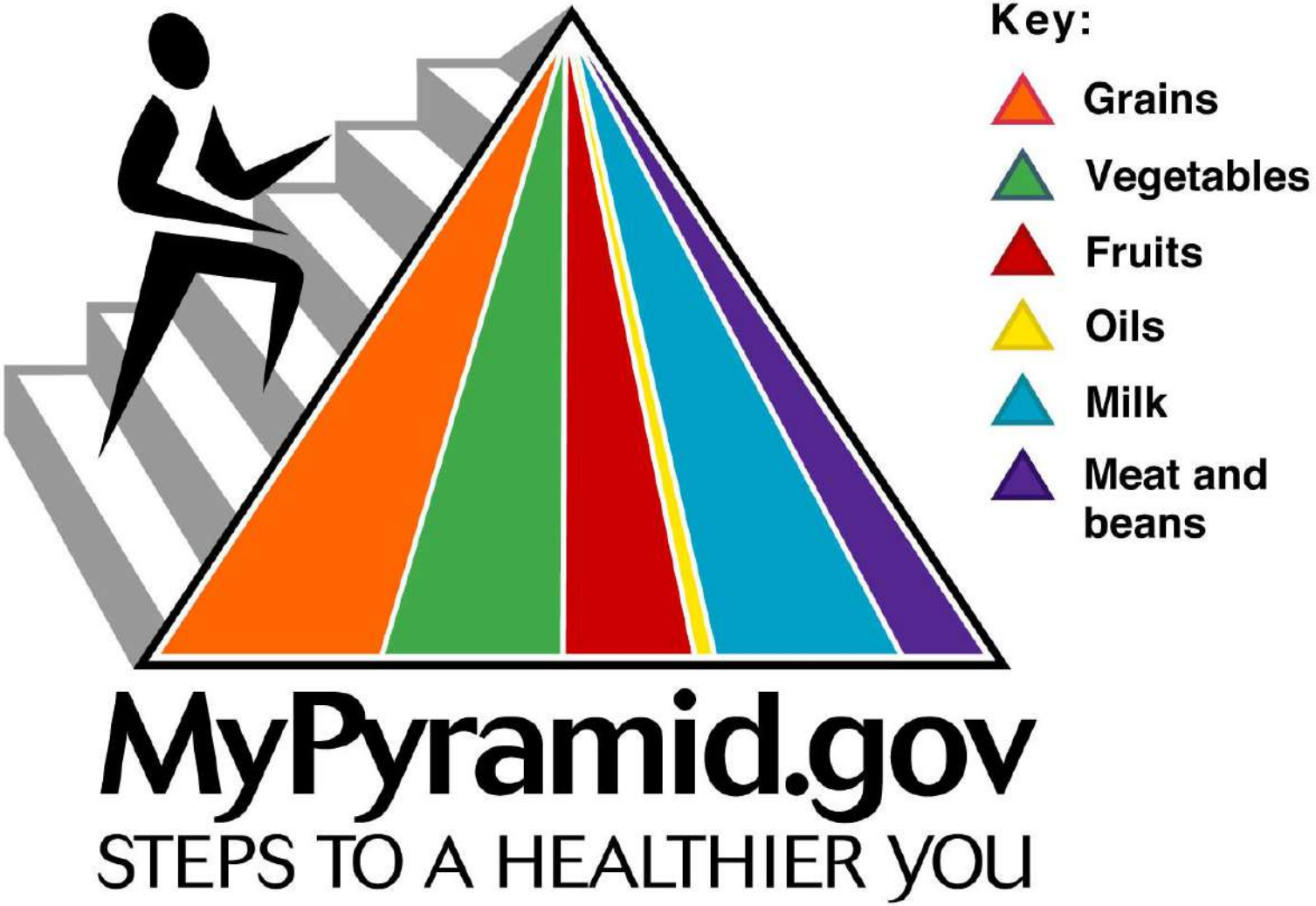


Figure 14.17

Dietary Sources of Major Nutrients

- **Carbohydrates**
  - Most are derived from plants
  - Exceptions: lactose from milk and small amounts of glycogens from meats
- **Lipids**
  - **Saturated fats from animal products**
  - **Unsaturated fats from nuts, seeds, and vegetable oils**
  - **Cholesterol from egg yolk, meats, and milk products**

Dietary Sources of Major Nutrients

- Proteins
  - Complete proteins—contain all essential amino acids
    - Most are from animal products
  - Legumes and beans also have proteins, but are incomplete
- Vitamins
  - Most vitamins are used as coenzymes
  - Found in all major food groups

Dietary Sources of Major Nutrients

- Minerals
  - Play many roles in the body
  - Most mineral-rich foods are vegetables, legumes, milk, and some meats