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Human Anatomy & Physiology

Ninth Edition

PowerPoint® Lecture Slides
prepared by
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CHAPTER 23

The Digestive System: Part A

Digestive System

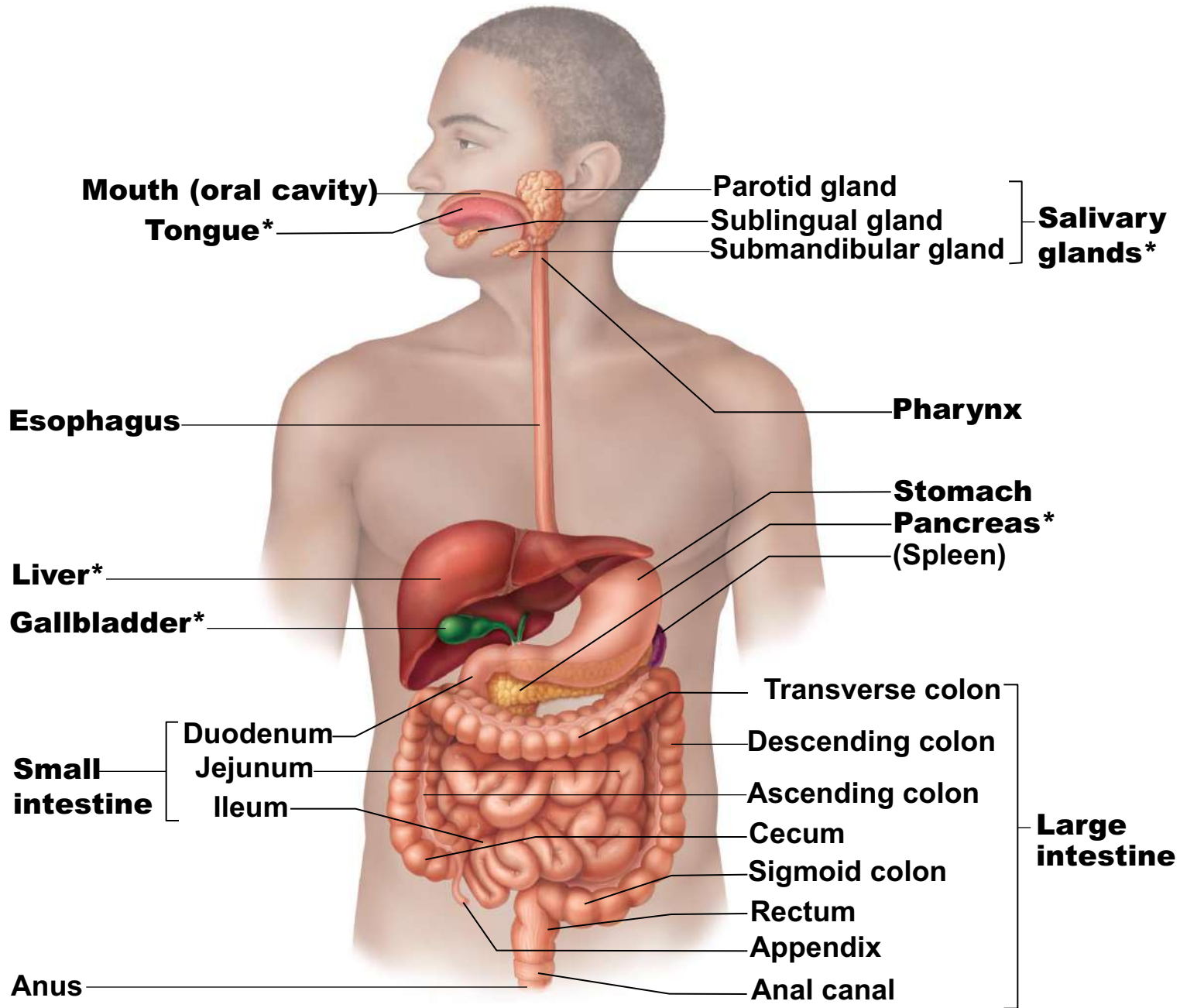
- Two groups of organs
 1. Alimentary canal (gastrointestinal or GI tract)
 - Mouth to anus
 - Digests food and absorbs fragments
 - Mouth, pharynx, esophagus, stomach, small intestine, and large intestine

Digestive System

2. Accessory digestive organs

- Teeth, tongue, gallbladder
- Digestive glands
 - Salivary glands
 - Liver
 - Pancreas

Figure 23.1 Alimentary canal and related accessory digestive organs.



Digestive Processes

- Six essential activities
 1. Ingestion
 2. Propulsion
 3. Mechanical breakdown
 4. Digestion
 5. Absorption
 6. Defecation

Figure 23.2 Gastrointestinal tract activities.

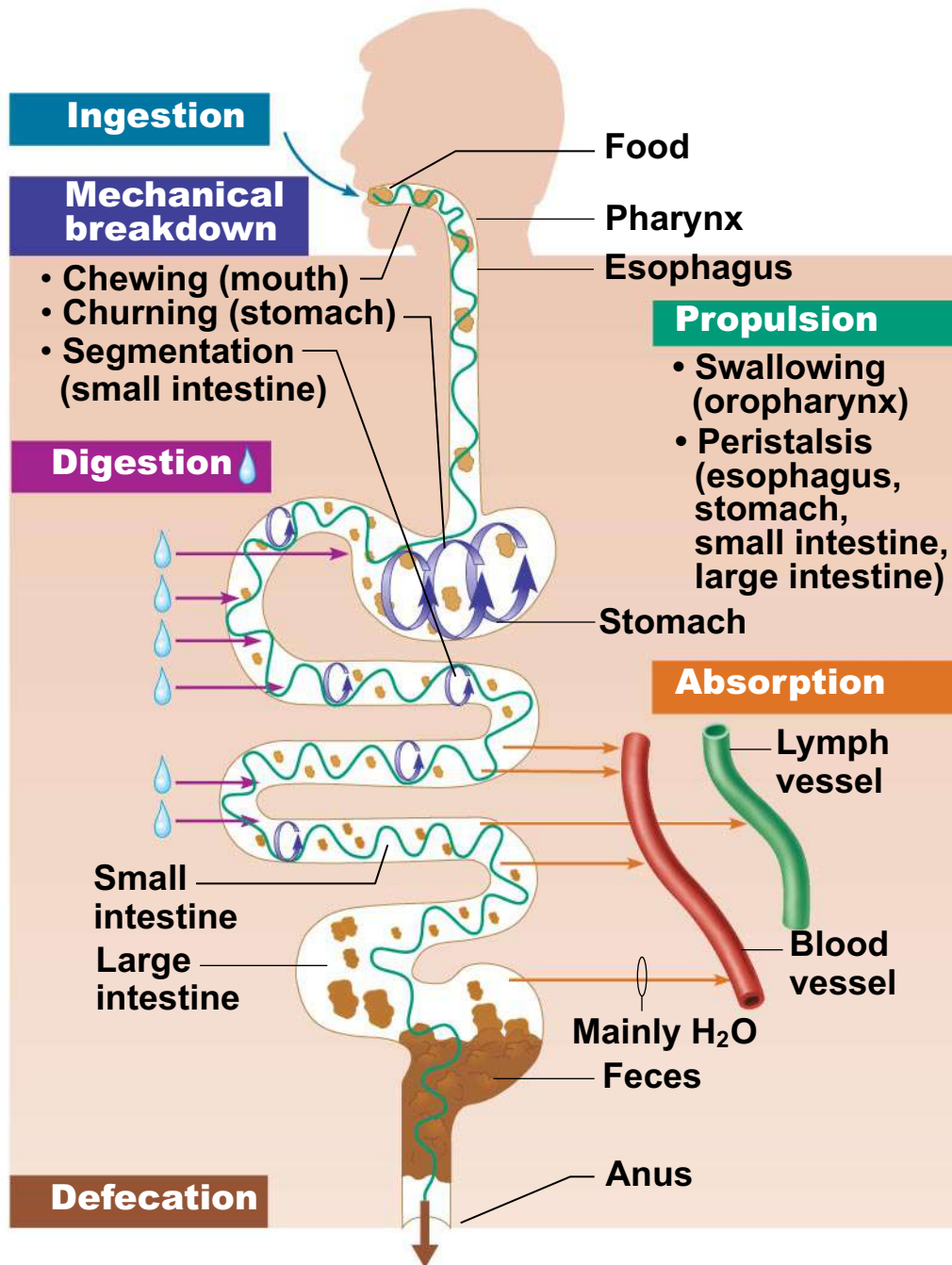
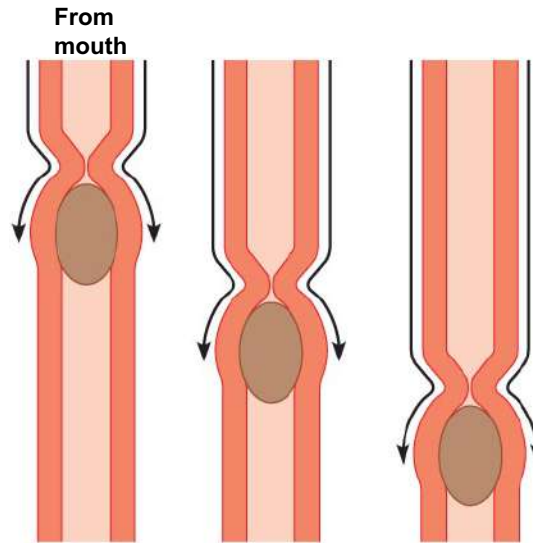
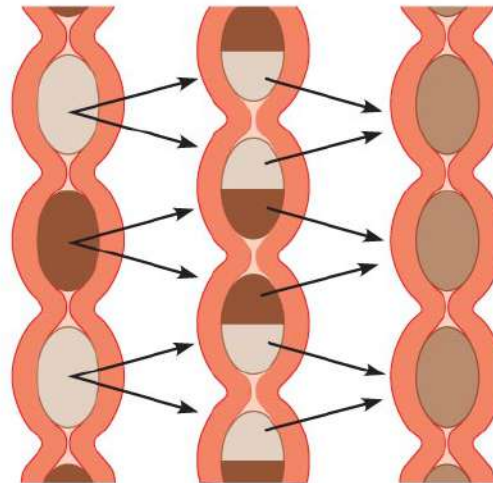


Figure 23.3 Peristalsis and segmentation.



(a) Peristalsis: Adjacent segments of alimentary tract organs alternately contract and relax, moving food along the tract distally.



(b) Segmentation: Nonadjacent segments of alimentary tract organs alternately contract and relax, moving food forward then backward. Food mixing and slow food propulsion occur.

GI Tract Regulatory Mechanisms

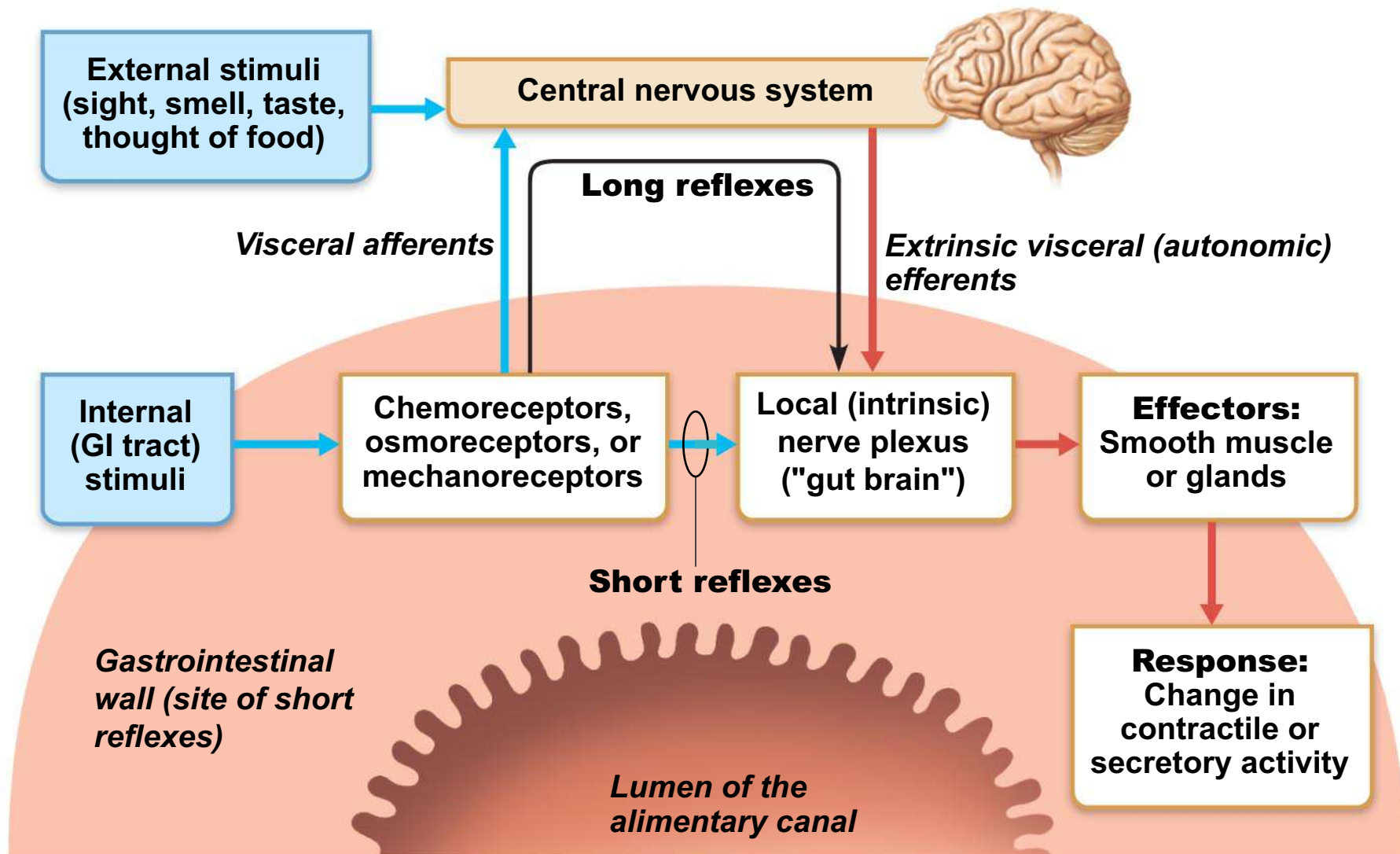
1. Mechanoreceptors and chemoreceptors
 - Respond to stretch, changes in osmolarity and pH, and presence of substrate and end products of digestion
 - Initiate reflexes that
 - Activate or inhibit digestive glands
 - Stimulate smooth muscle to mix and move lumen contents

GI Tract Regulatory Mechanisms

2. Intrinsic and extrinsic controls

- **Short reflexes** - enteric nerve plexuses (gut brain) respond to stimuli in GI tract
- **Long reflexes** respond to stimuli inside or outside GI tract; involve CNS centers and autonomic nerves
- Hormones from cells in stomach and small intestine stimulate target cells in same or different organs to secrete or contract

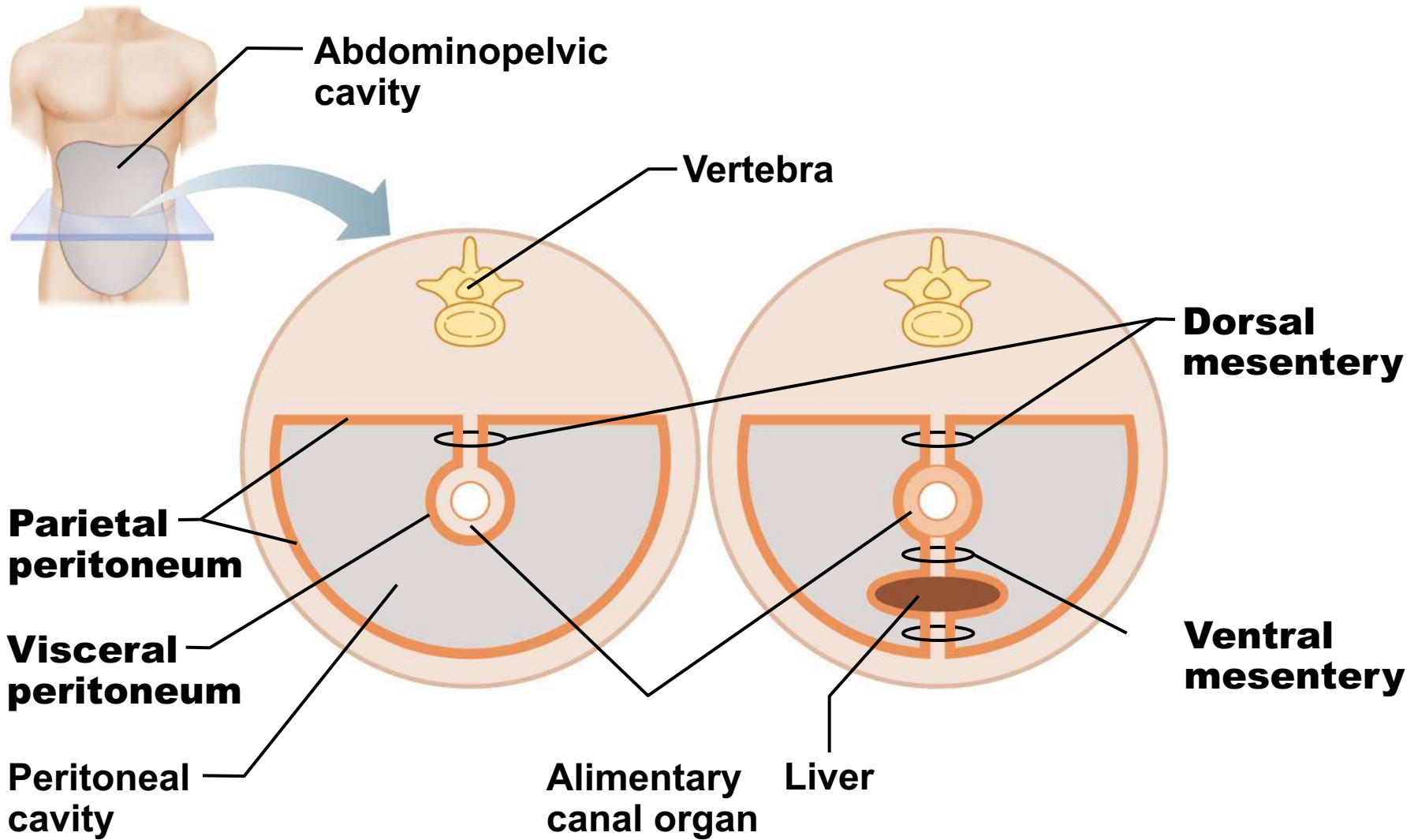
Figure 23.4 Neural reflex pathways initiated by stimuli inside or outside the gastrointestinal tract.



Peritoneum and Peritoneal Cavity

- **Peritoneum** - serous membrane of abdominal cavity
 - **Visceral peritoneum** on external surface of most digestive organs
 - **Parietal peritoneum** lines body wall
- **Peritoneal cavity**
 - Between two peritoneums
 - Fluid lubricates mobile organs

Figure 23.5a The peritoneum and the peritoneal cavity.



(a) Two schematic cross sections of abdominal cavity illustrate the peritoneums and mesenteries.

Peritoneum and Peritoneal Cavity

- **Mesentery** - double layer of peritoneum
 - Routes for blood vessels, lymphatics, and nerves
 - Holds organs in place; stores fat
- **Retroperitoneal organs** posterior to peritoneum
- **Intraperitoneal (peritoneal) organs** surrounded by peritoneum

Homeostatic Imbalance

- Peritonitis
 - Inflammation of peritoneum
 - Causes by e.g., piercing abdominal wound, perforating ulcer, ruptured appendix
 - Peritoneal coverings stick together, localizing infection
 - Dangerous and lethal if widespread
 - Treated with debris removal and antibiotics

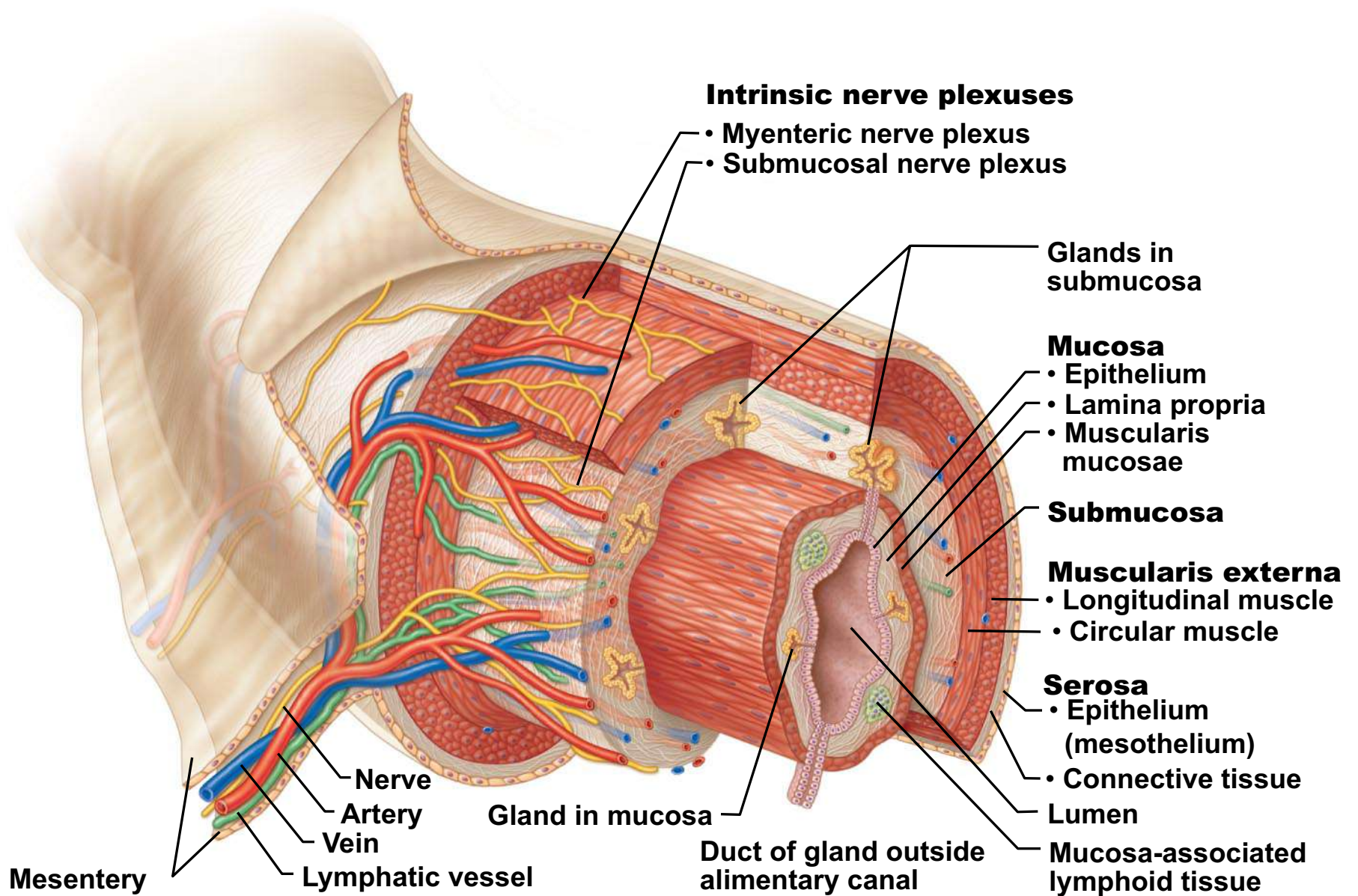
Blood Supply

- **Hepatic portal circulation**
 - Drains nutrient-rich blood from digestive organs
 - Delivers it to the liver for processing

Histology of the Alimentary Canal

- Four basic layers (tunics)
 - **Mucosa**
 - **Submucosa**
 - **Muscularis externa**
 - **Serosa**

Figure 23.6 Basic structure of the alimentary canal.



Mucosa

- Lines lumen
- Functions – different layers perform 1 or all 3
 - Secretes mucus, digestive enzymes, and hormones
 - Absorbs end products of digestion
 - Protects against infectious disease
- Three sublayers: **epithelium, lamina propria, and muscularis mucosae**

Mucosa

- Epithelium
 - Simple columnar epithelium and mucus-secreting cells (most of tract)
 - Mucus
 - Protects digestive organs from enzymes
 - Eases food passage
 - May secrete enzymes and hormones (e.g., in stomach and small intestine)

Mucosa

- Lamina propria
 - Loose areolar connective tissue
 - Capillaries for nourishment and absorption
 - Lymphoid follicles (part of MALT)
 - Defend against microorganisms
- Muscularis mucosae: smooth muscle → local movements of mucosa

Submucosa

- Submucosa
 - Areolar connective tissue
 - Blood and lymphatic vessels, lymphoid follicles, and submucosal nerve plexus

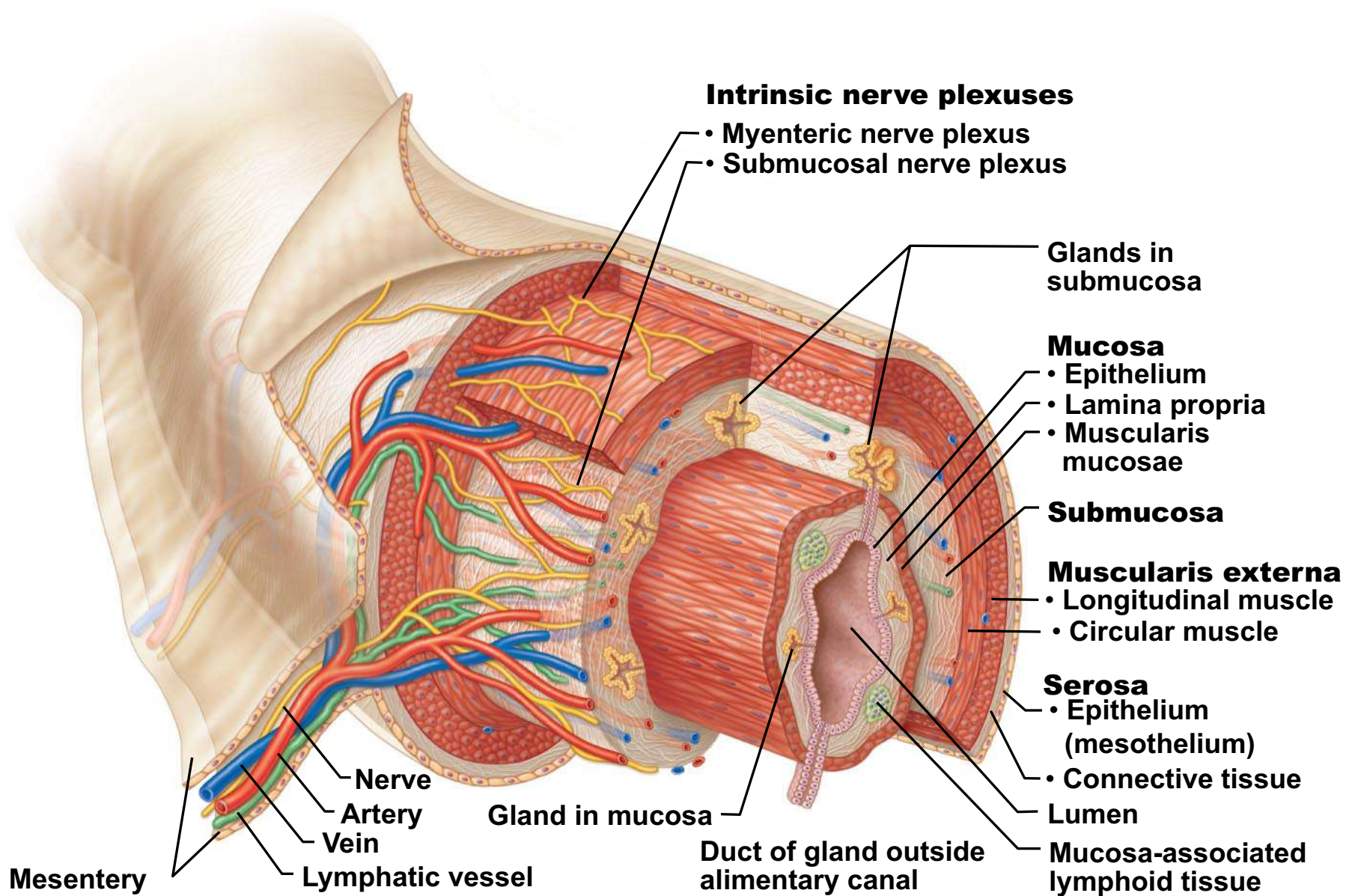
Muscularis Externa

- Muscularis externa
 - Responsible for **segmentation** and **peristalsis**
 - Inner circular and outer longitudinal layers
 - Circular layer thickens in some areas → **sphincters**
 - Myenteric nerve plexus between two muscle layers

Serosa

- Visceral peritoneum
 - Areolar connective tissue covered with mesothelium in most organs
 - Replaced by fibrous **adventitia** in esophagus
 - Retroperitoneal organs have both an adventitia and serosa

Figure 23.6 Basic structure of the alimentary canal.



Enteric Nervous System

- Intrinsic nerve supply of alimentary canal – **enteric neurons** (more than spinal cord)
- Major nerve supply to GI tract wall; control motility
 - **Submucosal nerve plexus**
 - Regulates glands and smooth muscle in the mucosa
 - **Myenteric nerve plexus**
 - Controls GI tract motility

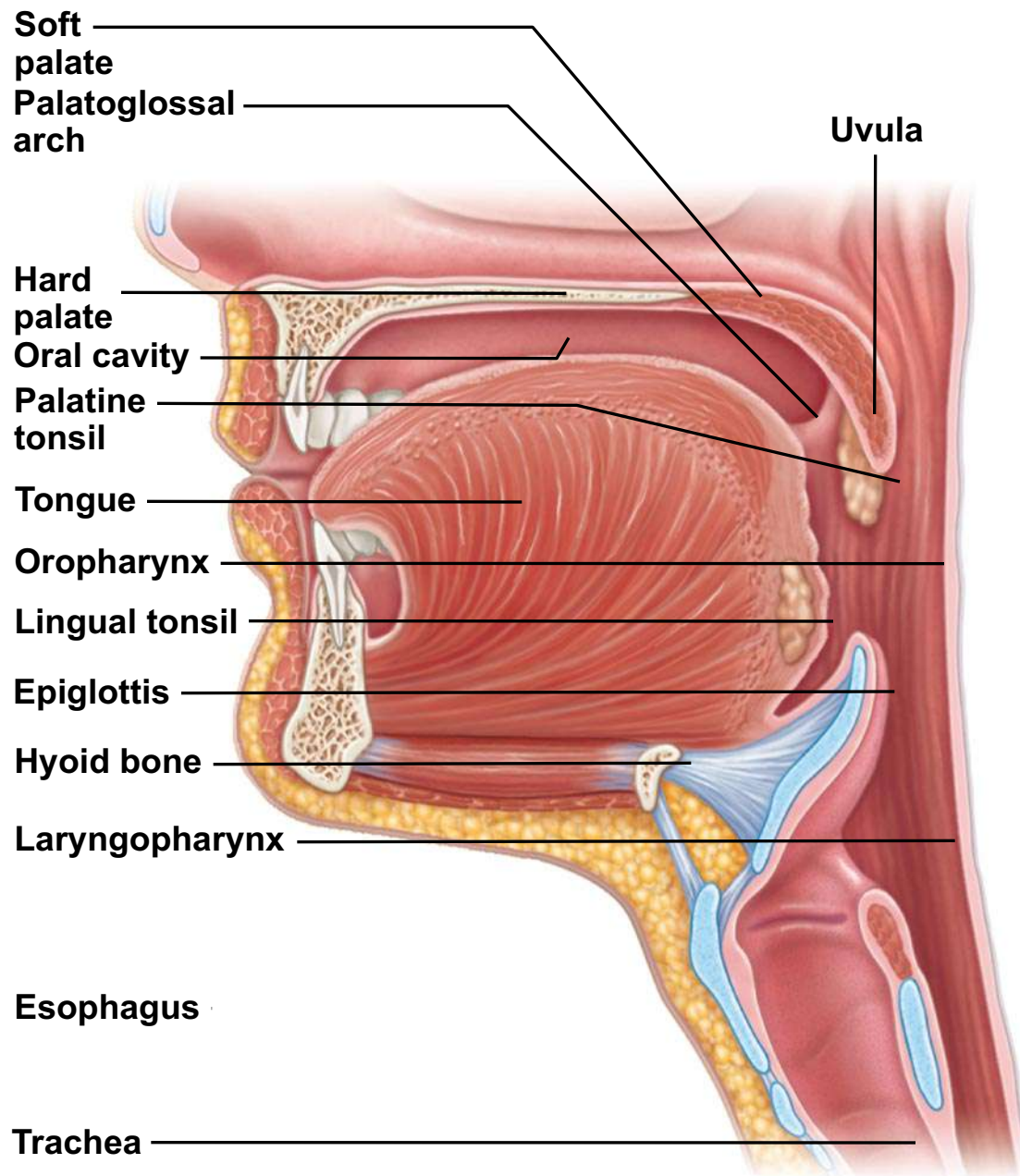
Enteric Nervous System

- Linked to CNS via afferent visceral fibers
- Long ANS fibers synapse with enteric plexuses
 - Sympathetic impulses inhibit digestive activities
 - Parasympathetic impulses stimulate digestive activities

Functional Anatomy: Mouth

- Oral (buccal) cavity
 - Bounded by lips, cheeks, palate, and tongue
 - **Oral orifice** is anterior opening
 - Lined with stratified squamous epithelium

Figure 23.7a Anatomy of the oral cavity (mouth).

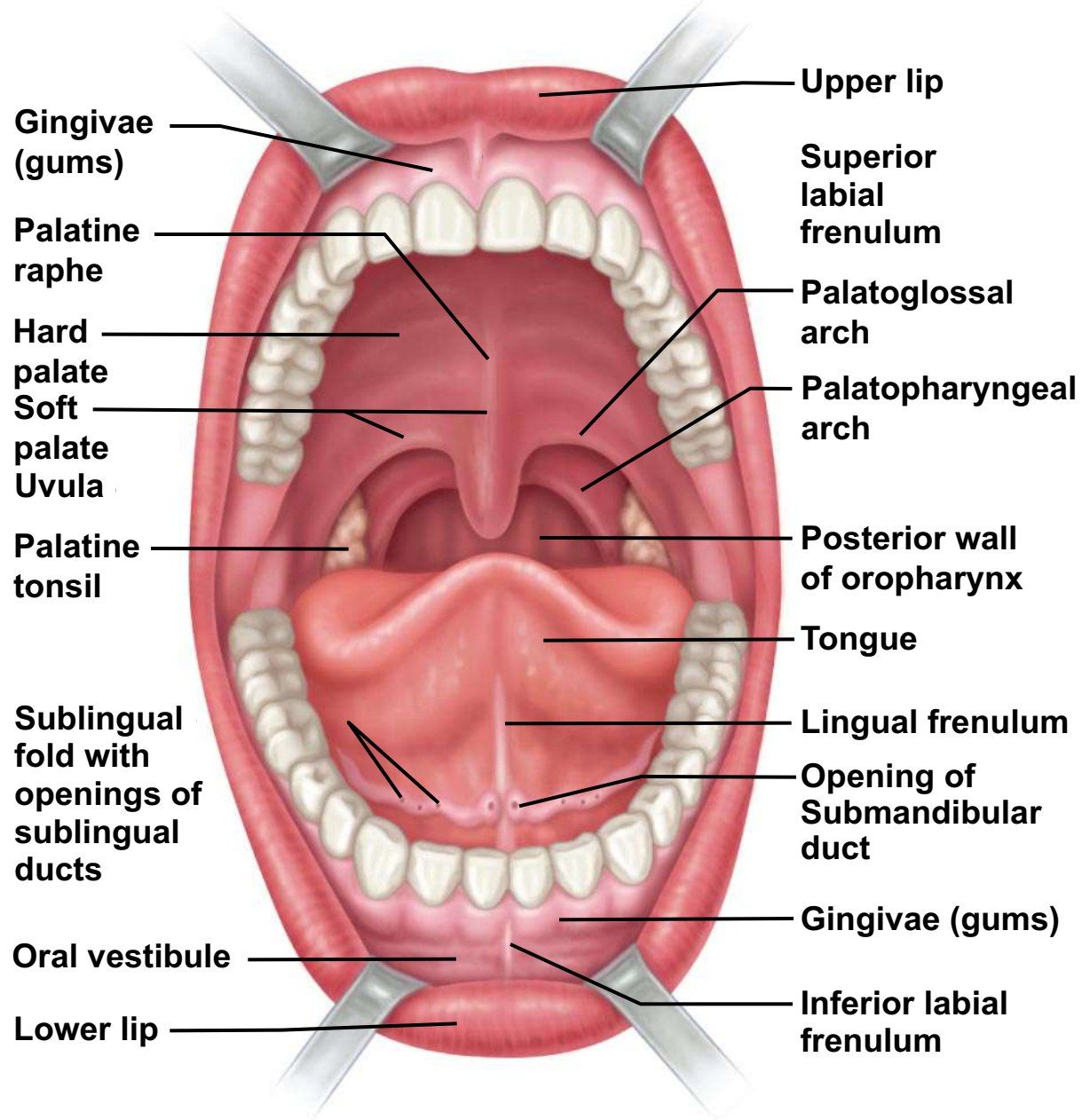


(a) Sagittal section of the oral cavity and pharynx

Lips and Cheeks

- Contain orbicularis oris and buccinator muscles
- **Oral vestibule** - recess internal to lips (labia) and cheeks, external to teeth and gums
- **Oral cavity** proper lies within teeth and gums
- **Labial frenulum** - median attachment of each lip to gum

Figure 23.7b Anatomy of the oral cavity (mouth).



(b) Anterior view

Palate

- **Hard palate** - palatine bones and palatine processes of maxillae
 - Slightly corrugated to help create friction against tongue
- **Soft palate** - fold formed mostly of skeletal muscle
 - Closes off nasopharynx during swallowing
 - **Uvula** projects downward from its free edge

Digestive Processes: Mouth

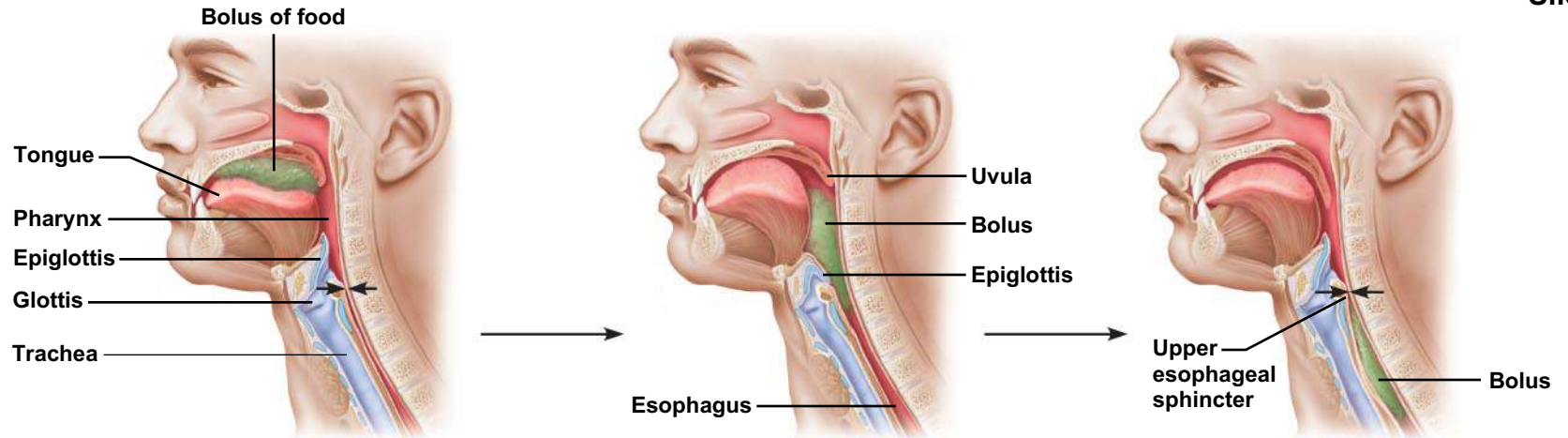
- **Ingestion**
- **Mechanical breakdown**
 - Chewing
- **Propulsion**
 - **Deglutition** (swallowing)
- **Digestion** (salivary amylase and lingual lipase)
- ~ No absorption, except for few drugs

Mastication

- Cheeks and closed lips hold food between teeth
- Tongue mixes food with saliva; compacts food into bolus
- Teeth cut and grind
- Partly voluntary
- Partly reflexive
 - Stretch reflexes; pressure receptors in cheeks, gums, tongue

Deglutition

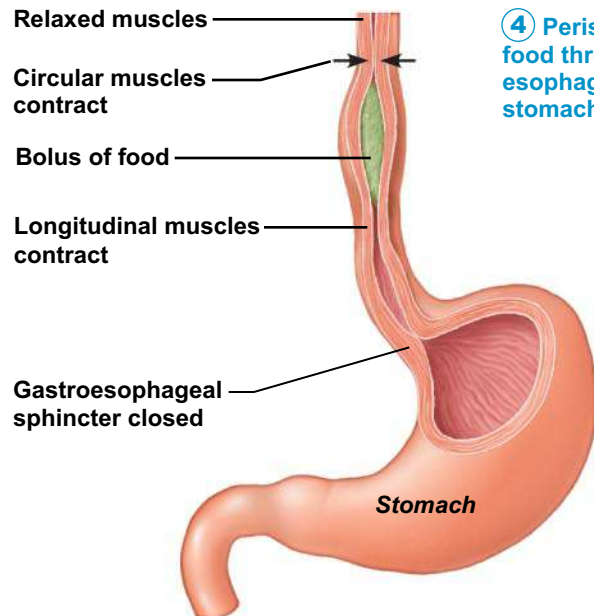
- Involves tongue, soft palate, pharynx, esophagus
- Requires coordination of 22 muscle groups
- **Buccal phase**
 - Voluntary contraction of tongue
- **Pharyngeal-esophageal phase**
 - Involuntary – primarily vagus nerve
 - Control center in the medulla and lower pons



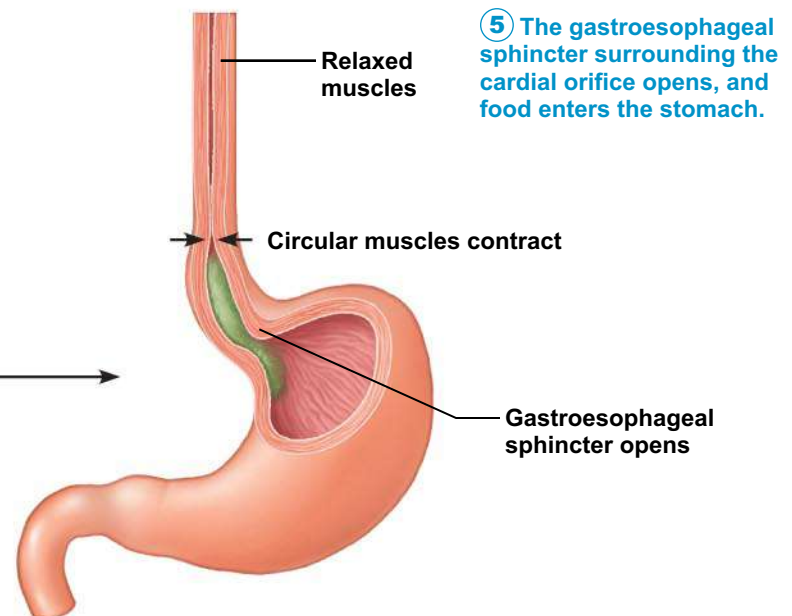
① During the buccal phase, the upper esophageal sphincter is contracted. The tongue presses against the hard palate, forcing the food bolus into the oropharynx.

② The pharyngeal-esophageal phase begins as the uvula and larynx rise to prevent food from entering respiratory passageways. The tongue blocks off the mouth. The upper esophageal sphincter relaxes, allowing food to enter the esophagus.

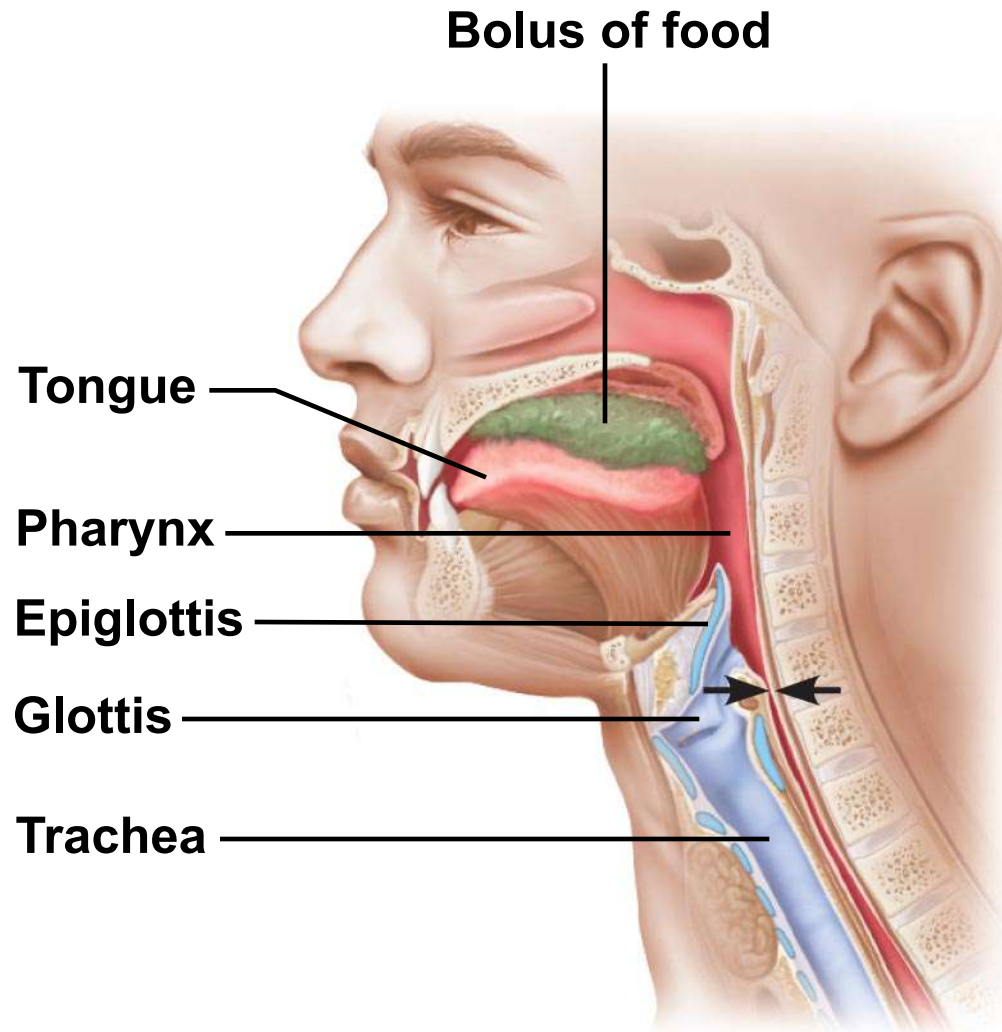
③ The constrictor muscles of the pharynx contract, forcing food into the esophagus inferiorly. The upper esophageal sphincter contracts (closes) after food enters.



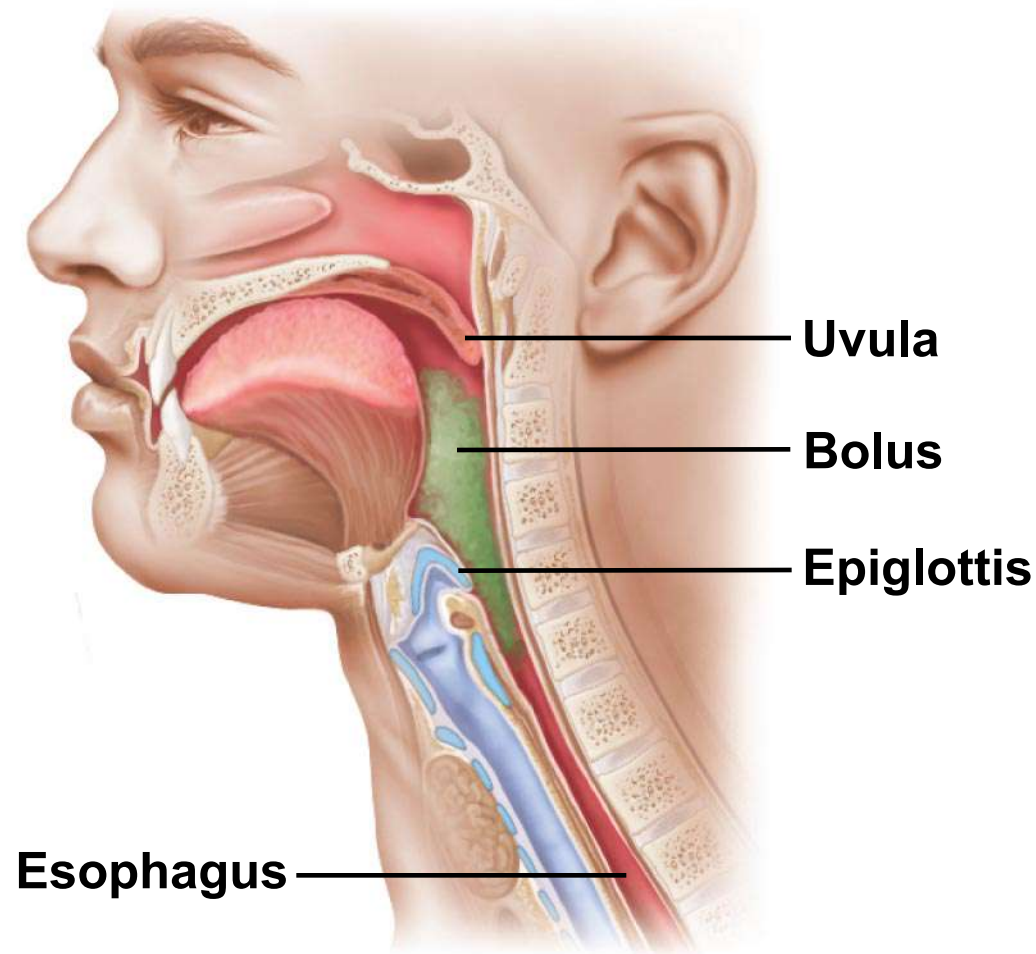
④ Peristalsis moves food through the esophagus to the stomach.



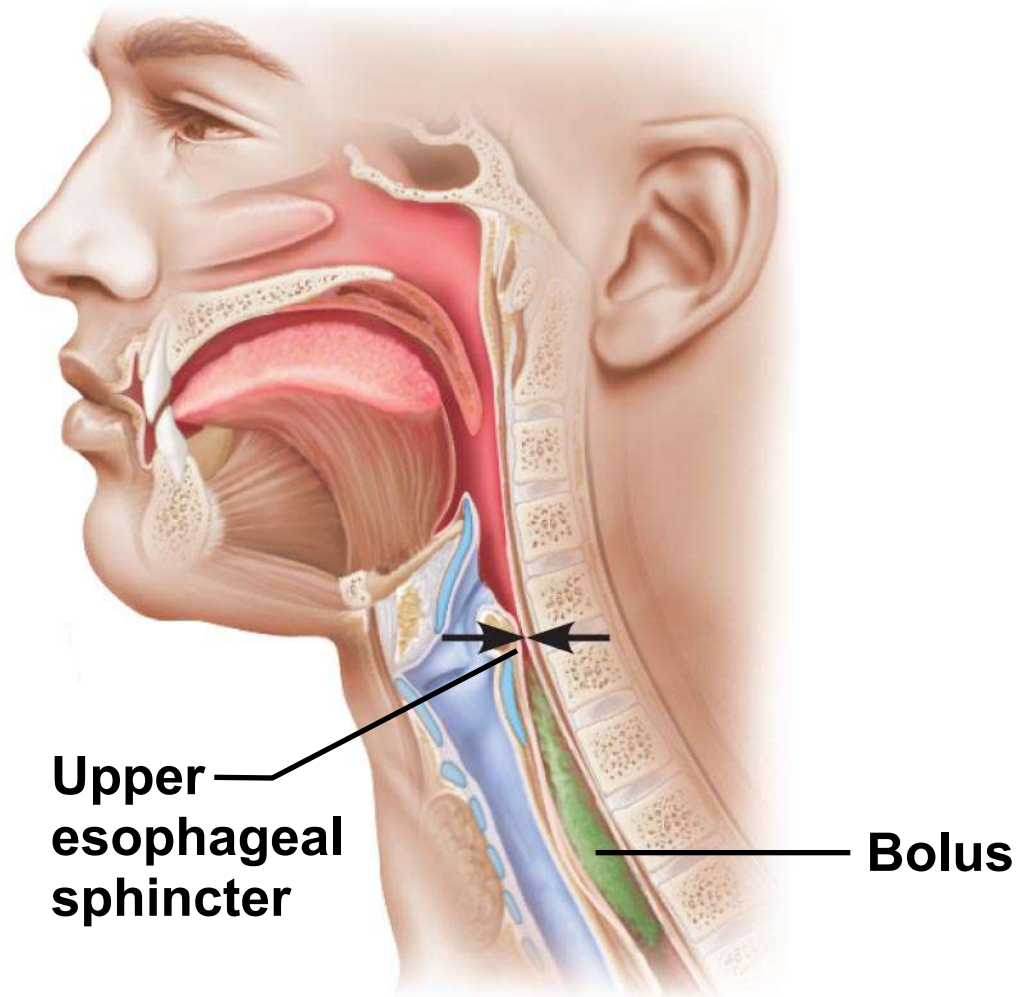
⑤ The gastroesophageal sphincter surrounding the cardiac orifice opens, and food enters the stomach.



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Relaxed muscles —————

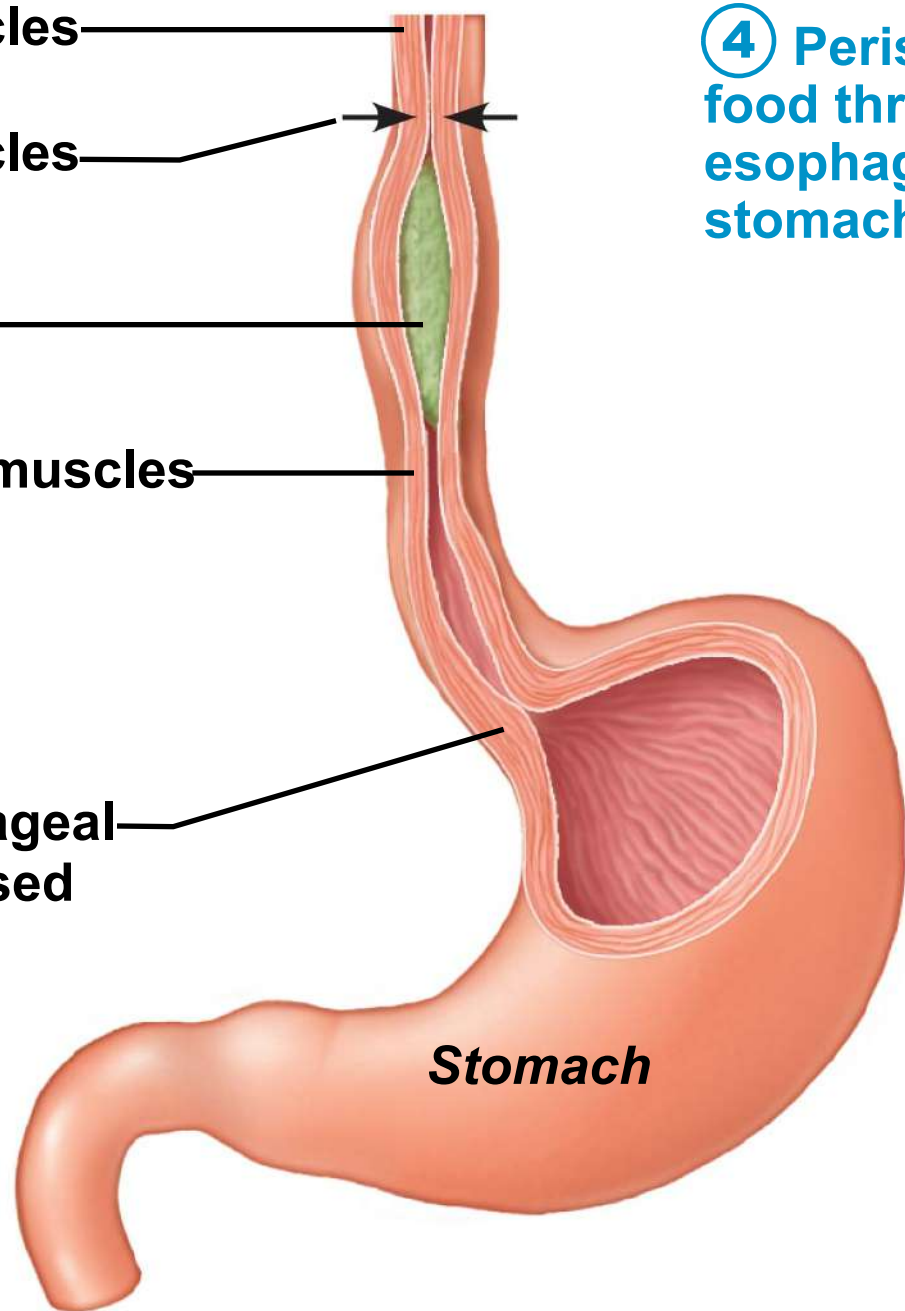
Circular muscles contract —————

Bolus of food —————

Longitudinal muscles contract —————

Gastroesophageal sphincter closed —————

④ Peristalsis moves food through the esophagus to the stomach.



Stomach

Relaxed muscles —————

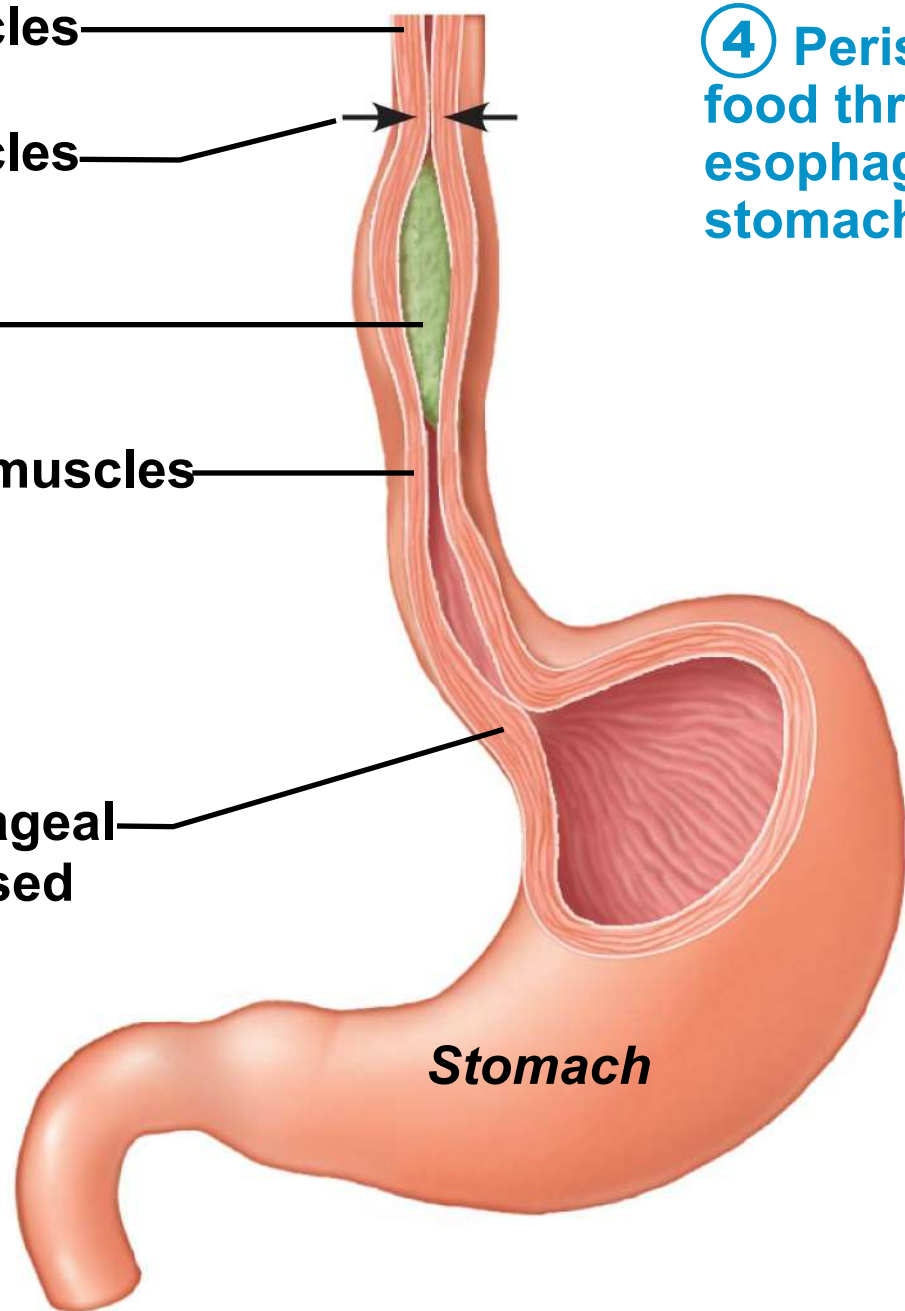
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Gastroesophageal sphincter closed —————

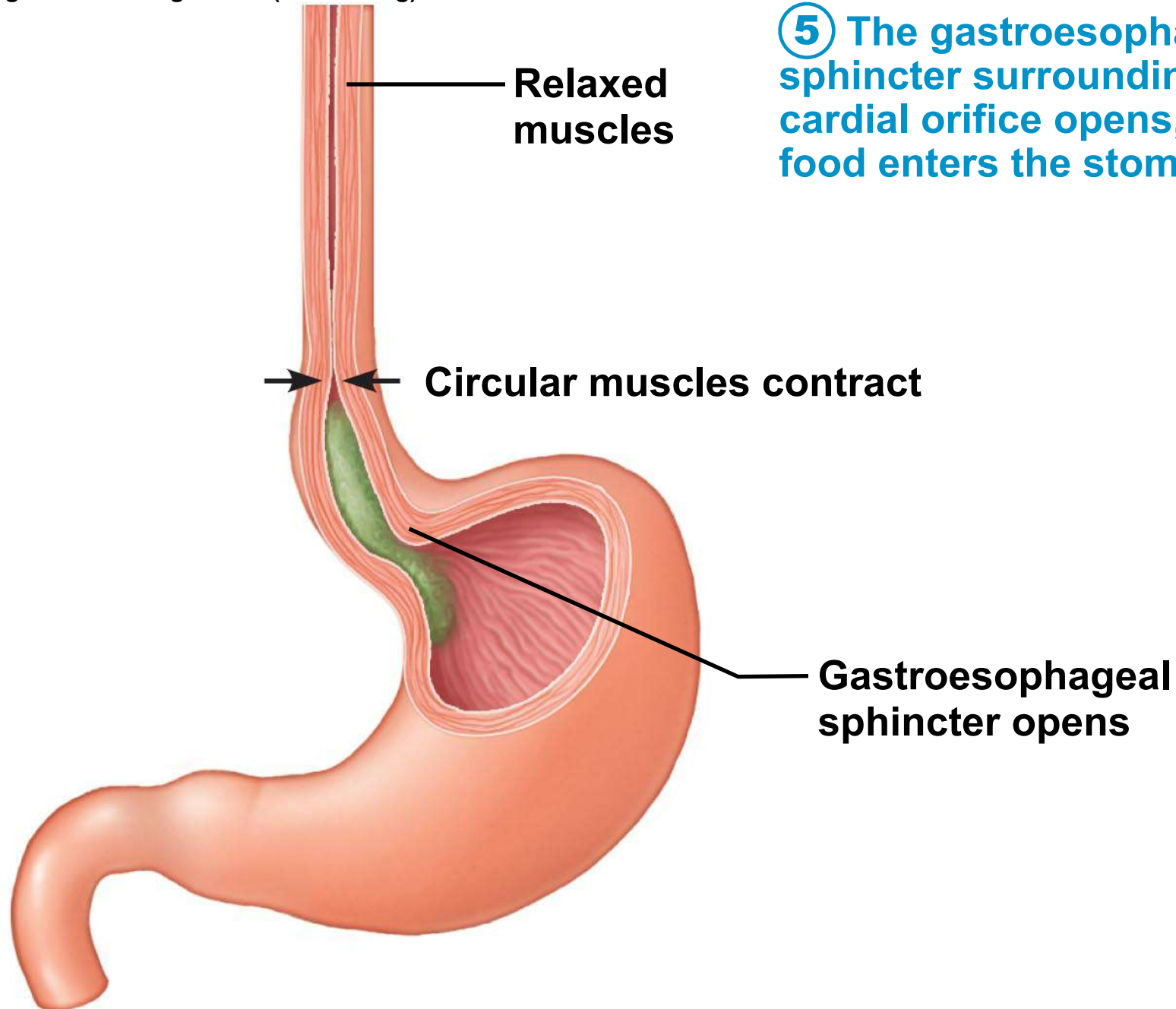
④ Peristalsis moves food through the esophagus to the stomach.



Stomach

Figure 23.13 Deglutition (swallowing).

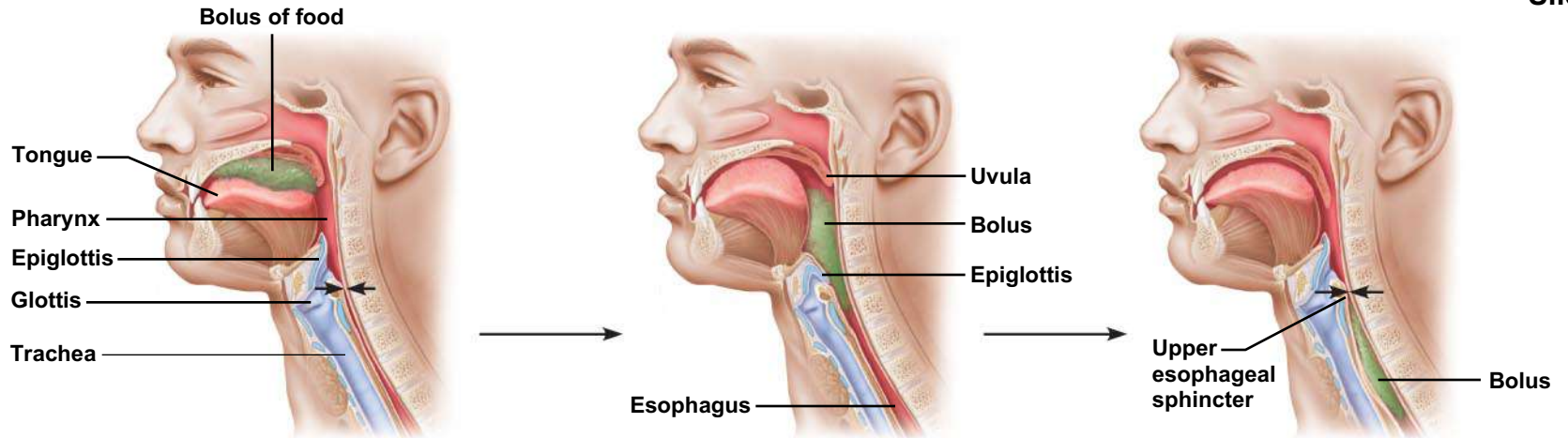
⑤ The gastroesophageal sphincter surrounding the cardiac orifice opens, and food enters the stomach.



Relaxed
muscles

Circular muscles contract

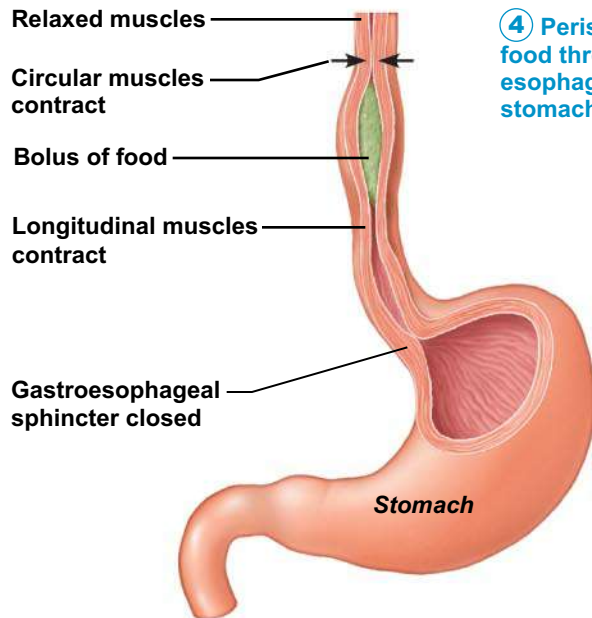
Gastroesophageal
sphincter opens



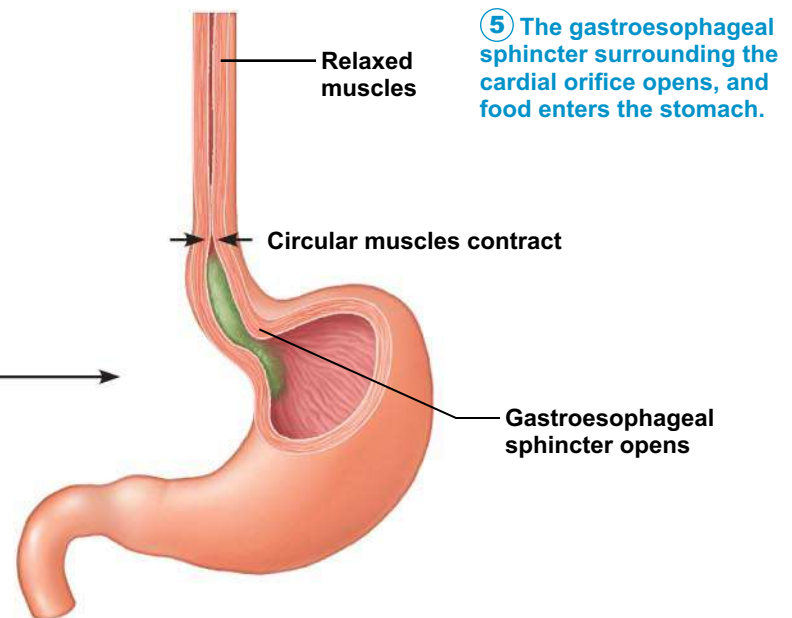
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④ Peristalsis moves food through the esophagus to the stomach.



⑤ The gastroesophageal sphincter surrounding the cardiac orifice opens, and food enters the stomach.

Tongue

- Skeletal muscle
- Functions include
 - Repositioning and mixing food during chewing
 - Formation of bolus
 - Initiation of swallowing, speech, and taste
- Intrinsic muscles change shape of tongue
- Extrinsic muscles alter tongue's position
- **Lingual frenulum**: attachment to floor of mouth

Tongue

- Surface bears papillae
 - **Filiform**—whitish, give the tongue roughness and provide friction; do not contain taste buds
 - **Fungiform**—reddish, scattered over tongue; contain taste buds
 - **Vallate (circumvallate)**—V-shaped row in back of tongue; contain taste buds
 - **Foliate**—on lateral aspects of posterior tongue; contain taste buds that function primarily in infants and children

Tongue

- Lingual lipase
 - Secreted by serous cells beneath foliate and vallate papillae secrete
 - Fat-digesting enzyme functional in stomach

Figure 23.8 Dorsal surface of the tongue, and the tonsils.

Epiglottis —————

Palatopharyngeal arch —————

Palatine tonsil —————

Lingual tonsil —————

Palatoglossal arch —————

Terminal sulcus —————

Foliate papillae —————

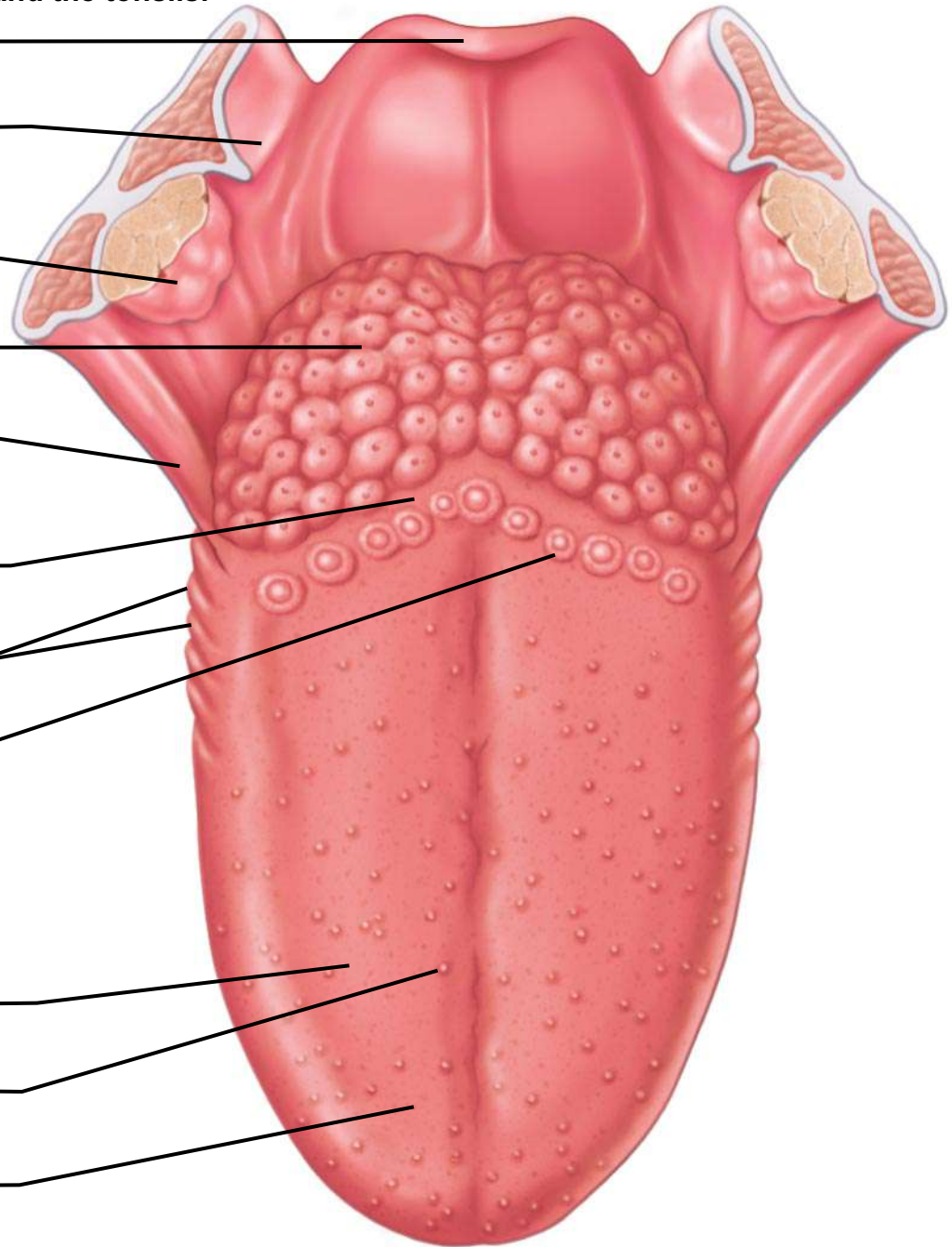
Vallate papilla —————

Medial sulcus of the tongue

Dorsum of tongue —————

Fungiform papilla —————

Filiform papilla —————



Salivary Glands

- **Major salivary glands**
 - Produce most **saliva**; lie outside oral cavity
 - **Parotid**
 - **Submandibular**
 - **Sublingual**
- **Minor salivary glands**
 - Scattered throughout oral cavity; augment slightly

Salivary Glands

- Function of saliva
 - Cleanses mouth
 - Dissolves food chemicals for taste
 - Moistens food; compacts into bolus
 - Begins breakdown of starch with enzymes

Salivary Glands

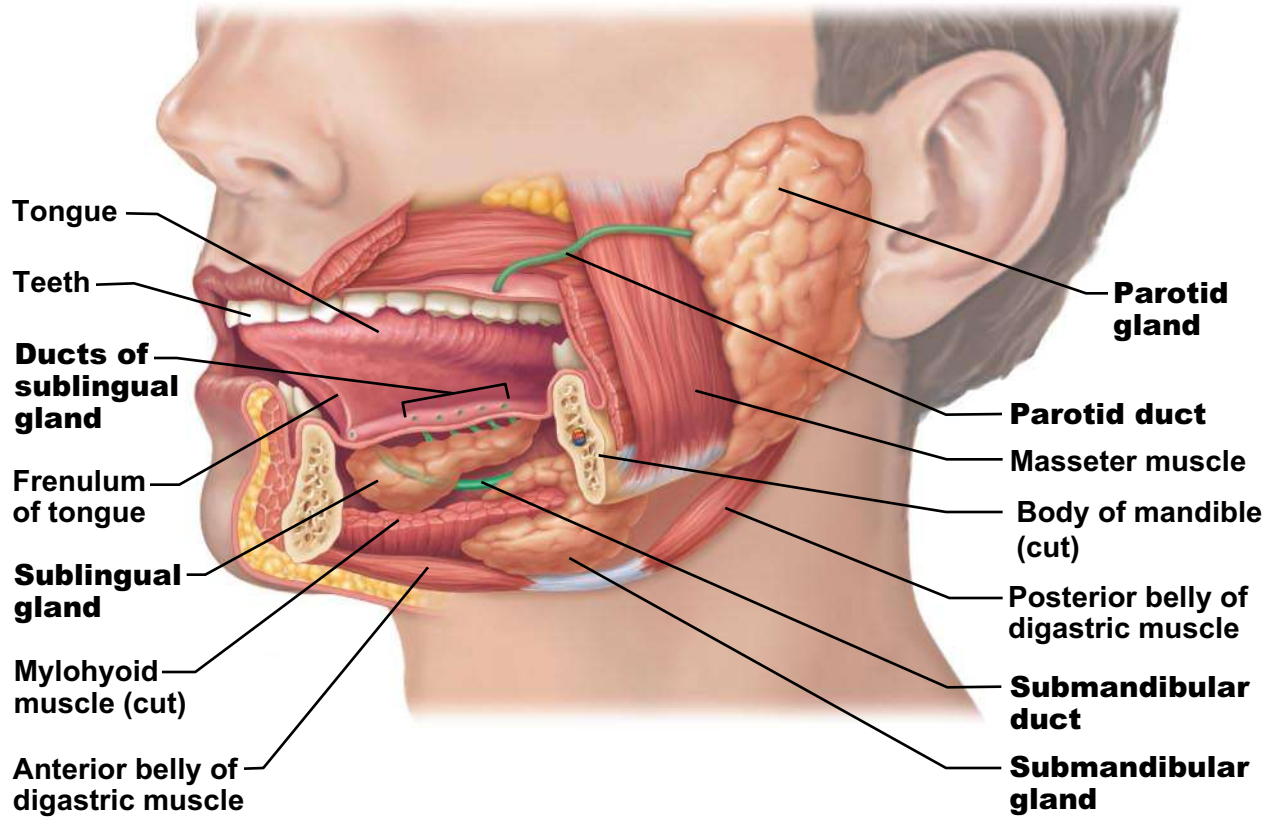
- **Parotid gland**

- Anterior to ear; external to masseter muscle
- Parotid duct opens into oral vestibule next to second upper molar
- *Mumps* is inflammation of parotid glands

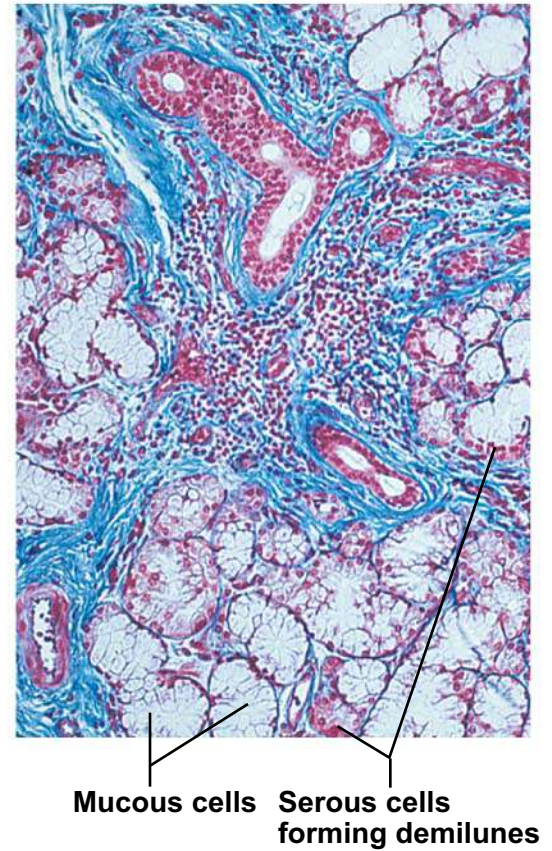
Salivary Glands

- **Submandibular gland**
 - Medial to body of mandible
 - Duct opens at base of lingual frenulum
- **Sublingual gland**
 - Anterior to submandibular gland under tongue
 - Opens via 10–12 ducts into floor of mouth

Figure 23.9 The salivary glands.



(a)



(b)

Salivary Glands

- Two types of secretory cells
 - **Serous cells**
 - Watery, enzymes, ions, bit of mucin
 - **Mucous cells**
 - Mucus
- Parotid, submandibular glands mostly serous; sublingual mostly mucous

Composition of Saliva

- 97–99.5% water, slightly acidic
 - Electrolytes— Na^+ , K^+ , Cl^- , PO_4^{2-} , HCO_3^-
 - Salivary amylase and lingual lipase
 - Mucin
 - Metabolic wastes—urea and uric acid
 - Lysozyme, IgA, defensins, and a cyanide compound protect against microorganisms



Animation: Rotating head

Control of Salivation

- 1500 ml/day
- Intrinsic glands continuously keep mouth moist
- Major salivary glands activated by parasympathetic nervous system when
 - Ingested food stimulates chemoreceptors and mechanoreceptors in mouth →
 - **Salivatory nuclei** in brain stem send impulses along parasympathetic fibers in cranial nerves VII and IX
- Strong sympathetic stimulation inhibits salivation and results in dry mouth (xerostomia)

Teeth

- Tear and grind food for digestion
- Primary and permanent dentitions formed by age 21
- 20 deciduous teeth erupt (6–24 months of age)
 - Roots resorbed, teeth fall out (6–12 years of age) as permanent teeth develop
- 32 permanent teeth
 - All but third molars in by end of adolescence
 - Third molars at 17–25, or may not erupt

Classes of Teeth

- **Incisors**

- Chisel shaped for cutting

- **Canines**

- Fanglike teeth that tear or pierce

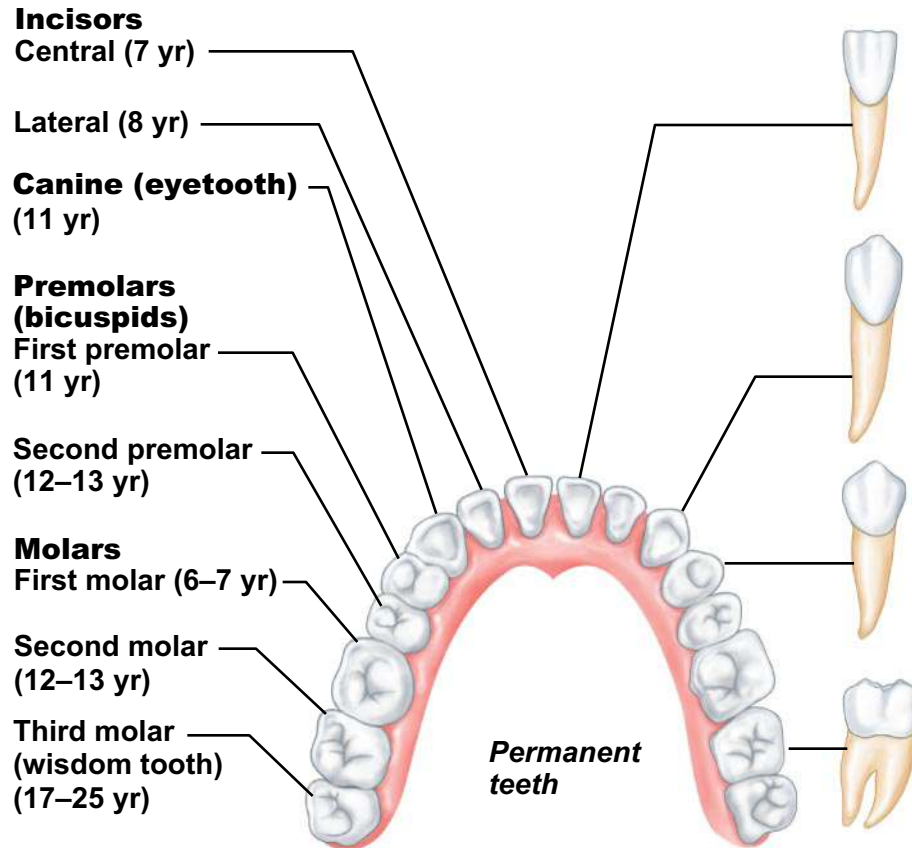
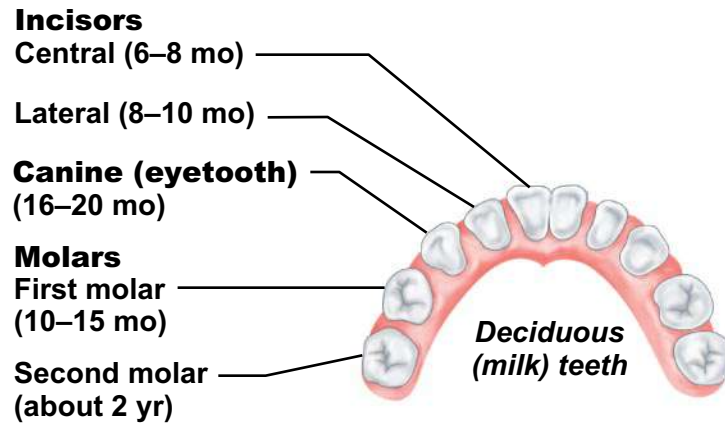
- **Premolars (bicuspid)**

- Broad crowns, rounded cusps – grind/crush

- **Molars**

- Broad crowns, rounded cusps – best grinders

Figure 23.10 Human dentition.



Tooth Structure

- **Crown** - exposed part above **gingiva** (gum)
 - Covered by enamel—hardest substance in body (calcium salts and hydroxyapatite crystals)
 - Enamel-producing cells degenerate when tooth erupts → no healing if decay or crack
- **Root** - portion embedded in jawbone
 - Connected to crown by **neck**

Tooth Structure

- Canine, incisor, and premolar → one root
 - First upper premolar often has two
- First two upper molars → three roots
- First two lower molars → two roots
- Third molar roots vary; often single fused root

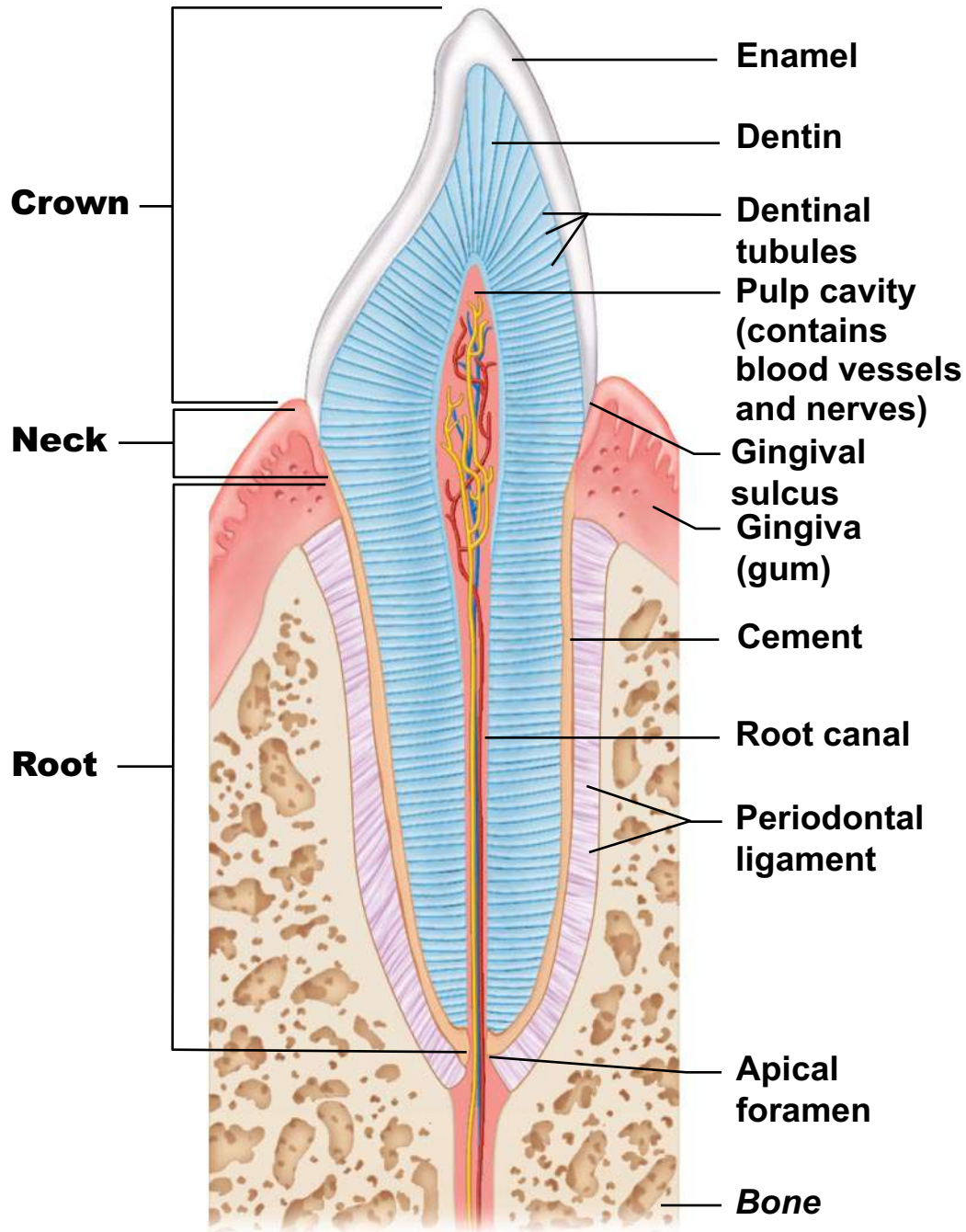
Tooth Structure

- **Cement** - calcified connective tissue
 - Covers root; attaches it to periodontal ligament
- **Periodontal ligament**
 - Forms fibrous joint called **gomphosis**
 - Anchors tooth in bony socket
- **Gingival sulcus** - groove where gingiva borders tooth

Tooth Structure

- **Dentin** - bonelike material under enamel
 - Maintained by odontoblasts of pulp cavity
- **Pulp cavity** - surrounded by dentin
 - **Pulp** - connective tissue, blood vessels, and nerves
- **Root canal** - as pulp cavity extends to root
- **Apical foramen** at proximal end of root
 - Entry for blood vessels, nerves, etc.

Figure 23.11 Longitudinal section of a canine tooth within its bony socket (alveolus).



Tooth and Gum Disease

- **Dental caries** (cavities) - demineralization of enamel and dentin from bacterial action
 - **Dental plaque** (film of sugar, bacteria, and debris) adheres to teeth
 - Acid from bacteria dissolves calcium salts
 - Proteolytic enzymes digest organic matter
 - Prevention: daily flossing and brushing

Tooth and Gum Disease

- **Gingivitis**

- Plaque calcifies to form **calculus** (tartar)
- Calculus disrupts seal between gingivae and teeth
- Anaerobic bacteria infect gums
- Infection reversible if calculus removed

Tooth and Gum Disease

- **Periodontitis** (from neglected gingivitis)
 - Immune cells attack intruders and body tissues
 - Destroy periodontal ligament
 - Activate osteoclasts → dissolve bone
 - Possible tooth loss; may promote atherosclerosis and clot formation in coronary and cerebral arteries
 - Risk factors - smoking, diabetes mellitus, oral piercing