



Physiology of Digestive System

By

Dr. Hassan Y. Hassan

3rd Year/ Lecture 1

Introduction

- ▶ Most nutrients we eat cannot be used in existing form
 - ▶ Must be broken down into smaller components before the body can make use of them
- ▶ Digestive system—essentially a disassembly line
 - ▶ To break down nutrients into a form that can be used by the body
 - ▶ To absorb them so they can be distributed to the tissues
- ▶ Gastroenterology—the study of the digestive tract and the diagnosis and treatment of its disorders

Digestive Function

- ▶ Digestive system—the organ system that processes food, extracts nutrients from it, and eliminates the residue

Digestive Function

- ▶ Five stages of digestion
 - ▶ Ingestion: selective intake of food
 - ▶ Digestion: mechanical and chemical breakdown of food into a form usable by the body
 - ▶ Absorption: uptake of nutrient molecules into the epithelial cells of the digestive tract and then into the blood and lymph
 - ▶ Compaction: absorbing water and consolidating the indigestible residue into feces
 - ▶ Defecation: elimination of feces

Digestive Function

- ▶ Mechanical digestion—the physical breakdown of food into smaller particles
 - ▶ Cutting and grinding action of the teeth
 - ▶ Churning action of stomach and small intestines
 - ▶ Exposes more food surface to the action of digestive enzymes

Digestive Function

- ▶ Chemical digestion—a series of hydrolysis reactions that breaks dietary macromolecules into their monomers (residues)
 - ▶ Carried out by digestive enzymes produced by salivary glands, stomach, pancreas, and small intestine
 - ▶ Results
 - ▶ Polysaccharides into monosaccharides
 - ▶ Proteins into amino acids
 - ▶ Fats into monoglycerides and fatty acids
 - ▶ Nucleic acids into nucleotides

Digestive Function

- ▶ Some nutrients are present in a usable form in ingested food
 - ▶ Absorbed without being digested
 - ▶ Vitamins, free amino acids, minerals, cholesterol, and water

General Anatomy

- ▶ Digestive system has two anatomical subdivisions
- ▶ Digestive tract (alimentary canal)
 - ▶ 30 ft long muscular tube extending from mouth to anus
 - ▶ Mouth, pharynx, esophagus, stomach, small intestine, and large intestine
 - ▶ Gastrointestinal (GI) tract is the stomach and intestines

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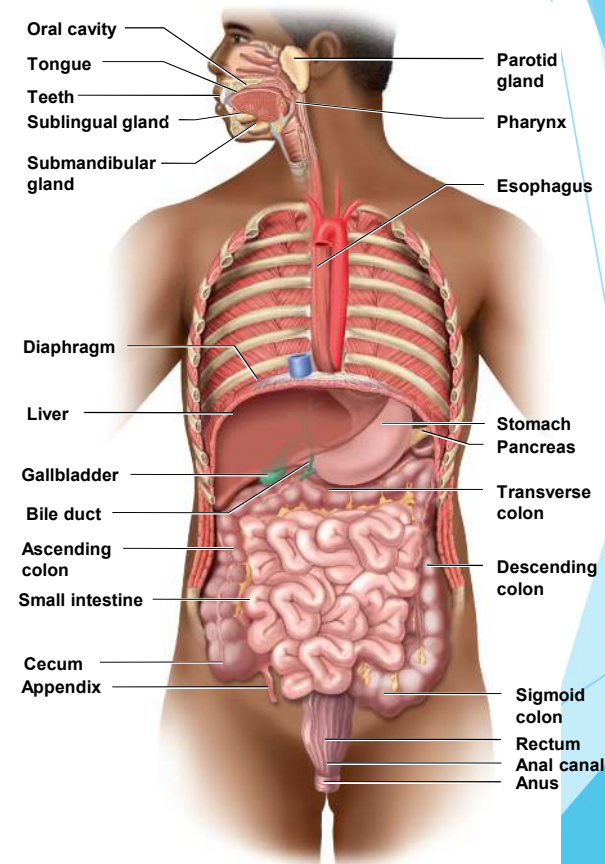


Figure 25.1

General Anatomy

Cont.

- ▶ Accessory organs
 - ▶ Teeth, tongue, salivary glands, liver, gallbladder, and pancreas

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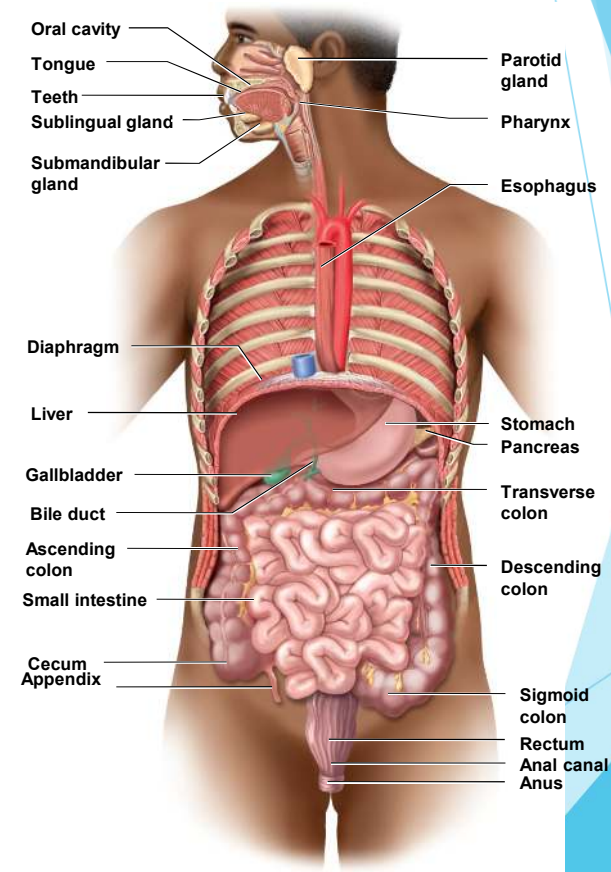


Figure 25.1

General Anatomy

- ▶ Digestive tract is open to the environment at both ends
- ▶ Most material in it has not entered the body tissues
 - ▶ Considered to be external to the body until it is absorbed by the epithelial cells of the alimentary canal
- ▶ On a strict sense, defecated food residue was never in the body

Tissue Layers of the Digestive Tract

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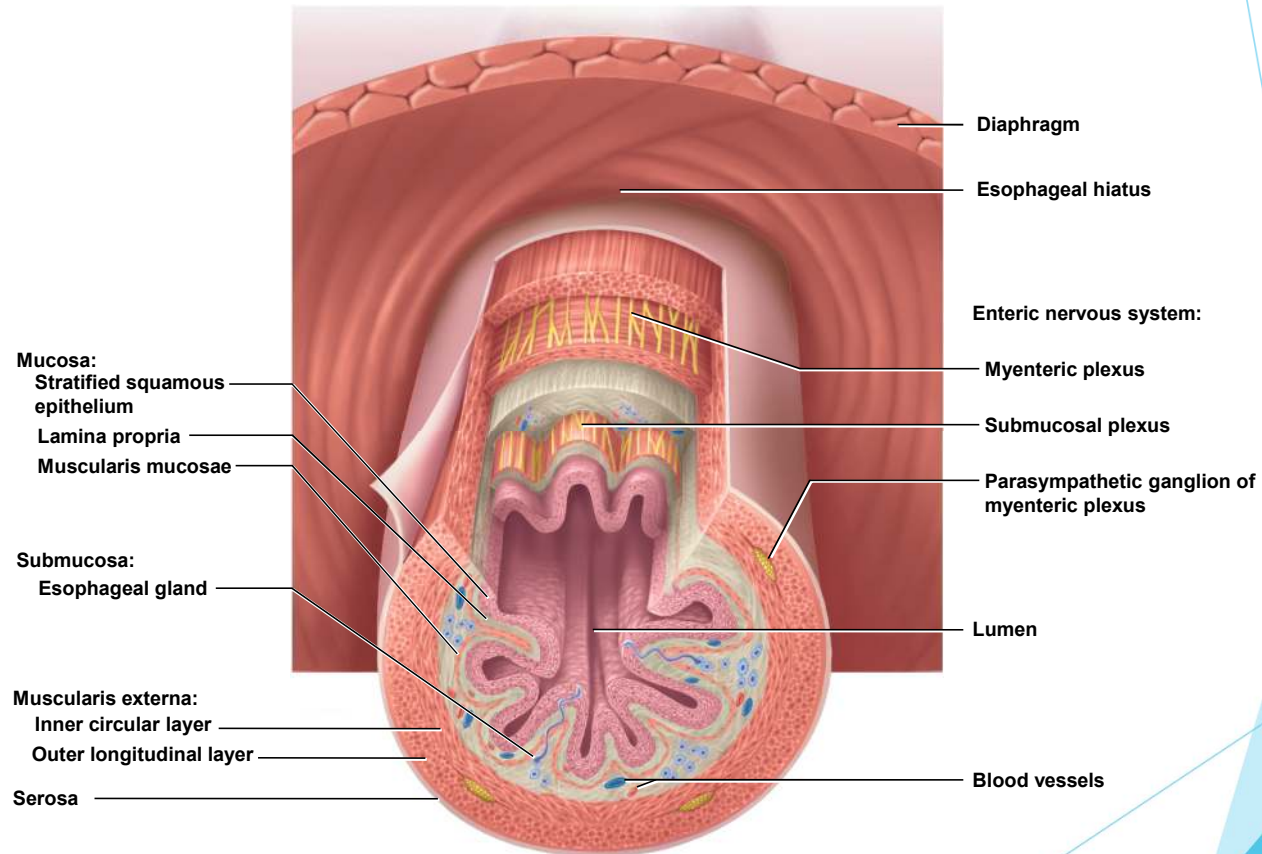


Figure 25.2

General Anatomy

- ▶ Enteric nervous system—a nervous network in the esophagus, stomach, and intestines that regulated digestive tract motility, secretion, and blood flow
 - ▶ Thought to have over 100 million neurons
 - ▶ More than the spinal cord
 - ▶ Functions completely independently of the central nervous system
 - ▶ CNS exerts a significant influence on its action
- ▶ Enteric nervous system contains sensory neurons that monitor tension in gut wall and conditions in lumen

General Anatomy

- ▶ Composed of two networks of neurons
 - ▶ Submucosal (Meissner) plexus: in submucosa
 - ▶ Controls glandular secretion of mucosa
 - ▶ Controls movements of muscularis mucosae
 - ▶ Myenteric (Auerbach) plexus: parasympathetic ganglia and nerve fibers between the two layers of the muscularis interna
 - ▶ Controls peristalsis and other contractions of muscularis externa

Regulation of the Digestive Tract

- ▶ Motility and secretion of the digestive tract are controlled by neural, hormonal, and paracrine mechanisms
- ▶ Neural control
 - ▶ Short (myenteric) reflexes: stretch or chemical stimulation acts through myenteric plexus
 - ▶ Stimulates parastaltic contractions of swallowing
 - ▶ Long (vagovagal) reflexes: parasympathetic stimulation of digestive motility and secretion
- ▶ Hormonal control
 - ▶ Gastrin and secretin

The Mouth

- ▶ The mouth is known as the oral, or buccal cavity
- ▶ Functions
 - ▶ Ingestion (food intake)
 - ▶ Other sensory responses to food: chewing and chemical digestion
 - ▶ Swallowing, speech, and respiration
- ▶ Mouth enclosed by cheeks, lips, palate, and tongue

Mastication

- ▶ Mastication (chewing)—breaks food into smaller pieces to be swallowed and exposes more surface to the action of digestive enzymes
 - ▶ First step in mechanical digestion
 - ▶ Food stimulates oral receptors that trigger an involuntary chewing reflex
 - ▶ Tongue, buccinator, and orbicularis oris manipulate food
 - ▶ Masseter and temporalis elevate the teeth to crush food
 - ▶ Medial and lateral pterygoids, and masseter swing teeth in side-to-side grinding action of molars

Saliva and the Salivary Glands

▶ Saliva

- ▶ Moisten mouth
- ▶ Begin starch and fat digestion
- ▶ Cleanse teeth
- ▶ Inhibit bacterial growth
- ▶ Dissolve molecules so they can stimulate the taste buds
- ▶ Moisten food and bind it together into bolus to aid in swallowing

Saliva and the Salivary Glands

- ▶ Hypotonic solution of 97.0% to 99.5% water and the following solutes:
 - ▶ Salivary amylase: enzyme that begins starch digestion in the mouth
 - ▶ Lingual lipase: enzyme that is activated by stomach acid and digests fat after the food is swallowed
 - ▶ Mucus: binds and lubricates the mass of food and aids in swallowing
 - ▶ Lysozyme: enzyme that kills bacteria
 - ▶ Immunoglobulin A (IgA): an antibody that inhibits bacterial growth
 - ▶ Electrolytes: Na^+ , K^+ , Cl^- , phosphate, and bicarbonate
- ▶ pH: 6.8 to 7.0

Saliva and the Salivary Glands

- ▶ Extrinsic salivary glands—three pairs connected to oral cavity by ducts
 - ▶ Parotid: located beneath the skin anterior to the earlobe
 - ▶ Mumps is an inflammation and swelling of the parotid gland caused by a virus
 - ▶ Submandibular gland: located halfway along the body of the mandible
 - ▶ Its duct empties at the side of the lingual frenulum, near the lower central incisors
 - ▶ Sublingual glands: located in the floor of the mouth
 - ▶ Has multiple ducts that empty posterior to the papilla of the submandibular duct

Extrinsic salivary glands secrete about of 1 to 1.5 L of saliva per day

The Extrinsic Salivary Glands

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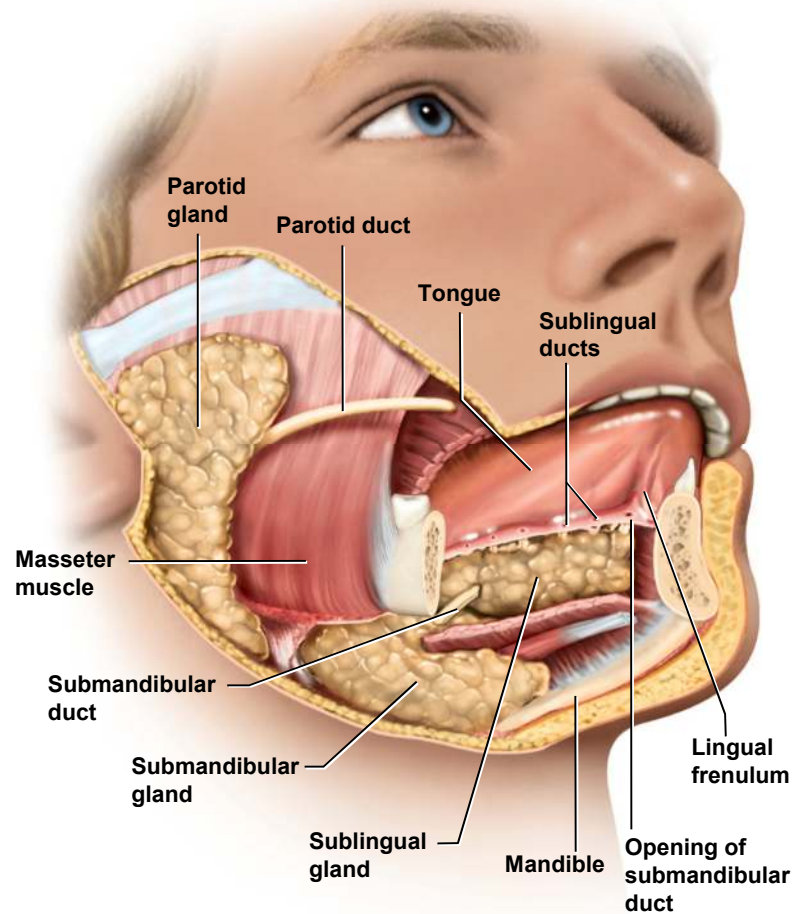


Figure 25.9

Histology of Salivary Glands

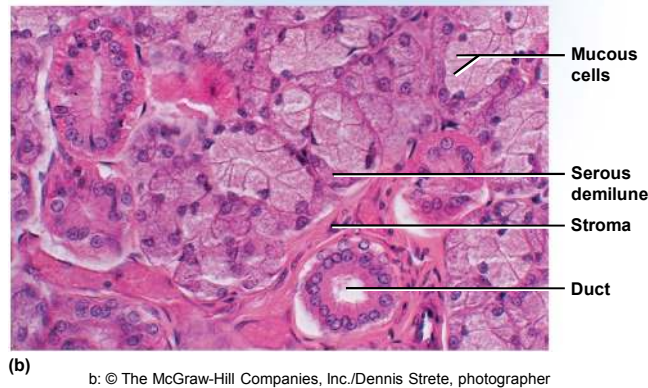
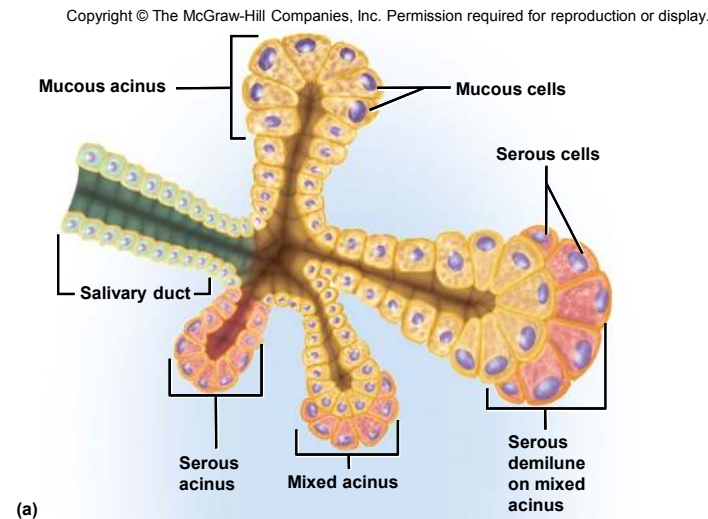


Figure 25.10a,b

- ▶ Compound tubuloacinar glands
 - ▶ Branched ducts ending in acini
- ▶ Mucous cells secrete mucus
- ▶ Serous cells secrete thin fluid rich in amylase and electrolytes
- ▶ Mixed acinus has both mucous and serous cells

Salivation

- ▶ Cells of acini filter water and electrolytes from blood and add amylase, mucin, and lysozyme
- ▶ Salivary nuclei in the medulla oblongata and pons respond to signals generated by presence of food
 - ▶ Tactile, pressure, and taste receptors
 - ▶ Salivary nuclei receive input from higher brain centers as well
 - ▶ Odor, sight, thought of food stimulates salivation

Salivation

Cont.

- ▶ Send signals by way of autonomic fibers in the facial and glossopharyngeal nerves to the glands
 - ▶ Parasympathetics stimulate the glands to produce an abundance of thin, enzyme-rich saliva
 - ▶ Sympathetic stimulation stimulates the glands to produce less, and thicker, saliva with more mucus
- ▶ Bolus—mass swallowed as a result of saliva binding food particles into a soft, slippery, easily swallowed mass

The Esophagus

- ▶ Esophagus—a straight muscular tube 25 to 30 cm long
 - ▶ Begins at level between C6 and the cricoid cartilage
 - ▶ Extends from pharynx to cardiac orifice of stomach passing through esophageal hiatus in diaphragm
 - ▶ Lower esophageal sphincter: food pauses at this point because of this constriction
 - ▶ Prevents stomach contents from regurgitating into the esophagus
 - ▶ Protects esophageal mucosa from erosive effect of the stomach acid
 - ▶ Heartburn—burning sensation produced by acid reflux into the esophagus

The Esophagus

Cont.

- ▶ Nonkeratinized stratified squamous epithelium
- ▶ Esophageal glands in submucosa secrete mucus
- ▶ Deeply folded into longitudinal ridges when empty
- ▶ Skeletal muscle in upper one-third, mixture in middle one-third, and only smooth muscle in the bottom one-third
- ▶ Meets stomach at level of T7
- ▶ Covered with adventitia

Swallowing

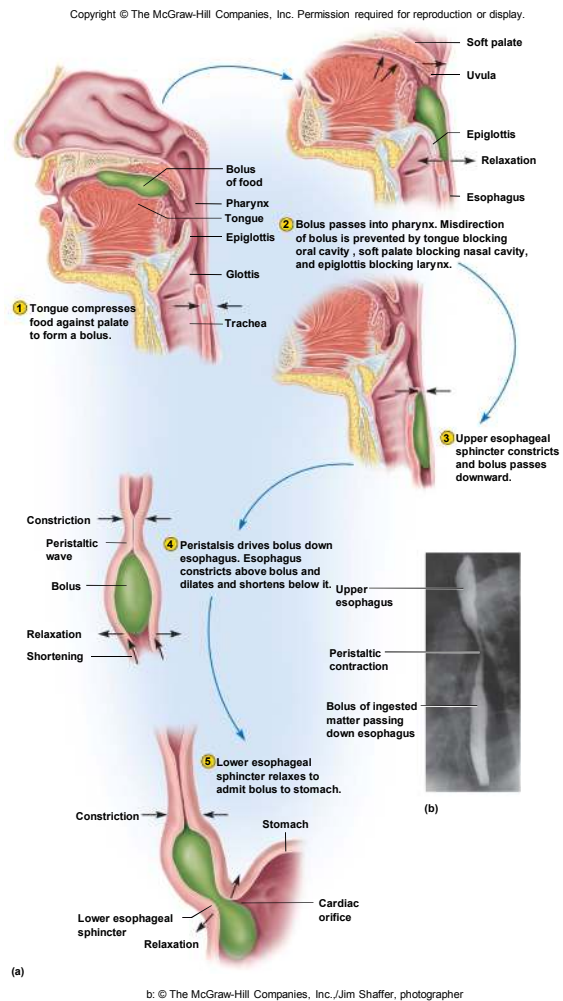


Figure 25.11a,b

Swallowing

- ▶ Swallowing (deglutition)—a complex action involving over 22 muscles in the mouth, pharynx, and esophagus
 - ▶ Swallowing center: pair of nuclei in medulla oblongata that coordinates swallowing
 - ▶ Communicates with muscles of the pharynx and esophagus by way of trigeminal, facial, glossopharyngeal, and hypoglossal nerves

Swallowing

- ▶ Swallowing occurs in two phases
 - ▶ Buccal phase: under voluntary control
 - ▶ Tongue collects food, presses it against the palate forming a bolus, and pushes it posteriorly
 - ▶ Food accumulates in oropharynx in front of “blade” of the epiglottis
 - ▶ Epiglottis tips posteriorly and food bolus slides around it through the laryngeal opening
 - ▶ Bolus enters laryngopharynx and stimulates tactile receptors and activates next phase

Swallowing

Cont.

- ▶ Pharyngoesophageal phase: involuntary
 - ▶ Three actions prevent food and drink from reentering the mouth or entering the nasal cavity or larynx
 - ▶ Root of the tongue blocks the oral cavity
 - ▶ Soft palate rises and blocks the nasopharynx
 - ▶ Infrahyoid muscles pull the larynx up to meet the epiglottis while laryngeal folds close the airway
 - ▶ Food bolus is driven downward by constriction of the upper, then middle, and finally the lower pharyngeal constrictors
 - ▶ Bolus enters esophagus, stretches it, and stimulates peristalsis

Swallowing

- ▶ Peristalsis—wave of muscular contraction that pushes the bolus ahead of it
 - ▶ Entirely involuntary reflex
- ▶ When standing or sitting upright, the food and liquid drops through the esophagus by gravity faster than peristalsis can keep up with it
- ▶ Peristalsis ensures you can swallow regardless of body position
- ▶ Liquid reaches the stomach in 1 to 2 seconds
- ▶ Food bolus in 4 to 8 seconds
- ▶ When it reaches lower end of the esophagus, the lower esophageal sphincter relaxes to let food pass into the stomach

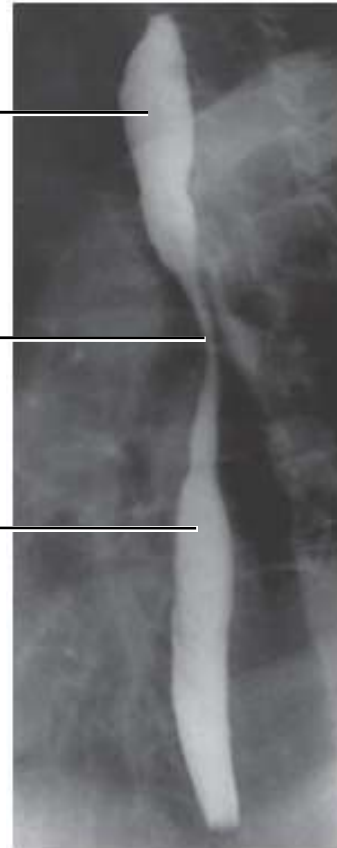
Swallowing

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**Upper
esophagus**

**Peristaltic
contraction**

**Bolus of ingested
matter passing
down esophagus**



(b)

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Figure 25.11b