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# **The Digestive System and Body Metabolism**

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# The Digestive System and Body Metabolism

- Digestion
  - Breakdown of ingested food
- Absorption
  - Passage of nutrients into the blood
- Metabolism
  - Production of cellular energy (ATP)

# Organs of the Digestive System

- Two main groups
  - Alimentary canal – continuous coiled hollow tube
  - Accessory digestive organs

# Organs of the Digestive System

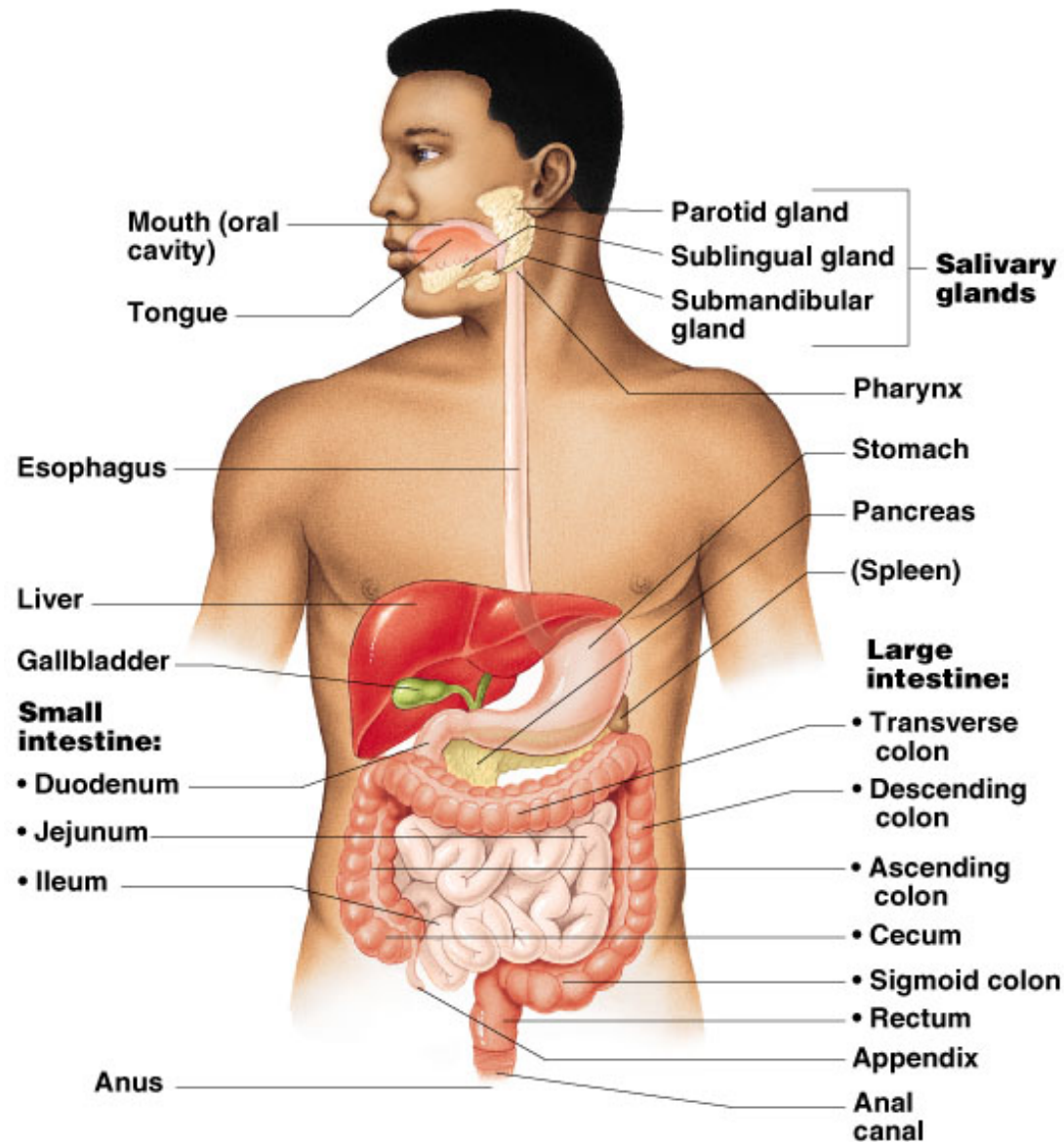


Figure 14.1

# Organs of the Alimentary Canal

- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

# Mouth (Oral Cavity) Anatomy

- Lips (labia) – protect the anterior opening
- Cheeks – form the lateral walls
- Hard palate – forms the anterior roof
- Soft palate – forms the posterior roof
- Uvula – fleshy projection of the soft palate

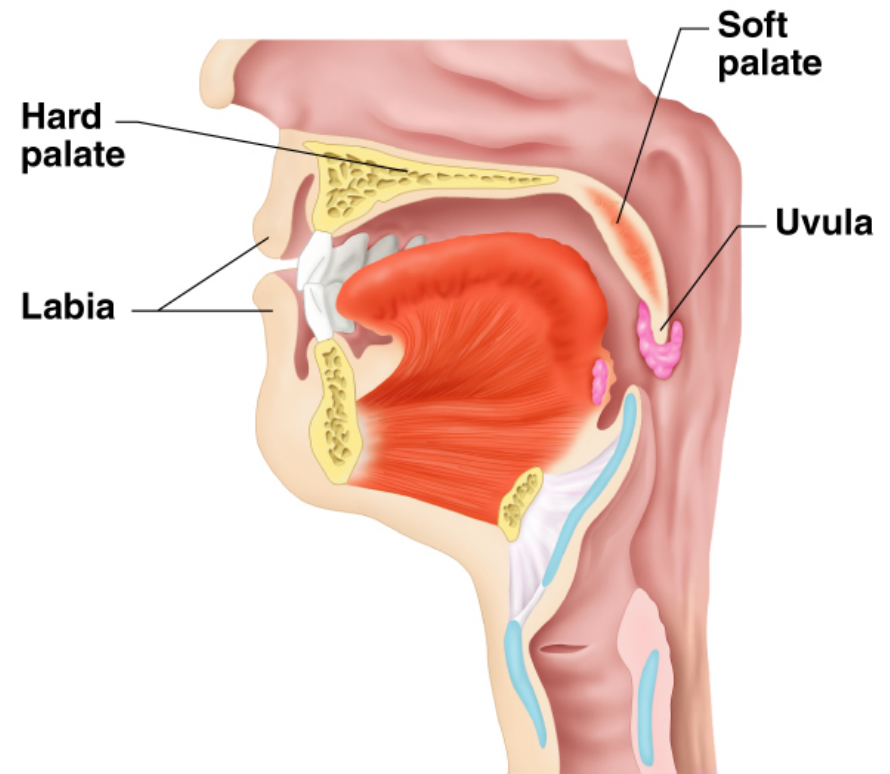
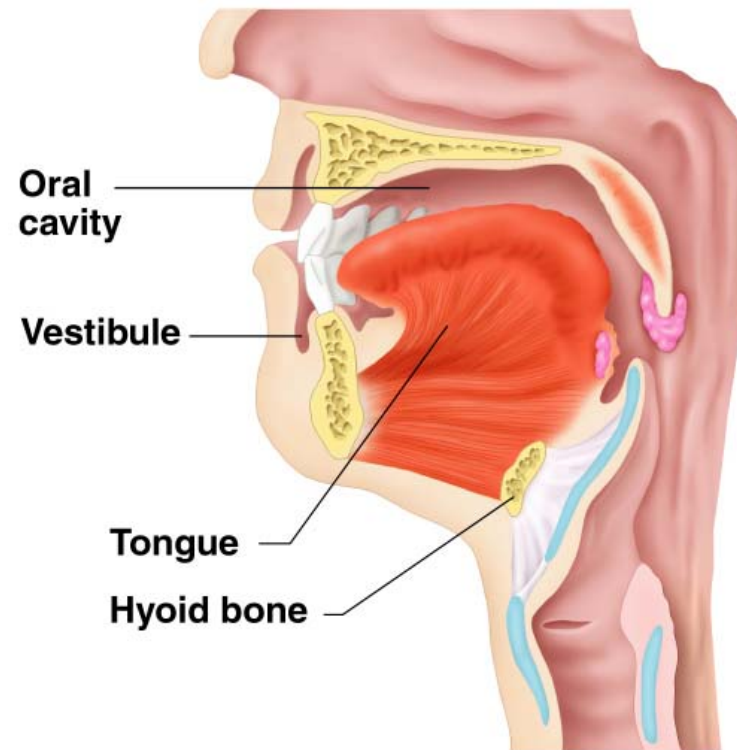


Figure 14.2a

# Mouth (Oral Cavity) Anatomy

- Vestibule – space between lips externally and teeth and gums internally
- Oral cavity – area contained by the teeth
- Tongue – attached at hyoid and styloid processes of the skull, and by the lingual frenulum

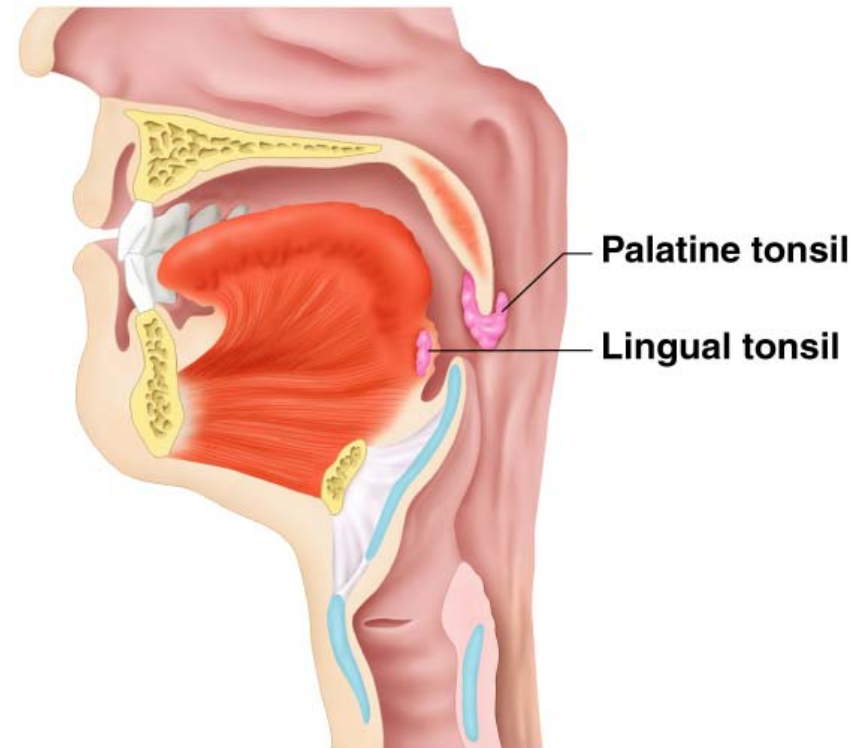


**(a)**

Figure 14.2a

# Mouth (Oral Cavity) Anatomy

- Tonsils
  - Palatine tonsils
  - Lingual tonsil



(a)

Figure 11.2a

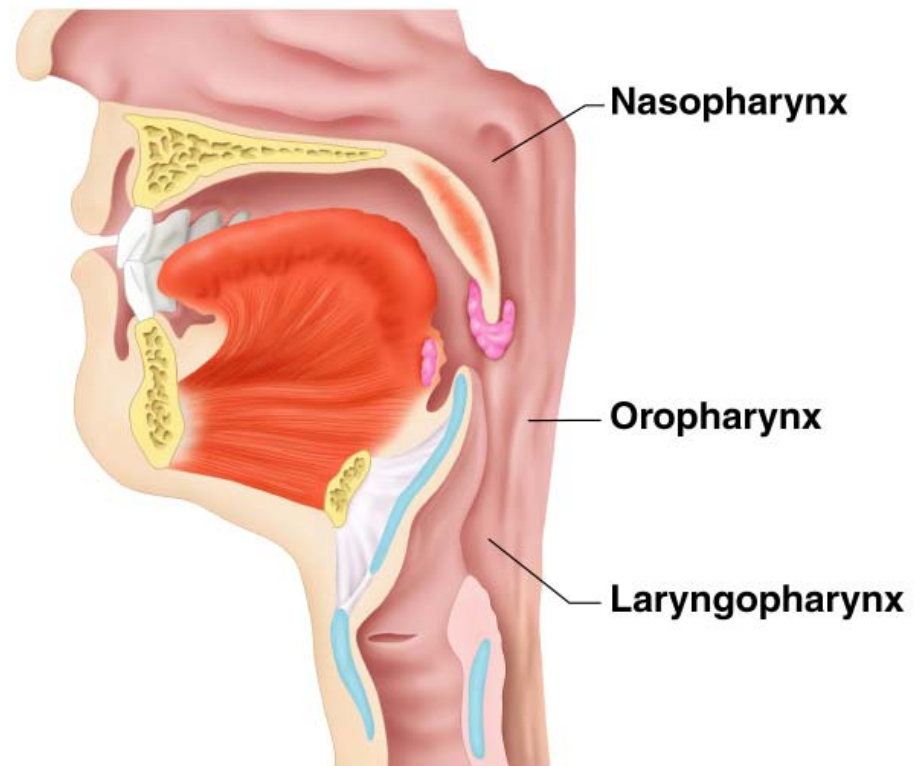


# Processes of the Mouth

- Mastication (chewing) of food
- Mixing masticated food with saliva
- Initiation of swallowing by the tongue
- Allowing for the sense of taste

# Pharynx Anatomy

- Nasopharynx – not part of the digestive system
- Oropharynx – posterior to oral cavity
- Laryngopharynx – below the oropharynx and connected to the esophagus



(a)

Figure 14.2a

# Pharynx Function

- Serves as a passageway for air and food
- Food is propelled to the esophagus by two muscle layers
  - Longitudinal inner layer
  - Circular outer layer
- Food movement is by alternating contractions of the muscle layers (peristalsis)

# Esophagus

- Runs from pharynx to stomach through the diaphragm
- Conducts food by peristalsis (slow rhythmic squeezing)
- Passageway for food only (respiratory system branches off after the pharynx)

# Layers of Alimentary Canal Organs

- Mucosa
  - Innermost layer
  - Moist membrane
    - Surface epithelium
    - Small amount of connective tissue (lamina propria)
    - Small smooth muscle layer

# Layers of Alimentary Canal Organs

- Submucosa
  - Just beneath the mucosa
  - Soft connective tissue with blood vessels, nerve endings, and lymphatics

# Layers of Alimentary Canal Organs

- Muscularis externa – smooth muscle
  - Inner circular layer
  - Outer longitudinal layer
- Serosa
  - Outermost layer – visceral peritoneum
  - Layer of serous fluid-producing cells

# Layers of Alimentary Canal Organs

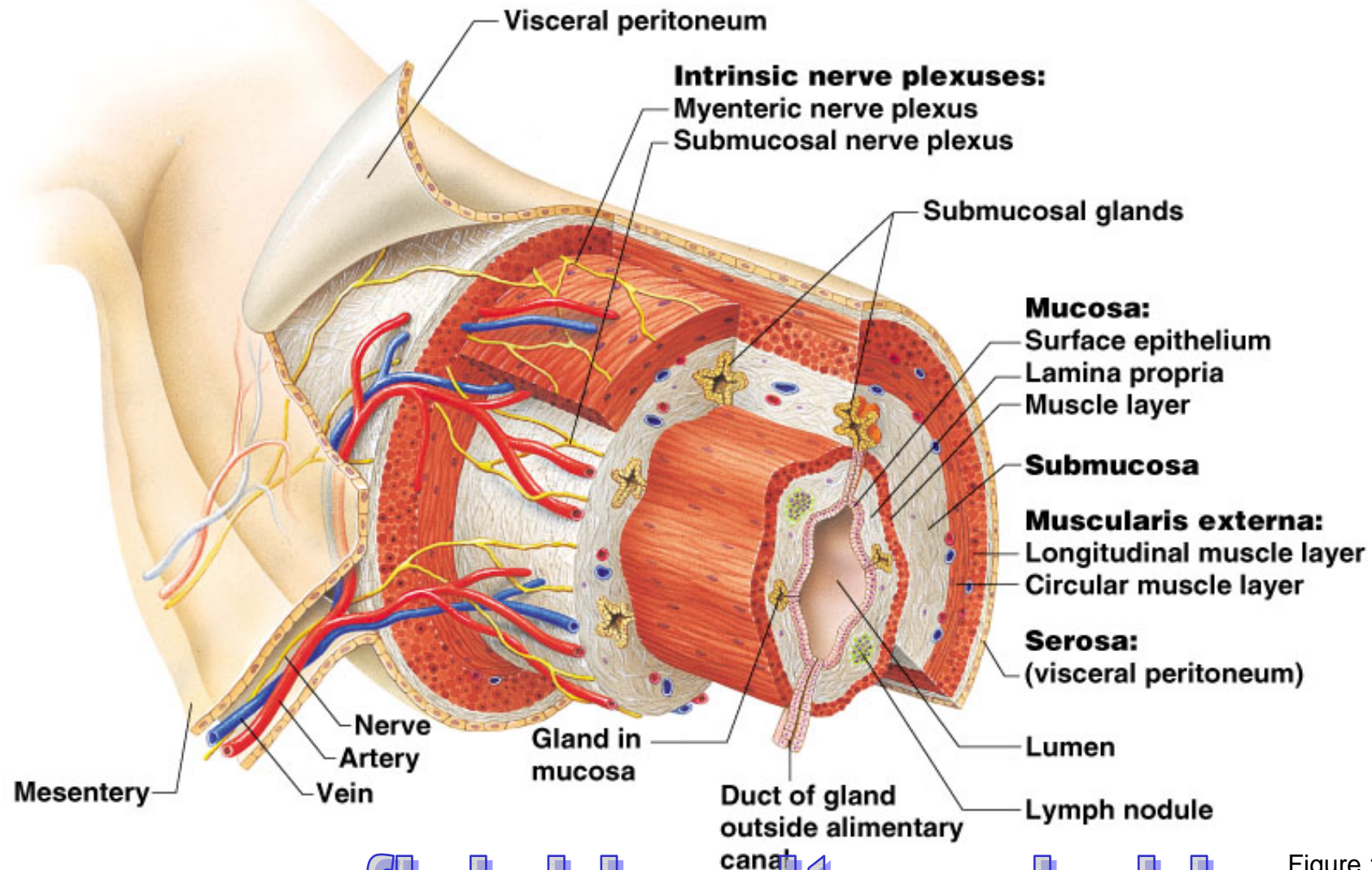


Figure 14.3



# Stomach Anatomy

- Located on the left side of the abdominal cavity
- Food enters at the cardioesophageal sphincter

# Stomach Anatomy

- Regions of the stomach
  - Cardiac region – near the heart
  - Fundus
  - Body
  - Pylorus – funnel-shaped terminal end
- Food empties into the small intestine at the pyloric sphincter

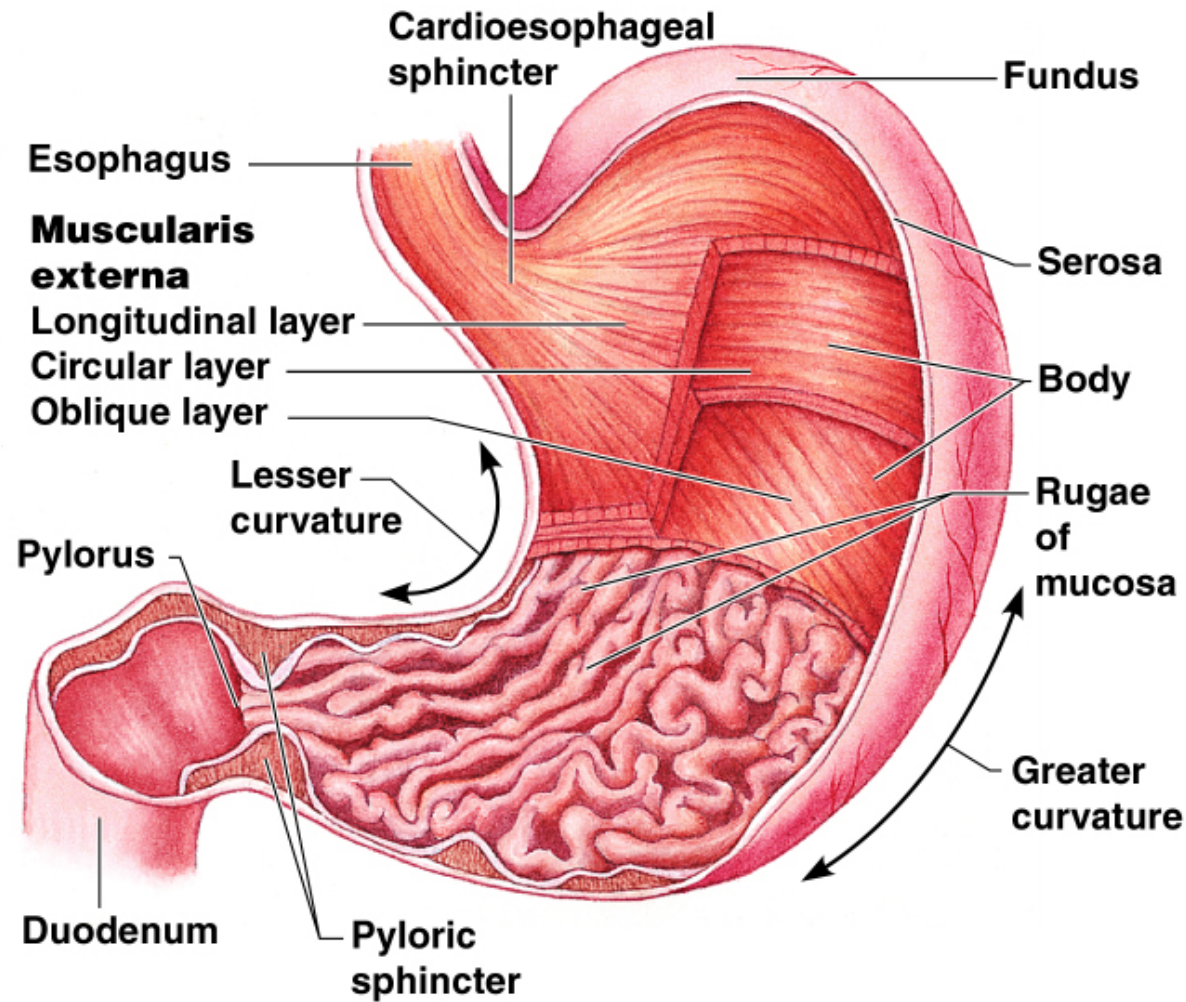
# Stomach Anatomy

- Rugae – internal folds of the mucosa
- External regions
  - Lesser curvature
  - Greater curvature

# Stomach Anatomy

- Layers of peritoneum attached to the stomach
  - Lesser omentum – attaches the liver to the lesser curvature
  - Greater omentum – attaches the greater curvature to the posterior body wall
  - Contains fat to insulate, cushion, and protect abdominal organs

# Stomach Anatomy



(a)

Figure 14.4a

# Stomach Functions

- Acts as a storage tank for food
- Site of food breakdown
- Chemical breakdown of protein begins
- Delivers chyme (processed food) to the small intestine

# Specialized Mucosa of the Stomach

- Simple columnar epithelium
  - Mucous neck cells – produce a sticky alkaline mucus
  - Gastric glands – secrete gastric juice
  - Chief cells – produce protein-digesting enzymes (pepsinogens)
  - Parietal cells – produce hydrochloric acid
  - Endocrine cells – produce gastrin

# Structure of the Stomach Mucosa

- Gastric pits formed by folded mucosa
- Glands and specialized cells are in the gastric gland region



# Structure of the Stomach Mucosa

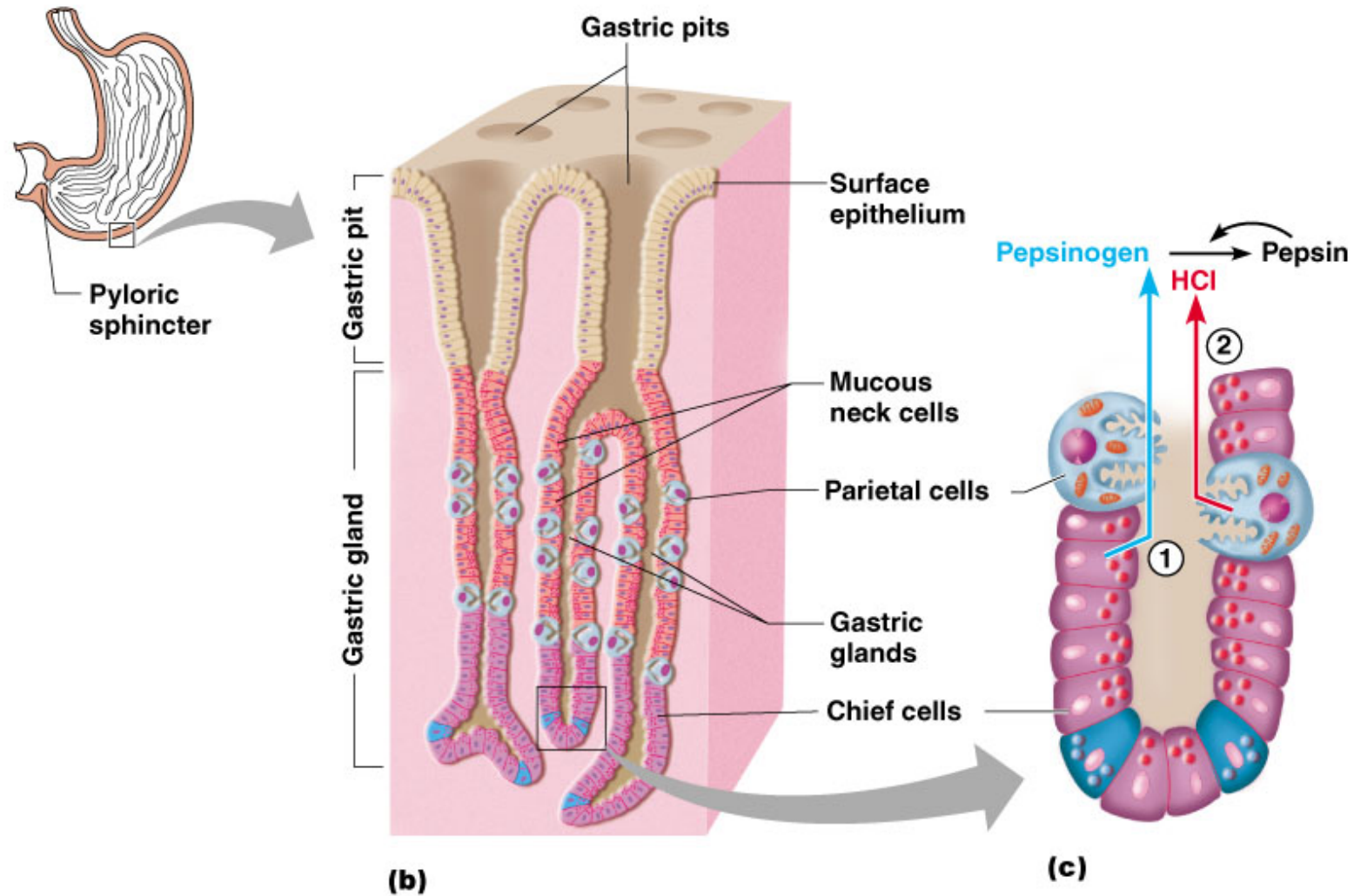


Figure 14.4b, c

# Small Intestine

- The body's major digestive organ
- Site of nutrient absorption into the blood
- Muscular tube extending from the pyloric sphincter to the ileocecal valve
- Suspended from the posterior abdominal wall by the mesentery

# Subdivisions of the Small Intestine

## “Dogs Just Itch!”

- Duodenum
  - Attached to the stomach
  - Curves around the head of the pancreas
- Jejunum
  - Attaches anteriorly to the duodenum
- Ileum
  - Extends from jejunum to large intestine

# Chemical Digestion in the Small Intestine

- Source of enzymes that are mixed with chyme
  - Intestinal cells
  - Pancreas
- Bile enters from the gall bladder

# Chemical Digestion in the Small Intestine

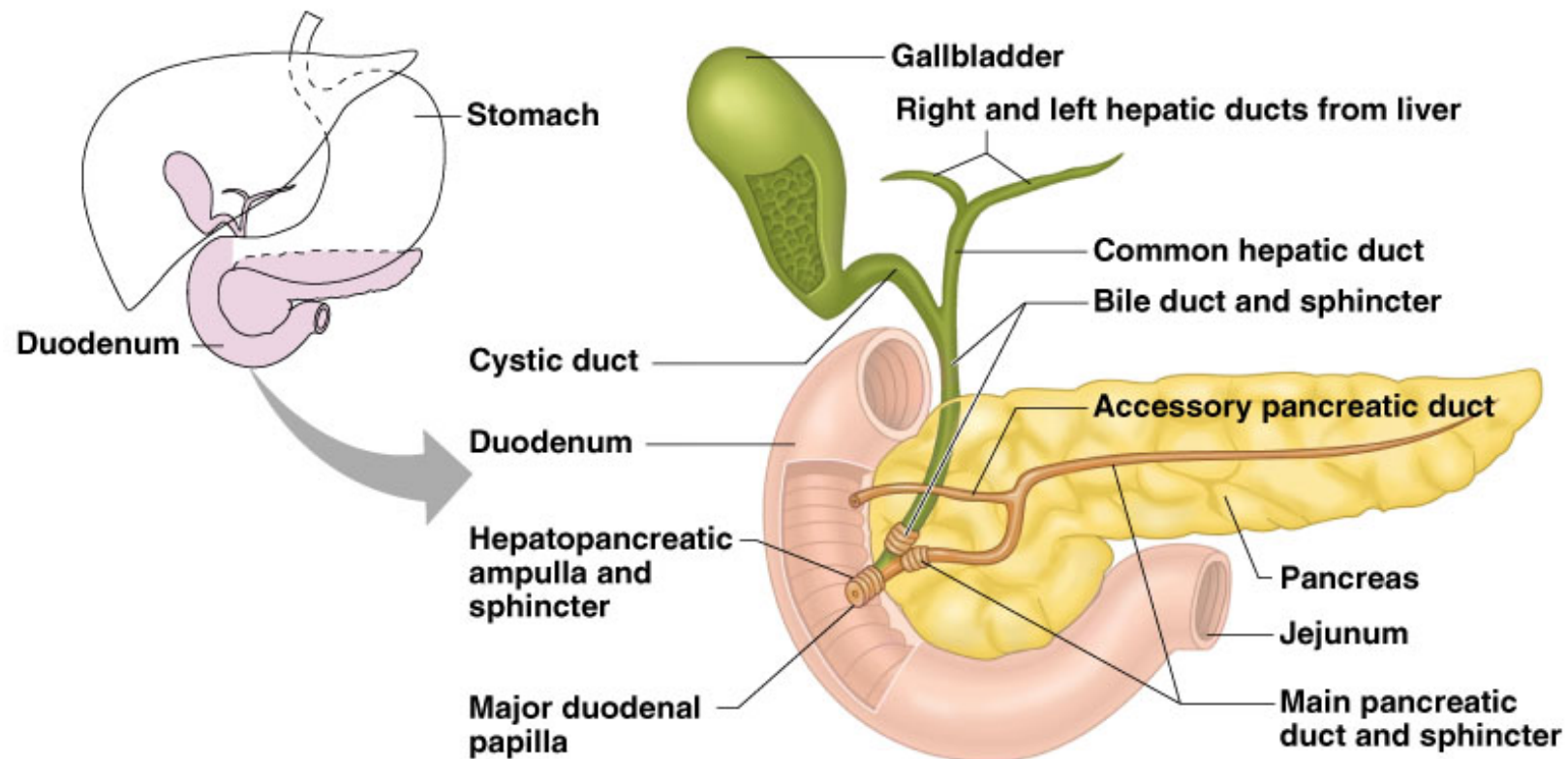
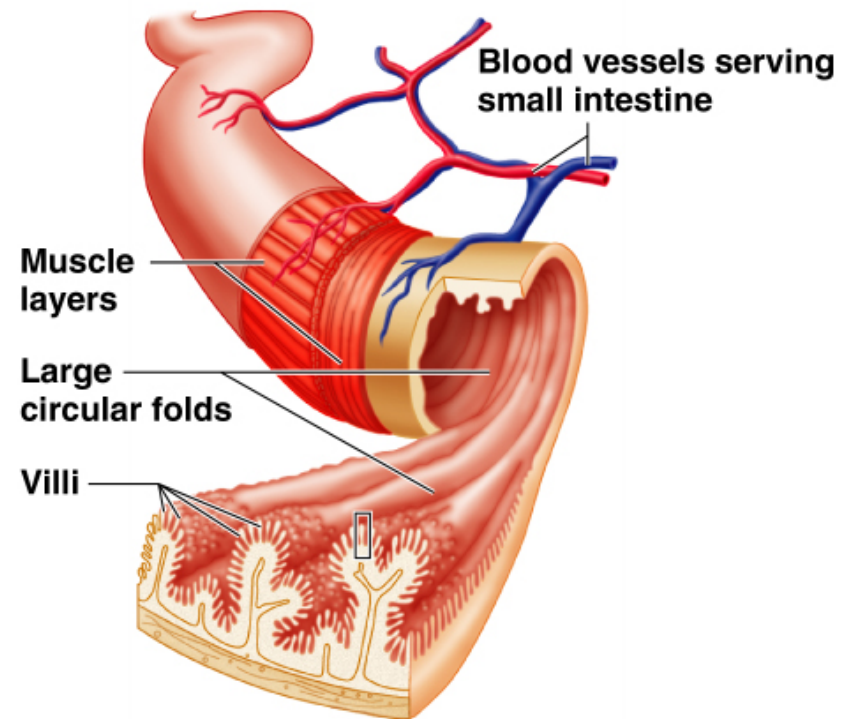


Figure 14.6

# Villi of the Small Intestine

- Fingerlike structures formed by the mucosa
- Give the small intestine more surface area

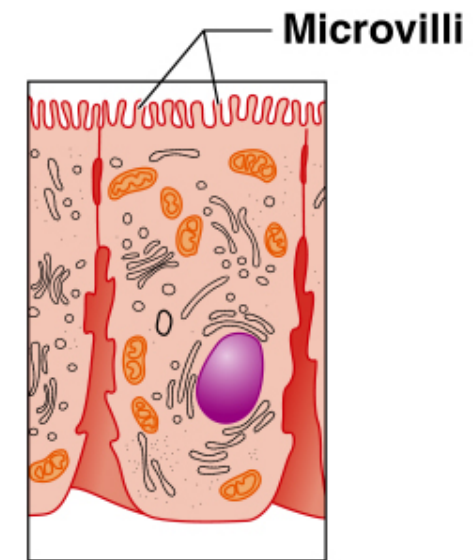


**(a) Small intestine**

Figure 14.7a

# Microvilli of the Small Intestine

- Small projections of the plasma membrane
- Found on absorptive cells



**(c) Absorptive cells**

Figure 14.7c

# Structures Involved in Absorption of Nutrients

- Absorptive cells
- Blood capillaries
- Lacteals (specialized lymphatic capillaries)

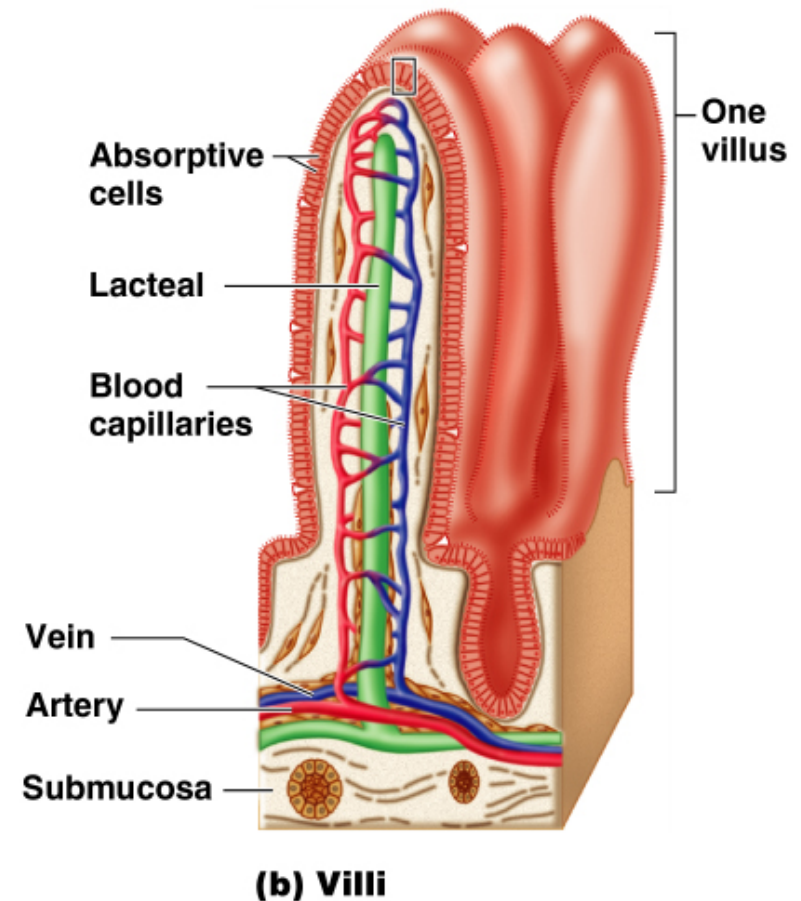


Figure 14.7b



# Folds of the Small Intestine

- Called circular folds or plicae circulares
- Deep folds of the mucosa and submucosa
- Do not disappear when filled with food
- The submucosa has Peyer's patches (collections of lymphatic tissue)

# Digestion in the Small Intestine

- Enzymes from the brush border
  - Break double sugars into simple sugars
  - Complete some protein digestion
- Pancreatic enzymes play the major digestive function
  - Help complete digestion of starch (pancreatic amylase)
  - Carry out about half of all protein digestion (trypsin, etc.)

# Digestion in the Small Intestine

- Pancreatic enzymes play the major digestive function (continued)
  - Responsible for fat digestion (lipase)
  - Digest nucleic acids (nucleases)
  - Alkaline content neutralizes acidic chyme

# 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

# Large Intestine

- Larger in diameter, but shorter than the small intestine
- Frames the internal abdomen

# Large Intestine

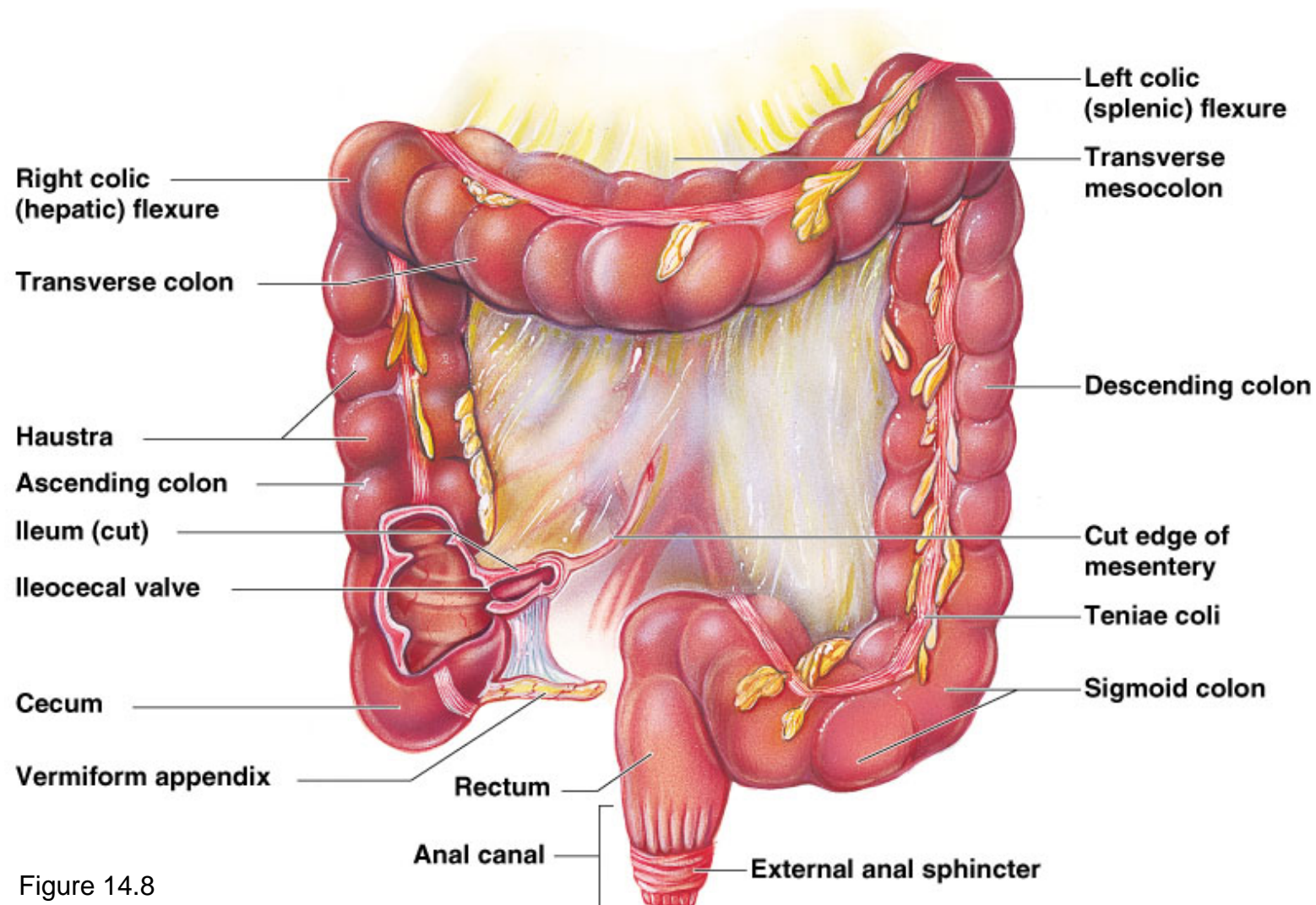


Figure 14.8

# Functions of the Large Intestine

- Absorption of water
- Eliminates indigestible food from the body as feces
- Does not participate in digestion of food
- Goblet cells produce mucus to act as a lubricant



# Structures of the Large Intestine

- Cecum – saclike first part of the large intestine
- Appendix
  - Accumulation of lymphatic tissue that sometimes becomes inflamed (appendicitis)
  - Hangs from the cecum

# Structures of the Large Intestine

- Colon
  - Ascending
  - Transverse
  - Descending
  - S-shaped sigmoidal
- Rectum
- Anus – external body opening

# Structures of the Large Intestine

- Colon
  - Ascending
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# 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

# 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

# Accessory Digestive Organs

- Salivary glands
- Teeth
- Pancreas
- Liver
- Gall bladder

# Salivary Glands

- Saliva-producing glands
  - Parotid glands – located anterior to ears
  - Submandibular glands
  - Sublingual glands

# 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



# Teeth

- The role 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 beginning between the ages of 6 to 12
  - A full set is 32 teeth, but some people do not have wisdom teeth

# Classification of Teeth

- Incisors
- Canines
- Premolars
- Molars

# Classification of Teeth

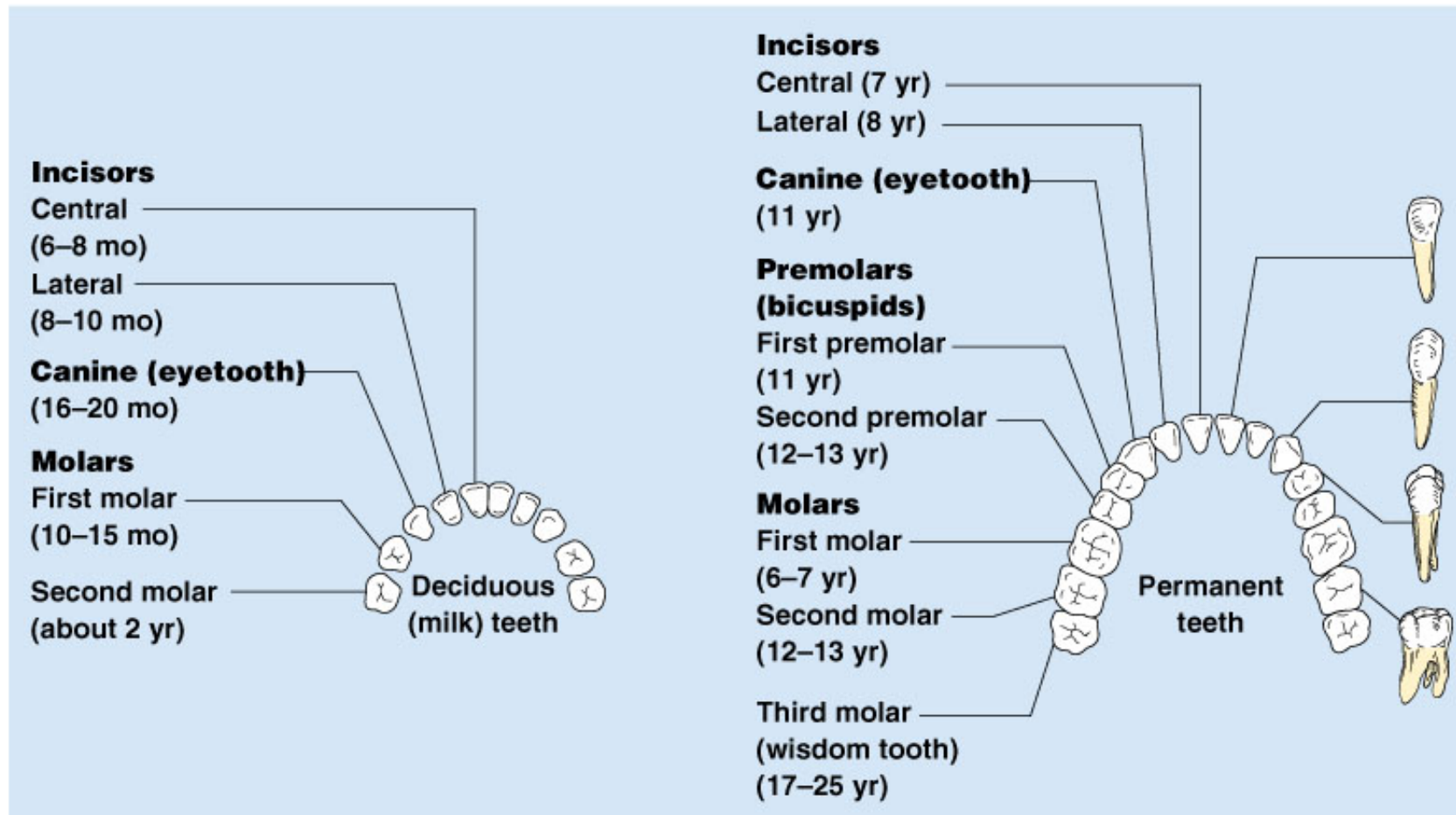


Figure 14.9

# Regions of a Tooth

- Crown – exposed part
  - Outer enamel
  - Dentin
  - Pulp cavity
- Neck
  - Region in contact with the gum
  - Connects crown to root

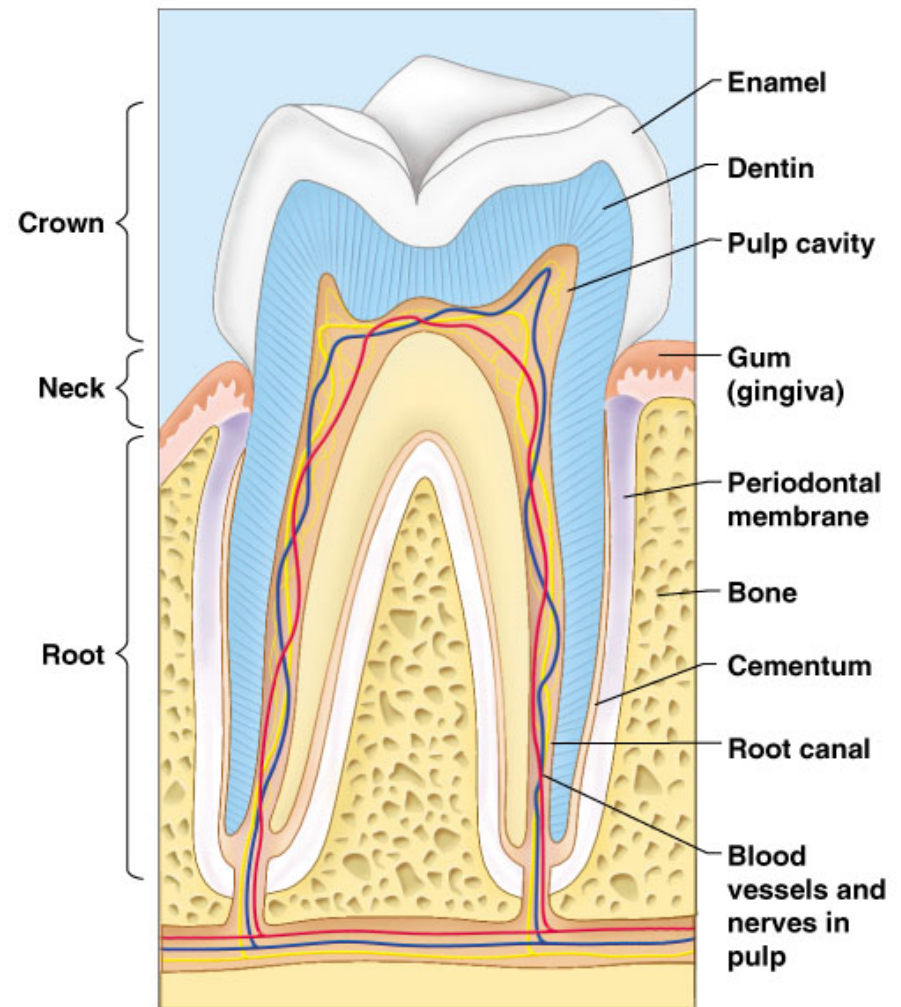


Figure 14.10

# Regions of a Tooth

- Root
  - Periodontal membrane attached to the bone
  - Root canal carrying blood vessels and nerves

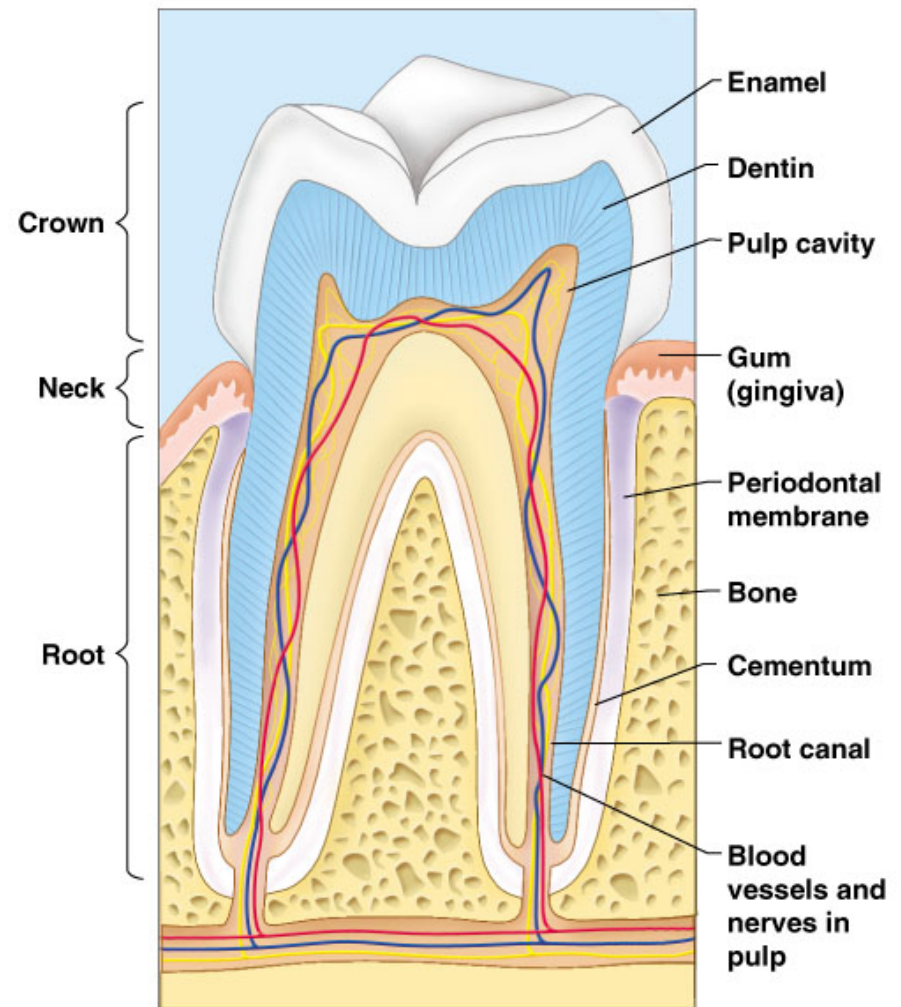


Figure 14.10

# 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
- Endocrine products of pancreas
  - Insulin
  - Glucagons

# 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 gall bladder via the common hepatic duct



# Bile

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

# Role of the Liver in Metabolism

- Several roles in digestion
- Detoxifies drugs and alcohol
- Degrades hormones
- Produce cholesterol, blood proteins (albumin and clotting proteins)
- Plays a central role in metabolism

# Gall Bladder

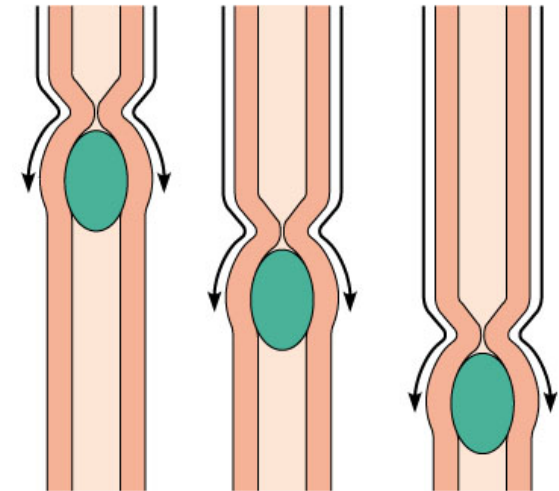
- Sac found in hollow fossa of liver
- Stores bile from the liver by way of the cystic duct
- Bile is introduced into the duodenum in the presence of fatty food
- Gallstones can cause blockages

# Processes of the Digestive System

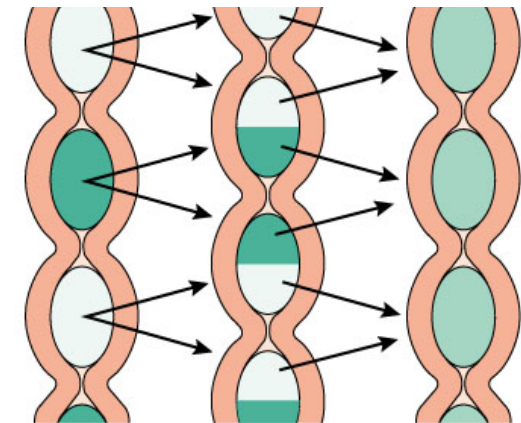
- Ingestion – getting food into the mouth
- Propulsion – moving foods from one region of the digestive system to another

# Processes of the Digestive System

- Peristalsis – alternating waves of contraction
- Segmentation – moving materials back and forth to aid in mixing



(a)



(b)

Figure 14.12

# Processes of the Digestive System

- Mechanical digestion
  - Mixing of food in the mouth by the tongue
  - Churning of food in the stomach
  - Segmentation in the small intestine

# Processes of the Digestive System

- 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

# Processes 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 as feces



# Processes of the Digestive System

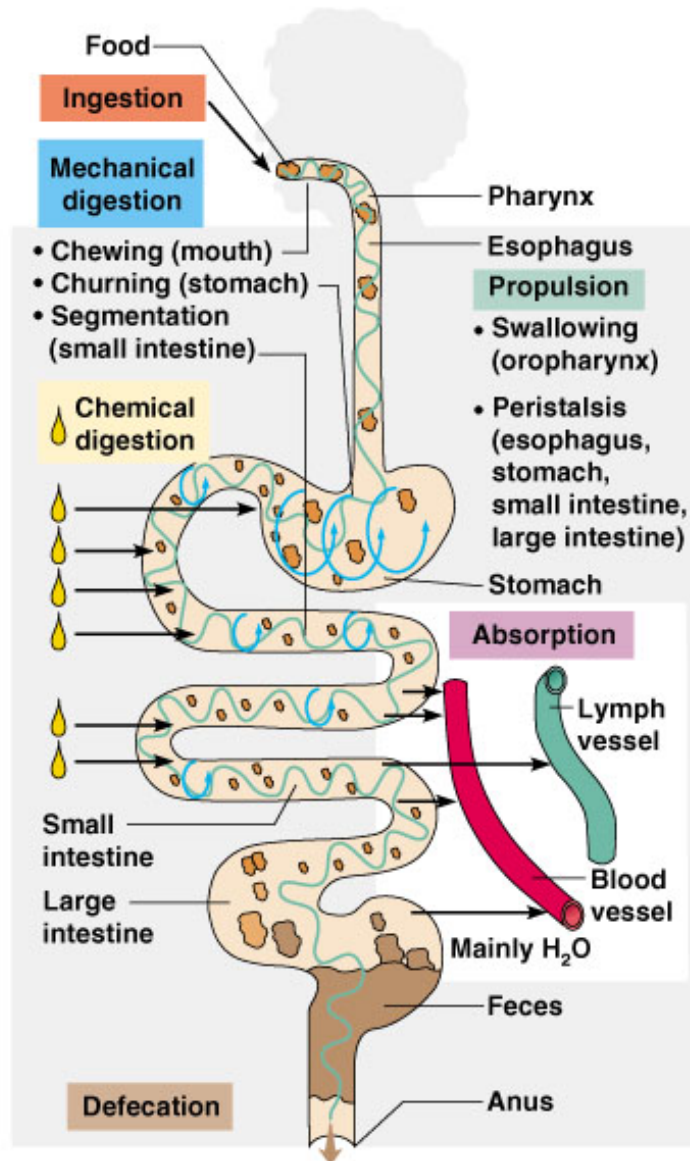


Figure 14.11

# 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

# Nutrition - Take a Class!

- Nutrient – substance used by the body for growth, maintenance, and repair
- Categories of nutrients
  - Carbohydrates: simple sugars, starches, fiber
  - Lipids: triglycerides, phospholipids, fatty acids
  - Proteins: amino acids
  - Vitamins

# Body Energy Balance

- Energy intake = total energy output (heat + work + energy storage)
  - Energy intake is liberated during food oxidation
  - Energy output
    - Heat is usually about 60%
    - Storage energy is in the form of fat or glycogen