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
Mouth (Oral Cavity) Anatomy

• Tonsils
  • Palatine tonsils
  • Lingual tonsil
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

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

Intrinsic nerve plexuses:
- Myenteric nerve plexus
- Submucosal nerve plexus

Visceral peritoneum

Submucosal glands

Mucosa:
- Surface epithelium
- Lamina propria
- Muscle layer

Submucosa

Muscularis externa:
- Longitudinal muscle layer
- Circular muscle layer

Serosa:
- (visceral peritoneum)

Mesentery

Nerve Artery

Vein

Gland in mucosa

Duct of gland outside alimentary canal

Lumen

Lymph nodule

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
  • Phylorus – 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 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

Slide 14 20b
Small Intestine

- The body’s major digestive organ
- Site of nutrient absorption into the blood
- Muscular tube extending form 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
Microvilli of the Small Intestine

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

Figure 14.7c

(c) Absorptive cells
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

- Right colic (hepatic) flexure
- Transverse colon
- Hastra
- Ascending colon
- Ileum (cut)
- Ileocecal valve
- Cecum
- Vermiform appendix
- Rectum
- Anal canal
- External anal sphincter
- Left colic (splenic) flexure
- Transverse mesocolon
- Descending colon
- Cut edge of mesentery
- Teniae coli
- Sigmoid colon
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
  - Transverse
  - Descending
  - S-shaped sigmoidal
- Rectum
- Anus – external body opening
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

- **Incisors**
  - Central (6–8 mo)
  - Lateral (8–10 mo)
- **Canine (eyetooth)**
  - (16–20 mo)
- **Molars**
  - First molar (10–15 mo)
  - Second molar (about 2 yr)

- **Permanent teeth**
- **Incisors**
  - Central (7 yr)
  - Lateral (8 yr)
- **Canine (eyetooth)**
  - (11 yr)
- **Premolars (bicuspids)**
  - First premolar (11 yr)
  - Second premolar (12–13 yr)
- **Molars**
  - First molar (6–7 yr)
  - Second molar (12–13 yr)
  - Third molar (wisdom tooth) (17–25 yr)
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

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

Ingestion
Mechanical digestion
- Chewing (mouth)
- Churning (stomach)
- Segmentation (small intestine)

Chemical digestion

Pharynx
Esophagus
Propulsion
- Swallowing (oropharynx)
- Peristalsis (esophagus, stomach, small intestine, large intestine)

Stomach
Small intestine
Mainly $H_2O$

Large intestine
Blood vessel
Lymph vessel

Absorption

Defecation

Feces
Anus
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