CHAPTER 14

The Digestive System and Nutrition
Digestive System

ACCESSORY ORGANS:

Salivary glands
- Saliva moistens food
- Bicarbonate maintains pH
- Amylase digests starch
- Lysozyme inhibits bacteria

Liver
- Produces bile
- Performs various functions associated with processing and storing nutrients

Gall bladder
- Stores and concentrates bile

Pancreas
- Secretes digestive enzymes into small intestine
- Secretes bicarbonate into small intestine to neutralize stomach acid

ORGANS:

Mouth
- Teeth chew food
- Tongue positions and tastes food

Pharynx
- Passageway for food and air
- Participates in swallowing

Esophagus
- Moves food from pharynx to stomach

Stomach
- Stores and mixes food
- Begins chemical digestion of protein by enzymes and acid
- Regulates delivery to the small intestine

Large intestine
- Absorbs nutrients
- Stores waste material

Small intestine
- DIGESTS proteins, fats, and carbohydrates
- Absorbs most of the nutrients
- Secretes digestive hormones and enzymes

Rectum
- Passageway for feces

Anus
- Expels undigested material
Gastrointestinal (GI) Tract Wall

- **Vein**
- **Artery**
- **Nerve**
- **Lymph vessel**

**Layers of the GI Tract Wall:**
- **Longitudinal layer**
- **Circular layer**
- **Serosa**
  - Connective tissue outer covering
  - Protects and anchors the digestive tract
- **Muscularis**
  - Two layers of smooth muscle
  - Responsible for motility of the digestive tract
- **Mucosa**
  - Mucous membrane layer
  - Lines the digestive tract
- **Submucosa**
  - Connective tissue layer
  - Contains blood vessels, lymph vessels and nerves

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Structure: common layers throughout the system

- **Mucosa**: innermost layer, nutrients pass through
- **Submucosa**: connective tissue, lymph and blood vessels, nerves
- **Muscularis**: two or three layers of smooth muscle, responsible for motility in GI tract
- **Serosa**: outermost layer, connective tissue sheath
Five Processes

• **Mechanical processing** and movement: chewing, mixing

• **Secretion**: fluid, digestive enzymes and hormones, bile, acid, alkali, mucus

• **Digestion**: breaking down food to smallest absorbable units

• **Absorption**: through mucosa, into blood or lymph vessels

• **Elimination**: undigested material eliminated
Motility: Peristalsis

(a) Peristalsis

Esophagus

Bolus of food

Stomach
Motility: Segmentation

(b) Segmentation
The Mouth: Teeth

(a)

(b)

Enamel
Dentin
Gingiva (gum)
Pulp cavity
Root canal
Periodontal membrane
Bone

Crown
The Mouth

Mouth: begins digestion

- Teeth
  - Types: incisors, canines, premolars, molars
  - Structure: crown, root
- Tongue: skeletal muscle, moves food in mouth, taste
- Saliva
  - Source: parotid, submandibular, sublingual salivary glands
  - Composition: mucin, salivary amylase, bicarbonate, lysozyme
Swallowing: Delivers Food to Stomach

Voluntary phase: tongue pushes bolus of food into pharynx

Involuntary phase/swallowing reflex: receptors in pharynx stimulated by presence of food

- Soft palate rises
- Larynx rises slightly
- Epiglottis closes opening to trachea
- Tongue pushes food further
- Food enters esophagus
Pharynx and Esophagus

- **Pharynx**
  - Common passageway for air and food
  - Participates in swallowing

- **Esophagus: connects pharynx to stomach**
  - Structure: mix of skeletal and smooth muscle
  - Mucus secreting cells: assist passage of food
  - Food motility: gravity and peristalsis
Structure of the Stomach Wall

- **Mucosa**
  - Opening of gastric gland (pit)
- **Submucosa**
  - Oblique layer
- **Muscularis**
  - Circular layer
- **Serosa**
  - Longitudinal layer

- **Mucus**
- **Mucus-secreting cells**
- **Gastric pits**
- **Acid-secreting cell**
- **Pepsinogen-secreting cell**
Stomach Function

- Functions: food storage, digestion, regulation of delivery

- Gastric juice: specific cells secrete
  - Hydrochloric acid: produces a pH of about 2, breaks down large bits of food
  - Intrinsic factor; made by same cells making acid, needed to absorb Vitamin B$_{12}$
  - Mucus: protects stomach lining from acid
  - Pepsinogen: with acid, begins protein breakdown
Stomach Contraction

Stomach contractions: blend food and propel forward

- Structural adaptation: third muscularis layer
- Direction: from lower esophageal sphincter to pyloric sphincter
- Chyme: result of mixing, affects hormone secretions regulating peristalsis and emptying of stomach
The Wall of the Small Intestine
Small Intestine

• Functions:
  • Digestion: neutralize acid from stomach, add digestive enzymes and bile, break proteins, carbohydrates and lipids to absorbable materials
  • Absorption: 95% of food absorbed here

• Structure
  • Regions: duodenum, jejunum, ileum
  • Mucosa adaptations: villi containing blood and lacteal capillaries
## Major Digestive Enzymes

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Source</th>
<th>Where Active</th>
<th>Substrate Digested</th>
<th>Breakdown Products</th>
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<tr>
<td><strong>Carbohydrate Digestion</strong></td>
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<tr>
<td>Salivary amylase</td>
<td>Salivary glands</td>
<td>Mouth</td>
<td>Polysaccharides</td>
<td>Disaccharides</td>
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<tr>
<td>Pancreatic amylase</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Polysaccharides</td>
<td>Disaccharides</td>
</tr>
<tr>
<td>Intestinal enzymes</td>
<td>Small intestine</td>
<td>Small intestine</td>
<td>Disaccharides</td>
<td>Monosaccharides (e.g., glucose)</td>
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<tr>
<td><strong>Protein Digestion</strong></td>
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<td></td>
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<td>Pepsin</td>
<td>Stomach</td>
<td>Stomach</td>
<td>Proteins</td>
<td>Peptides</td>
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<td>Peptides</td>
<td>Amino acids</td>
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<tr>
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<td>Amino acids</td>
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<td><strong>Lipid Digestion</strong></td>
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<td>Lipase</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Triglycerides</td>
<td>Free fatty acids, glycerol</td>
</tr>
</tbody>
</table>

Table 14.1
Accessory Organs: Aid Digestion and Absorption

- Pancreas: exocrine functions
  - Secretes digestive enzymes and sodium bicarbonate
- Liver
  - Produces bile (acts as emulsifier – begins fat breakdown)
  - Hepatic portal system: drains blood from digestive tract
  - Metabolic functions: storage, synthesis, chemical processing
- Gallbladder: stores bile
Large Intestine

Transverse colon

Ascending colon

Small intestine

Ileocecal valve

Cecum

Appendix

Rectum

Internal anal sphincter (smooth muscle)

Sigmoid colon

External anal sphincter (skeletal muscle)

Anus

Anal canal

Descending colon

Figure 14.12
Slide 14.13A
Large Intestine: Structure and Function

- Functions: absorbs nutrients and water, and eliminates waste

- Structure:
  - Cecum (blind pouch), appendix
  - Colon: ascending, transverse, descending, sigmoid
  - Rectum, anus
Absorption of Proteins and Carbohydrates
Absorption of Fats

Figure 14.14 Slide 14.14B
Absorption of Nutrients

- Proteins and carbohydrates: active transport
- Lipids: broken down and reassembled
- Water: osmosis
- Vitamins and minerals: assorted means
Endocrine and Nervous Systems Regulation of Digestion

• Regulation dependent on volume and content of food
  • Nervous system: stretch receptors in stomach
  • Hormones:
    • Gastrin: stimulates release of gastric juice
    • Secretin: stimulates pancreas to secrete water and bicarbonate
    • Cholecystokinin (CCK): signals pancreas to secrete digestive enzymes
Nutrients: Utilized or Stored Until Needed

**Figure 14.15**

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Food Guide Pyramid

“kaka”
Nutrition

• Carbohydrates: major energy source, simple or complex
• Lipids: cell components and energy sources, saturated or unsaturated
• Proteins: 20 amino acids
• Vitamins: fat soluble and water soluble
• Minerals: recommended daily allowance
• Fiber: some evidence decreases colon cancer
Weight Control: Energy Consumed versus Energy

- Basic Metabolic Rate (BMR) [easy formula 25 x wt. in kgs.]
  - Influencing factors: gender, body composition, age, stress, food intake, genetics

- Energy balance and body weight
  - Caloric content: fat = 9 Calories, Proteins and sugars = 4 Calories
  - Excess intake leads to increased storage (weight)

- Physical activity: uses calories (150 calories/mile walked or jogged)

- Have to accumulate -1500 calories = one pound wt. loss
Disorders of the Digestive System

Disorders of digestive (GI) tract: lactose intolerance, diverticulosis, colon polyps, colon cancer – most common in sigmoid colon

- Disorders of accessory organs: hepatitis, gallstones
- Malnutrition: 13% of world’s population undernourished
- Eating disorders: anorexia nervosa, bulimia
- Appendicitis: low, right side pain
- Hiatal hernia: part of stomach above diaphragm –\textbf{GERD}- gastroesophageal reflux disease