- Chapter 5
- Digestion, Absorption, and Metabolism
- Chapter 5

Lesson 5.1

- Key Concepts
- Through a balanced system of mechanical and chemical digestion, food is broken down into smaller substances and the nutrients are released for biologic use.
- Special organ structures and functions conduct these tasks through the successive parts of the overall system.
- Digestion: Basic Principles
- Principle of change
  - The body cannot use food as it is eaten.
  - Food must be changed into simpler substances to be absorbed and then used by cells to sustain life.
- Principle of wholeness
  - The parts of the digestive process comprise a continuous whole.
  - Food components travel through the gastrointestinal (GI) system until they are delivered to cells or excreted.
- The Gastrointestinal System
- Digestion: Mechanical and Chemical Changes
- Mechanical and chemical actions make up the digestive process.
- Food must undergo these changes to be delivered to cells.
- Specific actions occurring during digestion of carbohydrates, proteins, and fats are discussed in other chapters.

- **Mechanical Digestion**
- **GI motility: Beginning in the mouth, muscles and nerves in the tract coordinate their actions to provide motility, an automatic response to the presence of food.**
- **Mechanical Digestion, cont'd**
- **Muscles**
  - **Muscle tone/tonic contraction: Ensures continuous passage of the food mass and valve control along the way**
  - **Periodic muscle contraction and relaxation: Rhythmic waves that mix the food mass and move it forward**
- **Mechanical Digestion, cont'd**
- **Nerves**
  - **Specific nerves regulate muscle action along the GI tract**
  - **The intramural nerve plexus is the network of nerves in the GI wall extending from the esophagus to the anus**
- **Chemical Digestion**
- **Digestive enzymes: Break down nutrients**
- **Hydrochloric acid and buffer ions: Produce the correct pH necessary for enzyme activity**
- **Mucus: Lubricates and protects the GI tract tissues and helps mix the food mass**
- **Water and electrolytes: Carry and circulate the products of digestion through the tract and into the tissues**
- **Bile: Divides fat into smaller pieces to assist fat enzymes**
- **Digestion in the Mouth and Esophagus**
- **Mechanical digestion**

- Mastication breaks down food.
- Food is swallowed and passes down esophagus.
- Muscles at tongue base facilitate process.
- Gastroesophageal sphincter at stomach entrance relaxes, allowing food to enter, then constricts to retain food.

- Digestion in the Mouth and Esophagus, cont'd
- Chemical digestion
  - Salivary glands secrete material containing salivary amylase or ptyalin.
  - Ebner's glands at the back of the tongue secrete a lingual lipase.
  - Salivary glands also secrete a mucous material to lubricate and bind food particles, facilitating the swallowing of the food bolus.
  - Secretions from the mucous glands in the esophagus help move food toward the stomach.
- The Stomach
- Digestion in the Stomach
- Mechanical digestion
  - Under sphincter control, the food enters the upper portion of the stomach as individual bolus lumps.
  - Stomach muscles knead, store, mix, and propel the food mass forward.
  - By the time the food mass reaches the lower portion of the stomach, it is a semiliquid acid/food mix called chyme.
  - Chyme is released slowly into the first section of the small intestine (duodenum) by the pyloric valve.

- Digestion in the Stomach, cont'd
- Chemical digestion: three types of gastric secretions

- Hydrochloric acid: Parietal cells in the stomach lining secrete acid to promote gastric enzyme activity.
- Mucus: Secretions protect the stomach lining from the erosive effect of the acid and also bind and mix the food mass and help move it along.
- Enzymes: Pepsinogen is secreted by stomach cells and activated by acid to become pepsin, a protein-splitting enzyme.

- Digestion in the Small Intestine
- Mechanical digestion
  - Peristaltic waves slowly push food mass forward.
  - Pendular movements sweep back and forth.
  - Segmentation rings chop food mass into successive soft lumps and mix them with secretions.
  - Longitudinal rotation rolls food in a spiral motion, exposing new surfaces for absorption.
- Digestion in Small Intestine, cont'd
- Pancreatic enzymes
  - Carbohydrate: Pancreatic amylase converts starch to maltose and sucrose.
  - Protein: Trypsin and chymotrypsin split large protein molecules into small peptide fragments and eventually into single amino acids.
  - Fat: Pancreatic lipase converts fat to glycerides and fatty acids.
- Digestion in the Small Intestine, cont'd
- Intestinal enzymes
  - Carbohydrate: Disaccharidases convert disaccharides into monosaccharides.
  - Protein: Enterokinase activates trypsinogen from the pancreas to become trypsin; amino peptidase removes end amino acids from polypeptides; dipeptidase splits dipeptides into amino acids.
  - Fat: Intestinal lipase splits fat into glycerides and fatty acids.

- Digestion in the Small Intestine, cont'd
- Mucus: Large quantities of mucus protect the mucosal lining from irritation and erosion.
  - Bile: Emulsifying agent produced by the liver and stored in the gallbladder aids fat digestion and absorption.
  - Hormones
    - Secretin
    - Cholecystokinin
- The Biliary System
- Factors Influencing GI Tract Secretions
- Nervous control
- Conditioned reflexes
- Oral reflexes
- Physical contact
- Chapter 5

Lesson 5.2

- Key Concept
- Special organ structures and functions conduct these tasks through the successive parts of the overall system.
- Absorption and Transport
- Carbohydrates: Reduced to simple sugars (glucose, fructose, galactose)
- Fats: Changed into fatty acids and glycerides
- Proteins: Changed into single amino acids

- Vitamins and minerals: Liberated from food
- Bioavailability
- Bioavailability refers to:
  - Amount of nutrient present in the GI tract
  - Competition between nutrients for absorption
  - Form in which the nutrient is present
- All nutrients present in a food are not absorbed because of differing bioavailability.
  - This is considered when determining dietary intake standards
- Absorption in the Small Intestine
- Three absorbing structures
  - Mucosal folds: Surface of small intestine piles into folds
  - Villi: Small, finger-like projections cover the mucosal folds, increasing the area of exposed intestinal surface
  - Microvilli: Smaller projections cover each villi (look like bristles on a brush)
- Intestinal Wall
- Absorption Processes
- Simple diffusion: The force by which particles move outward in all directions—from areas of greater to lesser concentration.
- Facilitated diffusion: Similar to simple diffusion but uses a protein channel to carry larger items.
- Active transport: The force by which particles move from areas of greater to lesser concentration using a carrier to "ferry" particles.
- Pinocytosis: Penetration of larger materials by attaching to the cell membrane and being engulfed by the cell.
- Transport Pathways

- **Absorption in Large Intestine**
- **Water is taken up by the large intestine**
  - **Most water in chyme is absorbed in the first half of the colon**
  - **Only a small amount remains to form and eliminate feces**
- **Dietary fiber is not digested**
  - **Contributes bulk to food mass**
  - **Helps form feces**
- **Transport**
- **Nutrients must be transported to cells**
- **Vascular (blood circulatory) system**
  - **Veins and arteries**
  - **Transports waste, such as carbon dioxide and nitrogen, to lungs and kidneys for removal**
- **Lymphatic system**
  - **Route for fatty materials, which are not water soluble**
  - **Fat molecules pass into lymph vessels in villi**
- **Interstitial Villi**
- **Metabolism**
- **Nutrients are converted to energy or stored in the body**
- **Metabolism: The sum of body processes that change our food energy from the three energy nutrients**
  - **Chemical reactions within cell to maintain life**
  - **Occurs in mitochondrion of the cell**

- **Metabolism, cont'd**
- **Two metabolic processes**
  - **Catabolism: Breaking down of large substances into smaller units (e.g., breaking down a protein chain into amino acids)**
  - **Anabolism: Building of larger substances from smaller particles (e.g., building a complex protein from single amino acids)**

- **Metabolism, cont'd**
- **Metabolic processes ensure that the body has energy in the form of adenosine triphosphate (ATP).**
- **Metabolism of glucose from carbohydrates yields less energy than metabolism of fat. Still, glucose is the body's primary source of energy.**
- **Protein can be an energy source, but it is relatively inefficient.**
- **Metabolic Pathways**
- **Energy Storage: Glycogenesis**
- **Glycogenesis: Anabolic process of converting extra glucose into glycogen**
- **Glycogen is stored in the liver and muscles for quick energy to be used at a later time**
- **Energy Storage: Lipogenesis**
- **When glycogen reserves are full, additional excess energy from carbohydrates, fat, or protein is stored as fat in adipose tissue**
- **Lipogenesis: The building up of triglycerides for storage in adipose tissue**
- **Energy Storage: Gluconeogenesis**
- **Excess protein is not stored as muscle but is further broken down**

- Nitrogen unit is removed
- Remaining carbon chain can be converted to glucose (if needed) or to fat for storage

- Metabolic Pathways of Excess Energy
- Genetic Disease
- Phenylketonuria
  - Protein metabolism
- Galactosemia
  - Carbohydrate metabolism
- Lactose Intolerance
- Most common disaccharidase deficiency
- Lactase in insufficient amounts, not absent
- Causes abdominal cramping and diarrhea
- Summary
- Nutrients from food must be changed, released, regrouped, and rerouted into forms the body can use.
- The activities of digestion, absorption, and transport ensure that key nutrients are delivered to the cells so metabolic tasks can be completed.
- Summary, cont'd
- Mechanical digestion consists of spontaneous muscular activity responsible for initial mechanical breakdown and the movement of the food mass along the GI tract by the motion of peristalsis.
- Chemical digestion involves the enzymatic action that breaks food down into smaller components and releases nutrients for absorption.

- **Summary, cont'd**
- **Absorption involves the passage of food nutrients from the intestines into the mucosal lining of the intestinal wall.**
- **Nutrients absorbed are transported throughout the body by the circulatory system.**
- **Metabolism is the sum of the body processes that change food energy taken in (carbohydrate, protein, and fat) into various forms of energy**
- **Summary, cont'd**
- **Metabolism is balanced by two types of metabolic actions**
  - **Catabolism**
  - **Anabolism**