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.
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.

Metabolism is balanced by two types of metabolic actions:

- Catabolism
- Anabolism