The Digestive System and Body Metabolism
Metabolic Pathways Involved in Cellular Respiration

- Glycolysis – energizes a glucose molecule so that it can be split into two pyruvic acid molecules and yield ATP
Metabolic Pathways Involved in Cellular Respiration

1. Glycolysis
   - Glucose → Pyruvic acid
   - Cytosol of cell → Mitochondrial cristae
   - ATP

2. Krebs cycle
   - Chemical energy (high-energy electrons)
   - Mitochondrion
   - CO₂
   - ATP

3. Electron transport chain and oxidative phosphorylation
   - H₂O
   - Via oxidative phosphorylation
   - ATP

Figure 14.18
Metabolic Pathways Involved in Cellular Respiration

- **Krebs cycle**
  - Produces virtually all the carbon dioxide and water resulting from cell respiration
  - Yields a small amount of ATP
Metabolic Pathways Involved in Cellular Respiration

- Electron transport chain
  - Hydrogen atoms removed during glycolysis and the Krebs cycle are delivered to protein carriers
Metabolic Pathways Involved in Cellular Respiration

- Electron transport chain (continued)

- Hydrogen is split into hydrogen ions and electrons in the mitochondria
Metabolic Pathways Involved in Cellular Respiration

- Electron transport chain (continued)

  - Electrons give off energy in a series of steps to enable the production of ATP
Fat Metabolism

- Handled mostly by the liver
  - Use some fats to make ATP
  - Synthesize lipoproteins, thromboplastin, and cholesterol
  - Release breakdown products to the blood
- Body cells remove fat and cholesterol to build membranes and steroid hormones
Use of Fats for ATP Synthesis

- Fats must first be broken down to acetic acid
- Within mitochondria, acetic acid is completely oxidized to produce water, carbon dioxide, and ATP
Protein Metabolism

- Proteins are conserved by body cells because they are used for most cellular structures.
- Ingested proteins are broken down to amino acids.
Protein Metabolism

- Cells remove amino acids to build proteins
  - Synthesized proteins are actively transported across cell membranes
- Amino acids are used to make ATP only when proteins are overabundant or there is a shortage of other sources
Production of ATP from Protein

- Amine groups are removed from proteins as ammonia
- The rest of the protein molecule enters the Krebs cycle in mitochondria
- The liver converts harmful ammonia to urea which can be eliminated in urine
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
Metabolic Functions of the Liver

- Glycogenesis
  - Glucose molecules are converted to glycogen
  - Glycogen molecules are stored in the liver

- Glycogenolysis
  - Glucose is released from the liver after conversion from glycogen

- Gluconeogenesis
  - Glucose is produced from fats and proteins
Metabolic Functions of the Liver

- Fats and fatty acids are picked up by the liver
  - Some are oxidized to provide energy for liver cells
  - The rest are broken down into simpler compounds and released into the blood
Functions of cholesterol

- Serves as a structural basis of steroid hormones and vitamin D
- Is a major building block of plasma membranes
- Most cholesterol is produced in the liver and is not from diet
Cholesterol Transport

- Cholesterol and fatty acids cannot freely circulate in the bloodstream

- They are transported by lipoproteins (lipid-protein complexes)
  - Low-density lipoproteins (LDLs) transport to body cells
  - High-density lipoproteins (HDLs) transport from body cells to the liver
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
Regulation of Food Intake

- Body weight is usually relatively stable
  - Energy intake and output remain about equal
- Mechanisms that may regulate food intake
  - Levels of nutrients in the blood
  - Hormones
  - Body temperature
  - Psychological factors
Metabolic Rate and Body Heat Production

- Basic metabolic rate (BMR) – amount of heat produced by the body per unit of time at rest

- Factors that influence BMR
  - Surface area – small body usually has higher BMR
  - Gender – males tend to have higher BMR
Factors that influence BMR (continued)

- Age – children and adolescents have a higher BMR

- The amount of thyroxine produced is the most important control factor
  - More thyroxine means higher metabolic rate
Total Metabolic Rate (TMR)

- Total amount of kilocalories the body must consume to fuel ongoing activities
- TMR increases with an increase in body activity
- TMR must equal calories consumed to maintain homeostasis and maintain a constant weight
Body Temperature Regulation

- Most energy is released as foods are oxidized
- Most energy escapes as heat
Body Temperature Regulation

- The body has a narrow range of homeostatic temperature
  - Must remain between 35.6° to 37.8°C (96° to 100° F)
  - The body’s thermostat is in the hypothalamus
    - Initiates heat-loss or heat-promoting mechanisms
Heat Promoting Mechanisms

- Vasoconstriction of blood vessels
  - Blood is rerouted to deeper, more vital body organs
- Shivering – contraction of muscles produces heat
Heat Loss Mechanisms

- Heat loss from the skin via radiation and evaporation
  - Skin blood vessels and capillaries are flushed with warm blood
  - Evaporation of perspiration cools the skin
**Body Temperature Regulation**

**Figure 14.22**

- **Imbalance**
  - **Stimulus:** Decreased body temperature (e.g., due to cold environmental temperatures)
  - **Homeostasis:** Normal body temperature (35.5°C–37.5°C)
  - **Imbalance**

- **Body temperature increases:** Blood temperature rises and hypothalamus heat-promoting center "shuts off"
  - Skin blood vessels constrict: Blood is diverted from skin capillaries and withdrawn to deeper tissues; minimizes overall heat loss from skin surface
  - Blood cooler than hypothalamic set point
  - Activates heat-promoting center in hypothalamus

- **Body temperature decreases:** Blood temperature declines and hypothalamus heat-loss center "shuts off"
  - Skin blood vessels dilate: Capillaries become flushed with warm blood; heat radiates from skin surface
  - Blood warmer than hypothalamic set point
  - Activates heat-loss center in hypothalamus

- **Sweat glands activated:** Secretes perspiration, which is vaporized by body heat, helping to cool the body

**Stimulus:** Increased body temperature (e.g., when exercising or the climate is hot)
Developmental Aspects of the Digestive System

- The alimentary canal is a continuous tube by the fifth week of development
- Digestive glands bud from the mucosa of the alimentary tube
- The developing fetus receives all nutrients through the placenta
- In newborns, feeding must be frequent, peristalsis is inefficient, and vomiting is common
Developmental Aspects of the Digestive System

- Teething begins around age six months
- Metabolism decreases with old age
- Middle age digestive problems
  - Ulcers
  - Gall bladder problems
Developmental Aspects of the Digestive System

- Activity of digestive tract in old age
  - Fewer digestive juices
  - Peristalsis slows
  - Diverticulosis and cancer are more common