CHAPTER 4
BODY WEIGHT AND HEALTH

Enzymes and Metabolism

• **Enzymes**
  - Proteins that **catalyze** (speed up) chemical reactions in a cell
  - **Metabolism**: all chemical reactions occurring in the body
  - Enzymes work by lowering the **activation energy** needed for a reaction
• **Substrate** are substances being catalyzed
• **Active site** is where the substrate binds to the enzyme
• The binding of the substrate and enzyme causes a shape change and called **induced fit**
• **Specificity** of the enzyme to the substrate is based on enzyme shape and active site
• A **calorie** is the amount of energy required to raise the temperature of 1 gram of water by 1°C.
  - 1000 calories = 1 kilocalorie or Calorie
• **Calorie**:
  - Unit of energy represented on food labels
  - Calories are consumed by cells to do work
  - Extra calories can be stored as fat
  - **Metabolic rate**: the rate at which the body uses energy

• **Basal Metabolic Rate or BMR** represents the resting energy of a awake, resting but alert person.
  - **70 Calories/hour or 1680 Calories/day**
• Metabolic rate is influenced by many factors:
  - Body weight, sex, exercise, genetic makeup, age, and nutritional status

Cellular Respiration

• **Cellular respiration** is a series of enzymatic reaction that converts energy from food into energy stored in **ATP**.
• ATP consists of adenine, a sugar, and 3 phosphate groups.
• When a phosphate group is transferred from ATP to another molecule (**phosphorylation**), energy is transferred and **ADP** is produced.
• The energy from ATP can power different kinds of work in the cell.
• As ATP is used in the cell it must be replenished by cellular respiration.
• **Aerobic cellular respiration** occurs in the mitochondria and requires the presence of oxygen.
  - **C₆H₁₂O₆ + 6O₂ → 6CO₂ + 6H₂O**
• Aerobic cellular respiration takes the energy from glucose and uses it to make ATP.
• This process occurs in three complex steps starting in the cytosol of the cell and completing in the mitochondria.
**Cellular Respiration - Step 1: Glycolysis**
- 6-carbon glucose molecule is broken down into two 3-carbon pyruvic acid molecules.
- Takes place in the cytosol and doesn’t require oxygen and produces 2 ATP.
- NAD\(^+\) is used as a chemical taxi cab.
  - These pick up the electrons and hydrogen ions released during glycolysis and become NADH.

**Cellular Respiration - Step 2: Citric Acid Cycle**
- **Citric acid cycle**: series of chemical reactions catalyzed by 8 different enzymes in the mitochondrial matrix
- The result is the generation of 2 ATP, release of carbon dioxide and NADH.

**Cellular Respiration - Step 3: Electron Transport and ATP Synthesis**
- **Electron transport chain** acts like a conveyor belt, moving electrons through a series of proteins.
- NADH drops off its electrons and hydrogen ions
- The protein carriers move the electrons through the chain and move the hydrogen into the intermembrane space.
- The concentration of H\(^+\) ions increases within the intermembrane space.
- H\(^+\) ions are charged, and can’t simply diffuse back across the membrane.
- They pass through protein channels called **ATP synthase**, generating 32 or 34 ATP molecules as they do.
- At the end of the chain, the electrons combine with oxygen to produce water.

**Cellular Respiration - Metabolism of Other Nutrients**
- Proteins and fats can also provide energy when carbohydrates are unavailable.
- They are broken down and their subunits feed into aerobic cellular respiration.

**4.2 Cellular Respiration - Metabolism Without Oxygen: Anaerobic Respiration and Fermentation**
- Cells can generate energy without oxygen through **anaerobic respiration**.
- Muscle cells can produce lactic acid to regenerate NAD\(^+\) through **fermentation**.
- Bacteria in yogurt also use fermentation to make lactic acid.
- Yeast cells use fermentation to convert glucose to ethanol.

**Body Weight and Health**
- Difficult to define “overweight” precisely
- Women need more body fat to maintain fertility than men do
- Average healthy body fat percentages:
  - Women: 22% and Men: 14%
- **Body Mass Index (BMI)**: correlates amount of body fat with risk of illness and death, using both height and weight
  - Healthy range of BMI = 20-25
  - **Obesity**: BMI of 30 or higher
• Risk of obesity is influenced by both lifestyle (diet, exercise) and genetics
• Obesity increases risks of:
  • Diabetes
  • Hypertension
  • Heart disease
  • Stroke
  • Joint problems
• **Diabetes**: disorder of carbohydrate metabolism
• **Insulin**: hormone that triggers cells to take up glucose; produced by **beta cells** of the pancreas
• Type 1 Diabetes (not associated with obesity)
  • Usually arises in childhood
  • Cannot produce insulin (no beta cells)
  • Treated with daily insulin injections
• Type 2 Diabetes (associated with obesity)
  • Usually arises in adults
  • May be controlled by diet and exercise
• **Hypertension**: high blood pressure (the force exerted on blood vessels by the blood)
  • **Systolic**: blood pressure as the heart contracts
  • **Diastolic**: blood pressure while heart is relaxing
  • Normal blood pressure is about 120 systolic and 80 diastolic (120/80)
  • Hypertension: persistently over 140/90
• **Heart attack**: a sudden loss of blood to the heart because of blocked arteries
• **Stroke**: a sudden loss of blood to the brain because of blocked arteries
• **Cholesterol**: a lipid that can build up in arteries
  • **Low-density lipoproteins (LDLs)**: distribute cholesterol throughout the body and dumps excess in the arteries
  • **High-density lipoproteins (HDLs)**: carry excess cholesterol to the liver for excretion as bile
• **Anorexia**: self-starvation
  • Can starve heart muscles, producing altered rhythms
  • **Amenorrhea**: cessation of menstruation; can be permanent and result in sterility
  • Increases risk of **osteoporosis**
• **Bulimia**: binge-eating followed by purging
  • Many of the same health effects as anorexia
  • May lead to stomach rupture
  • Dental and gum problems from stomach acid
  • Dehydration (sometimes fatal)