

## 2 The Nature of Life

### Overview

This chapter begins with a discussion of the attributes of living organisms. These include growth, reproduction, response to stimuli, metabolism, movement, complexity of organization, and adaptation to the environment. Then it examines the chemical and physical basis of life. A brief look at the elements and their atoms is followed by a discussion of compounds, molecules, bonds, ions, valence, mixtures, acids, bases, and salts. Forms of energy and the chemical components of protoplasm are examined next. The chapter concludes with an introduction to carbohydrates, lipids, proteins, and nucleic acids.

### Detailed Lecture Outline

- I. Introduction
- II. Attributes of Living Organisms
  - A. Composition and Structure
  - B. Growth
  - C. Reproduction
  - D. Response to Stimuli
  - E. Metabolism
  - F. Movement
  - G. Complexity of Organization
  - H. Adaptation to the Environment
- III. Chemical and Physical Bases of Life
  - A. The Elements: Units of Matter
    1. Matter defined
    2. States of matter
      - a. Solid
      - b. Liquid
      - c. Gas
    3. Characteristics of matter
      - a. It occupies space
      - b. It has mass
      - c. It is composed of elements
    4. The Atom: Smallest stable subdivision of an element
      - a. Individual atoms composed of
        - 1) Nucleus
          - a) Protons
          - b) Neutrons
        - 2) Electrons
      - b. Atomic orbitals
      - c. Isotopes
  - B. Molecules: Combinations of Elements
    1. Compounds defined
      - two or more elements united in a definite ratio by chemical bonds
    2. Molecules defined
      - smallest independently existing particle of a compound or element

3. Chemical reactions between molecules
  - controlled by organic catalysts called enzymes
4. Polarity of molecules
  - a. Affects the way molecules interact with each other
  - b. Capillarity of water
  - c. Adhesive properties of water
5. Valence
- C. Bonds and Ions
  1. Ions defined
  2. Types of chemical bonds
    - a. Hydrogen bond
    - b. Covalent bond
    - c. Ionic bond
  3. Mixtures
- D. Acids, Bases, and Salts
  1. Polarity of water molecules
    - a. Acids defined
      - release hydrogen ( $H^+$ ) ions when dissolved in water
    - b. Bases defined
      - release negatively charged hydroxyl ( $OH^-$ ) ions when dissolved in water
    - c. Salts defined
  2. The pH scale
    - a. Hydrogen ion ( $H^+$ ) concentration of solution
    - b. Measured on a scale of 0-14
    - c. Pure water = pH 7.0
    - d. Acidity of solution below pH 7
    - e. Alkalinity (basic) of solution above pH 7
- E. Energy
  1. Energy defined
    - the ability to do work
  2. First Law of Thermodynamics
    - a. Defined
      - energy is constant; it cannot be increased or diminished, but it can be converted from one form to another
    - b. Energy has different forms
      - 1) Chemical
      - 2) Electrical
      - 3) Heat
      - 4) Light
  3. Second Law of Thermodynamics
    - a. Defined
      - when energy is converted from one form to another form, the amount of useful energy remaining is always less than before
    - b. Energy in motion
      - kinetic energy
    - c. Energy in storage form
      - potential energy
  4. Energy in the electron
    - electron shells
- F. Chemical Components of Cells

1. Organic and inorganic molecules
2. Monomers and Polymers
  - a. Biological macromolecules are polymers
  - b. Polymers are composed of identical, smaller molecules called monomers
  - c. Bonding of monomers occurs by dehydration synthesis
  - d. Polymers broken down into monomers by reverse reaction called hydrolysis
3. Four important classes of polymers
  - a. Carbohydrates
    - 1) Defined
      - molecules composed of C, H, and O in a ratio of  $[\text{CH}_2\text{O}]_n$
    - 2) Examples
      - a) Monosaccharides, e.g., glucose
        - isomers (fructose)
      - b) Disaccharides, e.g., sucrose
      - c) Polysaccharides, e.g., starch, cellulose
  - b. Lipids
    - 1) Defined
      - fatty or oily substances that are insoluble in water
    - 2) Fats and Oils
      - saturated, polyunsaturated
    - 3) Waxes
    - 4) Phospholipids
  - c. Proteins, polypeptides, and amino acids
    - 1) Defined
      - proteins composed of amino acids
    - 2) Amino acids
      - a) Amino group:  $\text{NH}_2$
      - b) Carboxyl group:  $\text{COOH}$
      - c) R groups
        - different R groups for each of the 20 naturally occurring amino acids
    - 3) Polypeptides
      - a) Defined
        - two or more amino acids bonded together
      - b) Peptide bond
      - c) Structural organization of peptides (proteins)
        - i) Primary structure
        - ii) Secondary structure
        - iii) Tertiary structure
        - iv) Quaternary structure
    - 4) Storage Proteins
      - i) Found in some tubers and bulbs
      - ii) Seeds may contain high amounts of proteins
    - 5) Enzymes
      - a) Large complex proteins
        - a special type of RNA can function as an enzyme
      - b) Organic catalysts
        - lowers energy of activation
      - c) Enzyme names end in -ase, e.g., maltase

- d. Nucleic Acids
  - 1) Defined
    - complex polymers consisting of repeating subunits called nucleotides
  - 2) Types
    - a) DNA—deoxyribonucleic acid
    - b) RNA—ribonucleic acid