UNIT 1: CHEMISTRY OF LIFE

Overview

Unit 1 introduces the chemical principles that support all biological systems. This unit focuses on the unique properties of water and the structure and function of biological macromolecules. Understanding these concepts explains how molecules interact and why these interactions are essential for life and future biological processes studied throughout the course.

Water

Water is a polar molecule because electrons are shared unevenly between oxygen and hydrogen atoms. Within a single water molecule, atoms are held together by covalent bonds, creating partial charges where oxygen is slightly negative and hydrogen is slightly positive. This unequal charge distribution forms a dipole.

When multiple water molecules interact, they form hydrogen bonds, which occur between the positive hydrogen of one molecule and the negative oxygen of another. Although hydrogen bonds are weaker than covalent bonds, their collective strength is critical for many biological and chemical processes.

Water

The bonding behavior of water explains several of its important properties, including:

- Cohesion (water sticking to water)
- Adhesion (water sticking to other substances)
- Surface tension
- High specific heat
- Evaporative cooling

These properties allow water to regulate temperature and support life.

- Hydrophilic substances interact easily with water because they contain polar or charged bonds.
- Hydrophobic substances do not mix well with water because they lack polarity and tend to avoid contact with water.

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Macromolecules

Macromolecules are large, carbon-based molecules essential to living organisms. The four main groups are carbohydrates, lipids, proteins, and nucleic acids. These molecules are typically polymers, meaning they are made from repeating smaller units called monomers. Monomers join together through dehydration synthesis, a process that removes water to form covalent bonds. In contrast, hydrolysis breaks these bonds by adding water, separating polymers back into monomers.

Macromolecules

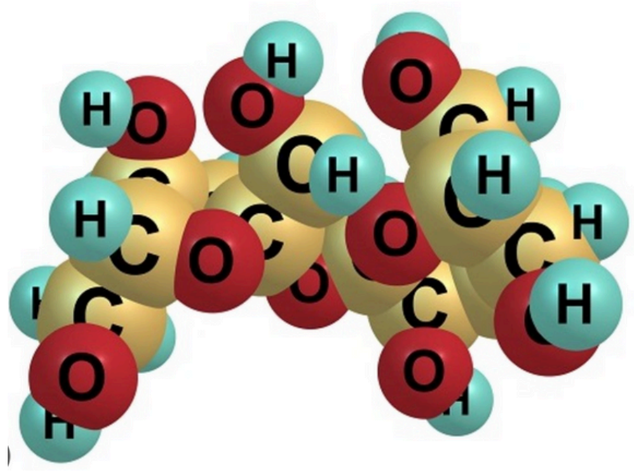
Carbon plays a key role in macromolecules due to its ability to form four covalent bonds. Other important elements include hydrogen, oxygen, nitrogen, phosphorus, and sulfur. These elements form functional groups, which influence molecular structure and function.
Key functional groups to know are Carboxyl, Carbonyl, Hydroxyl, Amino, Phosphate, Sulfhydryl. Functional groups determine how molecules interact and what roles they perform in cells.

Carbohydrates

Carbohydrates consist of carbon, hydrogen, and oxygen and include sugars and starches. They provide quick, short-term energy and also serve structural roles.
Examples include:

- Cellulose, which supports plant cell walls
- Chitin, which forms exoskeletons in arthropods

Carbohydrates are especially important for immediate energy needs.



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Lipids

Lipids are nonpolar macromolecules made primarily of carbon and hydrogen. They include fats, oils, steroids, and phospholipids and serve as long-term energy storage molecules.
Lipids can be:

- Saturated, meaning they contain no double bonds and are usually solid at room temperature
- Unsaturated, meaning they contain one or more double bonds and are typically liquid at room temperature

Lipids

Phospholipids have both polar and nonpolar regions. The hydrophilic head interacts with water, while the hydrophobic tails avoid water. This structure allows phospholipids to form bilayers, which make up cell membranes with hydrophobic interiors and hydrophilic surfaces.

Proteins

Levels of protein structure:

- Primary structure: the sequence of amino acids
- Secondary structure: local folding into alpha helices or beta sheets
- Tertiary structure: overall 3D shape from R-group interactions
- Quaternary structure: interaction of multiple polypeptide chains

Changes in temperature or pH can cause denaturation, altering protein shape and function.

Proteins

Proteins are composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Their monomers are amino acids, which link together to form polypeptide chains.
Proteins perform many functions, including:

- Acting as enzymes
- Transporting substances
- Providing structural support
- Regulating hormones
- Supporting immune responses

Protein function depends on its shape, which is determined by amino acid sequence and folding.

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Nucleic Acids

Nucleic acids include DNA and RNA and are made of carbon, hydrogen, oxygen, nitrogen, and phosphorus. Their monomers are nucleotides, each consisting of:

- A five-carbon sugar
- A phosphate group
- A nitrogenous base

DNA stores genetic information and is arranged in an antiparallel structure, with strands running in opposite 5′ to 3′ directions. RNA differs from DNA by containing uracil instead of thymine.