Chapter 1. What is Biochemistry?

Biochemistry describes in molecular terms the structures, mechanisms, and chemical processes shared by all organisms and provides organizing principles that underlie life in all its diverse forms, principles we refer to collectively as the molecular logic of life. Although biochemistry provides important insights and practical applications in medicine, agriculture, nutrition, and industry, its ultimate concern is with the wonder of life itself.

Biochemistry asks how the remarkable properties of living organisms arise from the thousands of different lifeless biomolecules. When these molecules are isolated and examined individually, they conform to all the physical and chemical laws that describe the behavior of inanimate matter—as do all the processes occurring in living organisms.

What are these distinguishing features of living organisms?

A high degree of chemical complexity and microscopic organization.

Systems for extracting, transforming, and using energy from the environment

A capacity for precise self-replication and self-assembly

Mechanisms for sensing and responding to alterations in their surroundings constantly adjusting to these changes by adapting their internal chemistry.

Defined functions for each of their components and regulated interactions among them.

A history of evolutionary change. Organisms change their inherited life strategies to survive in new circumstances

About four billion years ago, life arose—simple microorganisms with the ability to extract energy from organic compounds or from sunlight, which they used to make a vast array of more complex biomolecules from the simple elements and compounds on the Earth's surface.

Chemical Foundations

Only about 30 of the more than 90 naturally occurring chemical elements are essential to organisms. Most of the elements in living matter have relatively low atomic numbers. The four most abundant elements in living organisms, in terms of percentage of total number of atoms, are hydrogen, oxygen, nitrogen, and carbon, which together make up more than 99% of the mass of most cells. They are the lightest elements capable of forming one, two, three, and four bonds, respectively; in general, the lightest elements form the strongest bonds.

required shapes and diagrams are shown

Biomolecules Are Compounds of Carbon with a Variety of Functional Groups

The chemistry of living organisms is organized around carbon, which accounts for more than half the dry weight of cells. Carbon can form single bonds with hydrogen atoms, and both single and double bonds with oxygen and nitrogen atoms (Fig. 1–13). Of greatest significance in biology is the ability of carbon atoms to form very stable carbon–carbon single bonds. Each carbon atom can form single bonds with up to four other carbon atoms. Two carbon atoms also can share two (or three) electron pairs, thus forming double (or triple) bonds.

required figures and diagrams are shown

Cells Contain a Universal Set of Small Molecules

Dissolved in the aqueous phase (cytosol) of all cells is a collection of 100 to 200 different small organic molecules (Mr ~100 to ~500), the central metabolites in the major pathways occurring in nearly every cell—the metabolites and pathways that have been conserved throughout the course of evolution.

This collection of molecules includes the common amino acids, nucleotides, sugars and their phosphorylated derivatives, and a number of mono-, di-, and tricarboxylic acids. The molecules are polar or charged, water soluble, and present in micromolar to millimolar concentrations.

Inorganic molecules

Water and minerals

Three-Dimensional Structure Is Described by Configuration and Conformation

The covalent bonds and functional groups of a biomolecule are, of course, central to its function, but so also is the arrangement of the molecule's constituent atoms in three-dimensional space—its stereochemistry. A carbon-containing compound commonly exists as stereoisomers, molecules with the same chemical bonds but different stereochemistry—that is, different configuration, the fixed spatial arrangement of atoms.

required shapes and diagrams are shown

Interactions between Biomolecules Are Stereospecific

Biological interactions between molecules are stereospecific: the "fit" in such interactions must be stereochemically correct. The three-dimensional structure of biomolecules large and small—the combination of configuration and conformation—is of the most importance in their biological interactions.

Types of chemical reactions in metabolism

Oxidation-reduction

Formation or cleavage of covalent bonds (i.e. C-C bons)

Group transfer

Isomerization

Free radical reactions

required shapes and diagrams are shown

Water

Water is the most abundant substance in living systems, making up 70% or more of the weight of most organisms. The first living organisms doubtless arose in an aqueous environment, and the course of evolution has been shaped by the properties of the aqueous medium in which life began.

Functions of Water in the Body

Water carries nutrients to your cells and carries waste from your body.

Regulates body temperatures

Dissolves vitamines, minerals, amino acids, and other nutrients

Lubricates joints