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Introduction to Biochemistry

Biochemistry

Definition, scope and importance of biochemistry, chemical composition of the human body, atoms, molecules, chemical bonds, pH, acids, bases and buffers.

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CHAPTER 01

Introduction to Biochemistry

Definition, scope, body composition, chemical bonds, pH and buffers

1. Meaning and scope

Biochemistry is the study of the chemical substances, reactions and molecular processes that occur in living organisms. It explains the relationship between molecular structure and biological function, from the cell to the whole body. Clinical biochemistry applies these principles to the detection, monitoring and understanding of disease.

- Structural biochemistry: structure and properties of carbohydrates, proteins, lipids and nucleic acids.
- Metabolic biochemistry: reactions that release energy or build molecules.
- Molecular biology: storage, transmission and expression of genetic information.
- Clinical biochemistry: analysis of specimens such as blood and urine to assess organ function and metabolic health.

2. Chemical composition of the human body

Water is the largest component, commonly around 50-60% of adult body weight; the proportion varies with age, sex and body composition. Oxygen, carbon, hydrogen and nitrogen account for most body mass. Calcium, phosphorus, sulfur and other elements are needed for structural and regulatory functions.

Component	Major role
Water	Solvent, transport, temperature regulation and reaction medium
Carbohydrates	Energy and cell recognition
Proteins	Structure, enzymes, transport, immunity and signalling
Lipids	Energy storage, membranes, signalling and insulation
Nucleic acids	Genetic information and protein synthesis
Minerals	Bones, electrical activity, cofactors and fluid balance

3. Atoms, molecules and ions

An atom is the basic unit of an element. Protons are positively charged, neutrons are uncharged and electrons are negatively charged. Atomic number is the number of protons; mass number is the sum of protons and

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neutrons. Isotopes have the same atomic number but different neutron numbers. A molecule contains atoms bonded together; a compound contains atoms of different elements. An ion carries a charge after loss or gain of electrons (e.g., Na+, Cl).

Bond or interaction	Description and example
Covalent	Sharing electrons; peptide and glycosidic bonds
Ionic	Electrostatic attraction between oppositely charged ions
Hydrogen	Weak attraction involving a hydrogen donor and acceptor; DNA base pairing
Van der Waals	Weak short-range interactions; molecular packing
Hydrophobic interaction	Nonpolar groups associate in water; membrane formation

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4. Chemical reactions and metabolism

Hydrolysis uses water to split a bond; condensation joins molecules with release of small molecules such as water. Oxidation is electron loss; reduction is electron gain. ATP transfers energy for cellular work. Catabolism breaks molecules down; anabolism builds molecules and usually requires energy. Enzymes accelerate reactions without being consumed overall.

5. Acids, bases, pH and buffers

An acid donates protons; a base accepts protons. pH = -log10[H+]. At 25 C, neutral water has pH 7; lower values are acidic and higher values alkaline. Each pH unit represents a tenfold change in hydrogen ion concentration. Normal arterial blood pH is 7.35-7.45.

A buffer resists pH changes by reversibly binding or releasing protons. The major extracellular buffer is bicarbonate: CO2 + H2O H2CO3 H+ + HCO3 . Phosphate, haemoglobin and other proteins also buffer body fluids. Lungs regulate CO2; kidneys regulate bicarbonate and acid excretion (see Chapter 14).

6. Water and the chemical basis of life

Water is polar: oxygen bears a partial negative charge and hydrogen atoms partial positive charges. Hydrogen bonding explains much of its high heat capacity, solvent ability and cohesion. Water dissolves ions and many polar molecules, while nonpolar compounds tend to associate with one another. This behaviour is central to the formation of cell membranes and protein folding.

Functions of water in the body

- Provides a medium for biochemical reactions and the transport of nutrients, hormones and metabolic wastes.
- Helps maintain body temperature through its high heat capacity and evaporation.
- Participates directly in hydrolysis reactions and acts as a lubricant in body fluids.
- Maintains cell volume and contributes to blood volume and tissue perfusion.

7. Cellular organization and biomolecules

Structure	Biochemical role
Nucleus	Stores DNA; site of most nuclear transcription
Mitochondria	Oxidative metabolism and ATP production
Ribosomes	Protein synthesis
Rough endoplasmic reticulum	Synthesis and processing of many membrane and secreted proteins
Smooth endoplasmic reticulum	Lipid synthesis, calcium storage and selected drug metabolism
Golgi apparatus	Modifies, sorts and packages proteins and lipids
Lysosomes	Intracellular degradation of macromolecules

8. Examples of biochemical calculations

Concentration and units

Molarity expresses moles of solute per litre of solution. Clinical results may be reported as mmol/L, mg/dL or g/dL. Results cannot be compared without checking the substance and unit. For glucose, mg/dL divided by approximately 18 gives mmol/L; this conversion does not apply universally to other substances.

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pH example

A solution at pH 6 has ten times the hydrogen ion concentration of one at pH 7. Even small changes in arterial pH can substantially affect enzyme activity, membrane transport and physiological function.

9. Clinical importance and nursing applications

- Understand laboratory units, reference intervals, medication action and acid-base disturbances.
- Identify how abnormal glucose, electrolytes or organ markers relate to patient symptoms.
- Use correct specimen handling, report critical results and explain investigations to patients.

10. Important Examination Questions

Long Answer Questions

1. 1. Define biochemistry and explain its scope and nursing importance.
2. 2. Describe the chemical composition of the human body and the role of water.
3. 3. Explain the main chemical bonds and the concept of acids, bases and buffers.

Short Answer Questions

1. 1. Write a short note on Chemical bonds.
2. 2. Write a short note on pH and buffers.

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3. 3. Write a short note on anabolic versus catabolic reactions.

Very Short Answer Questions

1. 1. Define an atom and an ion. - Atom: basic unit of an element; ion: charged atom or molecule.
2. 2. What is hydrolysis? - Bond cleavage involving water.
3. 3. What is normal arterial blood pH? - 7.35-7.45.
4. 4. Differentiate anabolic and catabolic reactions. - Anabolism builds molecules; catabolism breaks them down.

Additional objective question

Which is the main extracellular buffer? - Bicarbonate.

11. Quick Revision

- Biochemistry connects molecular structure, metabolism and disease.
- Covalent bonds share electrons; hydrogen bonds contribute to molecular organization.
- ATP couples energy-releasing reactions to energy-requiring processes.
- Buffers resist changes in pH; lungs and kidneys help maintain blood pH.

Conclusion

Biochemistry provides the chemical foundation for understanding normal physiology, laboratory investigations and clinical nursing care.

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Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which type of chemical bond involves sharing electrons?

A. Ionic
B. Hydrogen
C. Covalent
D. Van der Waals

2. Which cellular structure is principally associated with oxidative metabolism and ATP production?

A. Ribosomes
B. Golgi apparatus
C. Lysosomes
D. Mitochondria

3. Which process builds molecules and usually requires energy?

A. Anabolism
B. Catabolism
C. Hydrolysis

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D. Oxidation

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Answer key and explanations

1. C - Covalent

Covalent bonds share electrons, as in peptide and glycosidic bonds.

2. D - Mitochondria

Mitochondria carry out oxidative metabolism and ATP production.

3. A - Anabolism

Anabolism builds molecules and generally consumes energy.

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