

Biomolecules

Biomolecules

- Living organisms exhibit a vast diversity in the biosphere.
- This raises an important question:
 - Are all living organisms made up of the same types of chemicals (elements and compounds)?

Elemental Analysis

- Elemental analysis is a method used in chemistry to identify and quantify the elements present in a substance.
- When elemental analysis is performed on **living tissues** (such as plant tissue, animal tissue, or microbial paste), the following elements are commonly found:
 - Carbon (C)
 - Hydrogen (H)
 - Oxygen (O)
 - And several others
- These elements are present in specific proportions per **unit mass** of the living tissue.

Comparison Between Living and Non-living Matter

- When the **same analysis** is conducted on **non-living matter** (e.g., a piece of the **earth's crust**):
 - A **similar list of elements** is obtained.
- This shows that:
 - All elements present in living organisms are also found in non-living matter.

Key Difference: Relative Abundance

- The **key difference** lies in the **relative abundance** of certain elements:
 - **Carbon** and **hydrogen** are found in much higher proportions in living organisms compared to non-living matter.

How to Analyze Chemical Composition in Living Organisms

Introduction

- Living organisms contain both organic and inorganic compounds.
- To study these, scientists perform **chemical analysis** of biological tissues.

Experimental Method for Chemical Analysis

A. Preparation of Tissue Sample

- A biological sample (e.g., vegetable, liver, leaf) is:
 - Ground in **trichloroacetic acid (Cl_3CCOOH)** using a mortar and pestle.
 - This forms a **thick slurry**.

B. Filtration and Fractionation

- The slurry is filtered through **cheesecloth or cotton**, yielding two fractions:

1. Acid-soluble pool (Filtrate):

- Contains small, water-soluble organic compounds (e.g., sugars, amino acids, nucleotides).

2. Acid-insoluble fraction (Retentate):

- Contains **macromolecules** such as proteins, nucleic acids (**DNA/RNA**), and polysaccharides.

Analysis Process

A. Organic Compound Analysis

- The compounds in the acid-soluble pool are:
 - Extracted
 - Separated and purified using various techniques.
 - Analyzed to determine their molecular formula and probable structure using analytical methods.
- These organic carbon compounds are termed **biomolecules**.

B. Inorganic Compound Analysis

- To analyze the inorganic content:
 - Take the **wet weight** of a tissue.
 - **Dry** it completely to remove water → this gives **dry weight**.
 - **Burn** the dry tissue → carbon compounds are oxidized to gases (CO_2 and water vapor).
 - The remaining solid is called **ash**.
- Ash contains **inorganic elements** such as:
 - Calcium
 - Magnesium
 - Iron
 - Phosphorus

- Sulphates, Phosphates, and other inorganic ions (also found in the acid-soluble fraction).

Comparison of Elements in Living vs. Non-living Matter

Element	Earth's Crust (%)	Human Body (%)
Oxygen (O)	46.6	65.0
Carbon (C)	0.03	18.5
Hydrogen (H)	0.14	9.5
Nitrogen (N)	Trace	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	Negligible

Inorganic Components in Living Tissues

Component	Chemical Form
Sodium	Na ⁺
Potassium	K ⁺
Calcium	Ca ²⁺
Magnesium	Mg ²⁺
Water	H ₂ O
Other salts	NaCl, CaCO ₃ , PO ₄ ³⁻ , SO ₄ ²⁻

Biologically Important Organic Compounds

1. Amino Acids

- Contain both an **amino group (-NH₂)** and a **carboxyl group (-COOH)** on the **α-carbon**.
- Classified as **α-amino acids** and are substituted methanes with four groups:
 - Hydrogen (H)
 - Carboxyl group (-COOH)
 - Amino group (-NH₂)
 - Side chain (R group)

Examples Based on R-group:

- Glycine – R = H
- Alanine – R = CH₃
- Serine – R = CH₂OH

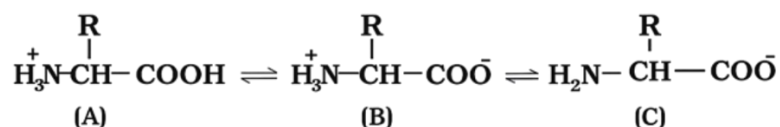
Classification by Nature:

- Acidic amino acids: e.g., Glutamic acid
- Basic amino acids: e.g., Lysine
- Neutral amino acids: e.g., Valine
- Aromatic amino acids: e.g., Tyrosine, Phenylalanine, Tryptophan

Zwitterionic Nature of Amino Acids

- Amino acids exhibit different ionic forms depending on the pH of the solution. The transformation is as follows:

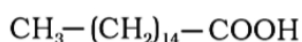
Zwitterion Equilibrium Reaction:



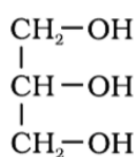
B is called zwitterionic form.

- **(A):** Fully protonated form
- **(B): Zwitterionic form** – contains both a positive and negative charge on the same molecule
- **(C):** Deprotonated form (basic condition)

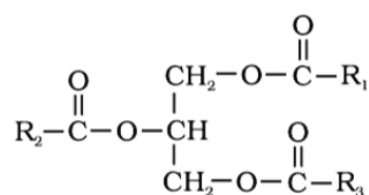
Form B is the zwitterionic form and is predominant at physiological pH (~7.4).



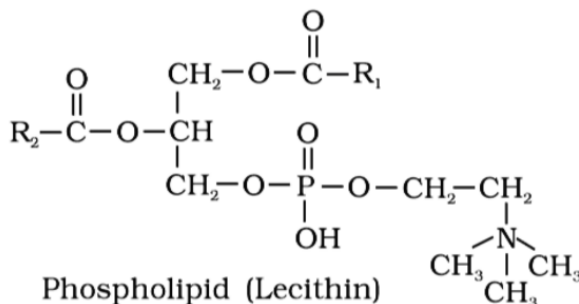
Fatty acid
(Palmitic acid)



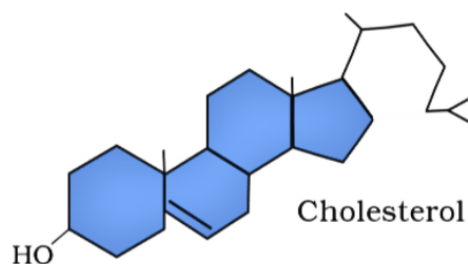
Glycerol



Triglyceride (R₁, R₂ and R₃ are fatty acids)

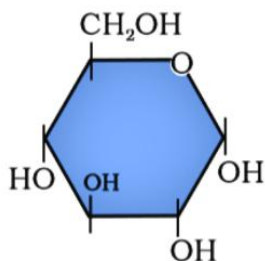
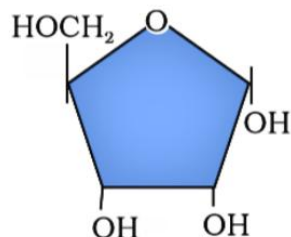
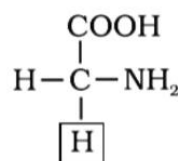


Phospholipid (Lecithin)

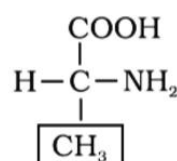


Cholesterol

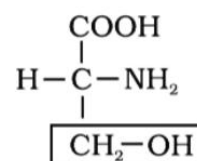
Fats and oils (lipids)

C₆H₁₂O₆ (Glucose)C₅H₁₀O₅ (Ribose)**Sugars (Carbohydrates)**

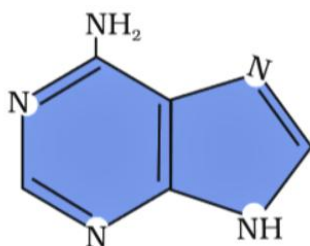
Glycine



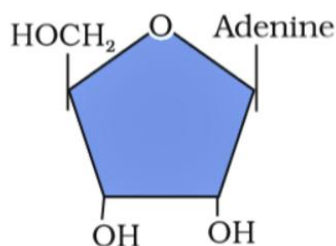
Alanine



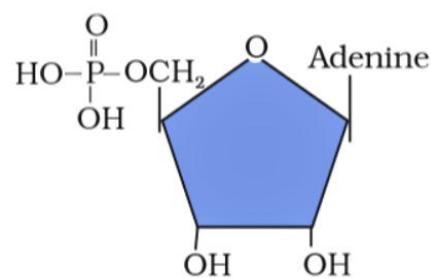
Serine

Amino acids

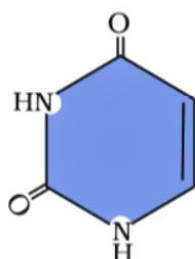
Adenine (Purine)



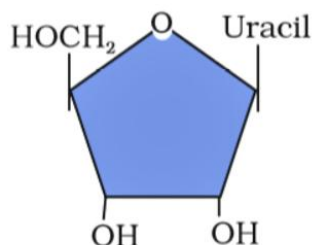
Adenosine



Adenylic acid



Uracil (Pyrimidine)



Uridine

Nitrogen bases**Nucleosides****Nucleotide**

Diagrammatic representation of small molecular weight organic compounds in living tissues

2. Lipids

Composed of **fatty acids** and **glycerol**.

Fatty Acids

- Have a carboxyl group (–COOH) and a hydrocarbon chain (R group)
- Examples:
 - *Palmitic acid* (16 carbons)
 - *Arachidonic acid* (20 carbons)

Types of Lipids**A. Saturated:**

- No C=C double bonds

B. Unsaturated:

- One or more C=C bonds

Glycerol

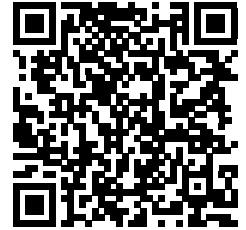


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