Biochemistry

• Study of chemical composition and reactions occurring in **living** matter
• Inorganic Compounds
  • Do not contain carbon
  • Exceptions - CO$_2$, CO, bicarbonates
  • Water is the most abundant and important inorganic material, making up 60% - 80% of all cells and 2/3 of body weight
Organic Compounds

- Contain the element carbon, hydrogen and oxygen.

- Carbon is found in things that are or once were living.

- Carbon atoms share electrons to form covalent bonds.
Organic Compounds

• Organic compounds are composed of hundreds to thousands of individual molecules.
  – The single molecules in a polymer are called **monomers**.

Fructose
Organic Compounds

• The long molecules formed by repeating patterns of monomers are called polymers.
Functional Groups

• A functional group is a group of atoms that characterize the structure of a family of organic compounds.

• Functional groups determine many of the properties of organic compounds.

• 3 Types to Know: Amine (NH$_2$), Carboxyl (COOH), Hydroxyl (OH).
Amine Group

\[ \text{N-H}_2 \]

\[ \text{H}_2\text{N-C-H} \rightarrow \text{COOH} \]
Carboxyl Group

COOH

Functional Groups
Hydroxyl Group

OH
Macromolecules

• 4 Types of Organic Compounds or macromolecules: carbohydrates, lipids, proteins, and nucleic acids.
  – Essential to maintaining life processes: cell function, storage, energy, homeostasis and genetic information.
Carbohydrates

- Make up sugars and starches
-Contain a hydroxyl (OH) group
-Contain atoms of carbon, hydrogen, and oxygen.

- The ratio of the atoms is 1 C : 2 H : 1 O
- Provide energy to the cells.
- Dissolve in water (hydrophilic)
Types of Carbohydrates

- Carbohydrates are classified according to size.
  - One sugar is a **monosaccharide** (monomer).
  - Two sugars make a **disaccharide**.
  - Many sugar molecules linked together form a **polysaccharide** (polymer).
Monosaccharide

Milk Sugar

Fruit Sugar

Galactose

Fructose
Disaccharide

Maltose is two glucose molecules; forms in digestive tract of humans during starch digestion.
Polysaccharide

Starch is a straight chain of glucose molecules with few side branches.
Lipids

- The three types of lipids are fats, oils, and waxes.
- Contain carbon, hydrogen, and oxygen
- Typically contain two monomers — glycerol and fatty acids

Glycerol contains the hydroxyl (OH) group.
Fatty acids contain the carboxyl (COOH) group.
Monomers in Lipids

FATS (Lipids)

Glycerol

Saturated Fatty Acid

Unsaturated Fatty Acid
Functions of Lipids

- Lipids store energy for later use by the body.
- Lipids also serve as padding and protection for the body.
- Lipids do not dissolve in water (hydrophobic), but may contain parts that can dissolve in water.
- The H : O ratio is higher in lipids than it is in carbohydrates.
Structure of a Lipid

- Dissolves in water (hydrophilic)
- Does not dissolve in water (hydrophobic)
Phospholipid

- Found in cell membranes
  - Head is the phosphate group.
    - Hydrophilic
  - Tails are the fatty acids.
    - Hydrophobic
Fatty Acids

• Long chains of carbon atoms with attached hydrogen atoms (hydrocarbons)
• **Saturated fats** contain only single bonds between the carbon atoms.
• **Unsaturated fats** contain one or more double or triple bonds between the carbon atoms.
Saturated & Unsaturated Fats

Saturated fatty acid

Unsaturated fatty acid

[some C-C bonds are dotted to indicate that they pass under H atoms]
Proteins

• Proteins are the building materials for the body.
  – Hair, skin, muscles, and organs are made mostly of proteins.
• Composed of carbon, hydrogen, nitrogen, and oxygen
• Contain amine (NH$_2$) and carboxyl (COOH) groups
Function of Proteins

- The building blocks of proteins are **amino acids** (monomers).
- Serve as **enzymes** which control rate of reactions and regulate cell processes.
- Amino acids are connected by a special type of bond called a **peptide bond**.
- Amino acid chains are called **polypeptides**.
- A protein contains one or more polypeptide chains.

![Chemical structure of a peptide bond](image)
Amino Acids

Glycine
\[
\text{H} \quad \text{H} \quad \text{O}
\]
\[
\text{H} \quad \text{N}^+ \quad \text{C} \quad \text{C} \quad \text{O}^-
\]
\[
\text{H} \quad \text{H}
\]

Alanine
\[
\text{H} \quad \text{H} \quad \text{O}
\]
\[
\text{H} \quad \text{N}^+ \quad \text{C} \quad \text{C} \quad \text{O}^-
\]
\[
\text{H} \quad \text{CH}_3
\]

Cysteine
\[
\text{H} \quad \text{H} \quad \text{O}
\]
\[
\text{H} \quad \text{N}^+ \quad \text{C} \quad \text{C} \quad \text{O}^-
\]
\[
\text{H} \quad \text{CH}_2\text{SH}
\]

H₂O

\[
\text{H} \quad \text{H} \quad \text{O}
\]
\[
\text{H} \quad \text{N}^+ \quad \text{C} \quad \text{C} \quad \text{O}^-
\]
\[
\text{H} \quad \text{H}
\]

peptide bonds

Function of Proteins
Types of Proteins

• There are two types of proteins – fibrous and globular.
  • **Fibrous protein** (found in skin, tendons, bones, and muscles) does not dissolve in water (hydrophobic).
  • **Globular protein** (found in enzymes, some hormones, and hemoglobin) can dissolve in water (hydrophilic).
Fibrous Proteins

- **Keratins** are a family of fibrous structural proteins; tough and insoluble, they form the hard but nonmineralized structures found in reptiles, birds, amphibians and mammals.

Types of Proteins
Globular Proteins

• **Enzymes** are **proteins** that **catalyze** (i.e. **accelerate**) **chemical reactions**.

• Almost all processes in a **biological cell** need enzymes in order to occur at significant rates.