2.4A: Organic Molecules and Functional Groups

Functional groups are groups of molecules attached to organic molecules and give them specific identities or functions.

Learning Objectives

- Describe the importance of functional groups to organic molecules

Key Points

- Functional groups are collections of atoms that attach the carbon skeleton of an organic molecule and confer specific properties.
- Each type of organic molecule has its own specific type of functional group.
- Functional groups in biological molecules play an important role in the formation of molecules like DNA, proteins, carbohydrates, and lipids.
- Functional groups include: hydroxyl, methyl, carbonyl, carboxyl, amino, phosphate, and sulfhydryl.

Key Terms

- **hydrophobic**: lacking an affinity for water; unable to absorb, or be wetted by water
- **hydrophilic**: having an affinity for water; able to absorb, or be wetted by water
Location of Functional Groups

Functional groups are groups of atoms that occur within organic molecules and confer specific chemical properties to those molecules. When functional groups are shown, the organic molecule is sometimes denoted as “R.” Functional groups are found along the “carbon backbone” of macromolecules which is formed by chains and/or rings of carbon atoms with the occasional substitution of an element such as nitrogen or oxygen. Molecules with other elements in their carbon backbone are substituted hydrocarbons. Each of the four types of macromolecules—proteins, lipids, carbohydrates, and nucleic acids—has its own characteristic set of functional groups that contributes greatly to its differing chemical properties and its function in living organisms.

Properties of Functional Groups

A functional group can participate in specific chemical reactions. Some of the important functional groups in biological molecules include: hydroxyl, methyl, carbonyl, carboxyl, amino, phosphate, and sulfhydryl groups. These groups play an important role in the formation of molecules like DNA, proteins, carbohydrates, and lipids.

Classifying Functional Groups

Functional groups are usually classified as hydrophobic or hydrophilic depending on their charge or polarity. An example of a hydrophobic group is the non-polar methane molecule. Among the hydrophilic functional groups is the carboxyl group found in amino acids, some amino acid side chains, and the fatty acid heads that form triglycerides and phospholipids. This carboxyl group ionizes to release hydrogen ions (H⁺) from the COOH group resulting in the negatively charged COO⁻ group; this contributes to the hydrophilic nature of whatever molecule it is found on. Other functional groups, such as the carbonyl group, have a partially negatively charged oxygen atom that may form hydrogen bonds with water molecules, again making the molecule more hydrophilic. The functional groups shown here are found in many different biological molecules, where “R” is the organic molecule.

Important Functional Groups in Biology

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Structure</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyl</td>
<td>![hydroxyl](<a href="https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_(Boundless)/2%3A_T%E2%80%A6">https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_(Boundless)/2%3A_T…</a></td>
<td>Polar</td>
</tr>
<tr>
<td>Methyl</td>
<td>![methyl](<a href="https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_(Boundless)/2%3A_T%E2%80%A6">https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_(Boundless)/2%3A_T…</a></td>
<td>Nonpolar</td>
</tr>
</tbody>
</table>
Important Functional Groups in Biology

Carbonyl

\[
R - C = R'
\]

Polar

Carboxyl

Charged, ionized to release H\(^{+}\). Since carboxyl groups can release H\(^{+}\) ions into a solution, they are considered acidic.

\[
R \quad C \quad OH
\]

Amino

Charged, accepts H\(^{+}\) to form NH\(_3^{+}\). Since amino groups can remove H\(^{+}\) from solution, they are considered basic.

\[
R \quad N \quad H
\]

Phosphate

Charged, ionizes to release H\(^{+}\). Since phosphate groups can release H\(^{+}\) ions into solution, they are considered acidic.

\[
R \quad P \quad OH \quad OH
\]

Sulphydryl

Polar

\[
R \quad S \quad H
\]

Hydrogen Bonds between Functional Groups

Hydrogen bonds between functional groups (within the same molecule or between different molecules) are important to the function of many macromolecules and help them to fold properly and maintain the appropriate shape needed to function correctly. Hydrogen bonds are also involved in various recognition processes, such as DNA complementary
base pairing and the binding of an enzyme to its substrate.

**Hydrogen bonds in DNA:** Hydrogen bonds connect two strands of DNA together to create the double-helix structure.