3.1: Organic Compounds

Learning objectives

- Define the terms organic compound and macromolecule, and list the four groups of organic compounds found in living matter
- Define functional groups and give examples

Animal tissues, plant tissues, bacteria, and fungi contain organic molecules; horns and nails, fallen leaves, eggs, fruits and vegetables contain organic compounds; wood, milk, paper, petroleum and gasoline contain organic compounds. In summary, all living matter, parts or products of living matter and remains of living matter contain organic compounds. Organic molecules associated with living organisms are also called biomolecules.

**Organic compounds** are molecules that contain carbon atoms covalently bonded to hydrogen atoms (C-H bonds). Many organic compounds are formed from chains of covalently-linked carbon atoms with hydrogen atoms attached to the chain (a hydrocarbon backbone). This means that all organic compounds have in common the presence of carbon atoms and hydrogen atoms. In addition, different organic compounds may contain oxygen, nitrogen, phosphorus, and other elements. Carbon dioxide (CO$_2$) does not have hydrogen; then, it is not an organic compound. Water (H$_2$O) has no carbon; then, it is not an organic compound. Sodium chloride has neither carbon nor hydrogen; then, it is not an organic compound. Generally, gases, and mineral salts (inorganic substances found in soil, or bodies of water or watercourses) are not organic.
Organic molecules have a diversity of shapes and sizes due to carbon’s ability to form four covalent bonds. Carbon can form long chains (such as the fatty acid seen in a); branched chains (as seen in b); rings (such as the cholesterol seen in c); or branched chains of rings (as the seen in d).

Most organic compounds making up our cells and body belong to one of four classes: carbohydrates, lipids, proteins, and nucleic acids. These molecules are incorporated into our bodies with the food we eat. In general, molecules in these four classes are very large, and we often call large molecules macromolecules (macro- = “very large”, or “on a large scale”).

Carbohydrate-rich food
Figure \(\PageIndex{3}\)) Protein-rich food

Figure \(\PageIndex{4}\)) Lipid-rich food

Figure \(\PageIndex{5}\)) Two types of nucleic acids, RNA and DNA
Study Question Write your answer in a sentence form (do not answer using loose words)

1. What is a biomolecule?
2. What is an organic compound?
3. What is a macromolecule?
4. What are the four classes of biomolecules found in living things?

Number of carbons that form the backbone of an organic compound, and shape of it (long chain, branched chain, ring) are not the only features that determine organic compounds properties. Groups of atoms of other elements associated to the carbon backbone give unique properties to the millions of different types of organic molecules. A specific group of atoms linked by strong covalent bonds is called a functional group. There are many important functional groups in human physiology. Some of them are hydroxyl, carboxyl, amino, methyl and phosphate groups.

<table>
<thead>
<tr>
<th>Functional group</th>
<th>Molecular Formula</th>
<th>Importance</th>
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<tbody>
<tr>
<td>Hydroxyl</td>
<td>-OH</td>
<td>Hydroxyl groups are polar. They are especially common in carbohydrates.</td>
</tr>
<tr>
<td>Carboxyl (Acid)</td>
<td>-COOH</td>
<td>Carboxyl groups are polar. They are found within fatty acids, amino acids (building blocks of proteins), and many other organic acids.</td>
</tr>
<tr>
<td>Amino</td>
<td>-NH₂</td>
<td>Amino groups are polar. They are found within amino acids (building blocks of proteins).</td>
</tr>
<tr>
<td>Methyl</td>
<td>-CH₃</td>
<td>Methyl groups are not polar. They are found in many organic compounds.</td>
</tr>
<tr>
<td>Phosphate</td>
<td>-PO₄²⁻</td>
<td>Phosphate groups are polar. They are found within phospholipids (building blocks of cell membranes), nucleotides (building blocks of nucleic acids), and many proteins.</td>
</tr>
</tbody>
</table>

Study Question Write your answer in a sentence form (do not answer using loose words)

1. What is a functional group?