• Objectives
  • Explain how carbon’s electron configuration accounts for its ability to form large, complex, and diverse organic molecules.
  • Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.
  • Describe the basic structure of a hydrocarbon and explain why these molecules are hydrophobic.
  • Distinguish among the three types of isomers: structural, geometric, and enantiomer.

• Name the major functional groups found in organic molecules. Describe the basic structure of each functional group and outline the chemical properties of the organic molecules in which they occur.
• Carbon is unparalleled in its ability to form large, complex, and varied molecules — organic chemistry is the study of carbon compounds
  • organic compounds range from simple molecules to colossal ones
• Living organisms consist mostly of carbon-based compounds
  — proteins, DNA, carbohydrates, and other molecules that distinguish living matter are all composed of carbon compounds

— Carbon can bond to four other atoms or groups of atoms, making a large variety of molecules possible.

• The concept of vitalism is the idea that organic compounds arise only within living organisms
  — disproved when Friedrich Wohler accidently synthesized urea from ammonium cyanate in 1828
• Stanley Miller’s classic experiment demonstrated the abiotic synthesis of organic compounds
  – experiments support the idea that abiotic synthesis of organic compounds, perhaps near volcanoes, could have been a stage in the origin of life
The Formation of Bonds with Carbon

- Carbon can form four covalent bonds with other carbon atoms.
- Linked carbon atoms form the backbone of organic molecules:
  - in molecules with multiple carbons, each carbon bonded to four other atoms has a tetrahedral shape.
  - however, when two carbon atoms are joined by a double bond, the atoms joined to the carbons are in the same plane as the carbons.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Molecular Formula</th>
<th>Structural Formula</th>
<th>Ball-end-Stick Model</th>
<th>Space-Filling Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Methane</td>
<td>CH₄</td>
<td>H – C – H – H</td>
<td><img src="image" alt="Methane Ball-end Stick Model" /></td>
<td><img src="image" alt="Methane Space-Filling Model" /></td>
</tr>
<tr>
<td>(b) Ethane</td>
<td>C₂H₆</td>
<td>H – H – C – C – H</td>
<td><img src="image" alt="Ethane Ball-end Stick Model" /></td>
<td><img src="image" alt="Ethane Space-Filling Model" /></td>
</tr>
<tr>
<td>(c) Ethene (Ethylene)</td>
<td>C₂H₄</td>
<td>H – C = C – H</td>
<td><img src="image" alt="Ethene Ball-end Stick Model" /></td>
<td><img src="image" alt="Ethene Space-Filling Model" /></td>
</tr>
</tbody>
</table>

- The electron configuration of carbon gives it covalent compatibility with many different elements.
Molecular Diversity Arising from Carbon Skeleton Variation

- Carbon chains form the skeletons of most organic molecules
  - chains vary in length and shape
- Carbon backbone maybe linear, branched or circular
Isomers

- The versatility of carbon’s bond forming is the basis for isomers
  - molecules with the same molecular formula but different structures and properties
  - three types of isomers
    - structural
    - geometric
    - enantiomers

- important to pharmaceutical industry as molecules used as drugs often have enantiomers which have no or undesired effects
  - thalidomide
    - one enantiomer acts as sedative, other causes severe birth defects
  - L-dopamine and D-dopamine
    - one useful in treating Parkinson’s disease, other has no effect
Hydrocarbons

- Hydrocarbons are molecules consisting of only carbon and hydrogen
  - hydrocarbons are found in many of a cell’s organic molecules
The Functional Groups Most Important in the Chemistry of Life

- Functional groups covalently linked to the carbon backbone of hydrocarbons give the molecule distinctive chemical properties

- Seven functional groups are important in the chemistry of life:
  - hydroxyl (-OH): polar, dissolves in water
  - carbonyl (=CO): polar, dissolves in water
  - carboxyl (-COOH): hydrogen dissociates; weak acid
  - amino (-NH$_2$): accepts hydrogen; basic
  - sulfhydryl (-SH): can form disulfide bonds
  - phosphate (-PO$_4$): acidic and polar, dissolves in water
  - methyl (-CH$_3$): non-polar
Addition of different side groups to the same backbone significantly changes a molecule’s action.

- compare estradiol (female sex hormone) with testosterone (male sex hormone)
ATP: An Important Source of Energy for Cellular Processes

- An important organic phosphate is adenosine triphosphate (ATP)
  - ATP consists of an organic molecule called adenosine attached to a string of three phosphate groups
  - ATP stores the potential to react with water, a reaction that releases energy to be used by the cell