Organic Chemistry

Vocabulary
- Adhesion
- Cohesion
- Atom
- Concentration
- Biological macromolecules
- Monomer
- Freezing point
- Carbohydrate
- Amino acid
- Protein
- Macromolecule
- Lipid
- Nucleic acid
- Enzyme
- Catalyst
- pH
- Molecule
- Specific heat
- Organic molecule

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Concepts to Know

1st Idea: Due to its properties, carbon is uniquely suited to form biological macromolecules.

➔ Use the diagrams below to fill in the blanks and describe why carbon is so important to life.

Figure 2: Covalent Bonding between Carbon and Hydrogen

- Electron from hydrogen
- Electron from carbon
• Carbon has **4 electrons** in the outer (valence) shell
  o **Valence shell** enables easy formation of four covalent bonds
  o **Covalent bonds** involve sharing of **electrons** between two atoms

![Diagram of carbon molecule]

Carbon has the ability to form **long chains** by forming several bonds in a row

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*Use the diagrams to fill in the blanks and describe how the variety of organic compounds can be explained by carbon's properties.*

![Diagram of organic compounds]

[H = Hydrogen, C = Carbon, - indicates a chemical bond between atoms]

• **Organic compounds** – Contain **carbon**

• **Variety** is created by the many partners that carbon can bond with

• **Properties** include polarity of molecule

• **Polarity** is a description of the balance of charges in a molecule
  - **Polar** means the charges are not balanced
  - **Nonpolar** means an even balance of charges

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**Water, a polar molecule**

**Ethane, a nonpolar molecule**
2nd Idea: Biological macromolecules form from monomers.

Use the diagrams to fill in the blanks and describe how carbon allows for the formation of macromolecules.

- Macromolecules are very large molecules
- Most macromolecules are polymers
- Polymers are long chains of bonded groups
- Monomers are the molecules that link to form polymers

Dehydration Synthesis generates water and is a common way for polymers to form

Hydrolysis is the process of breaking apart polymers

Use the outline above and video called “The Molecules of Life” (https://udkeystone.wikispaces.com/Organic+Chemistry) to complete the following concept map and answer the review questions at the end of this section.

MACROMOLECULES: STRUCTURE AND FUNCTION

- Diversity of life depends on carbon to make possible evolution of structural and functional properties
- Carbon can build complex organic molecules and can bind with functional groups to confer specific properties

A. Essential to
B. 4 covalent bonds
C. Complex organic molecules
D. Functional groups
E. Diversity

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Carbohydrates are broken down through hydrolysis to serve as fuel for the body or a source of carbon.

- Saccharide means sugar.

Carbohydrates can be:

- **Monosaccharides** (1 sugar)
- **Disaccharides**, (2 sugars), or
- **Polysaccharides** (more than 2 sugars)

<table>
<thead>
<tr>
<th>Class</th>
<th>Monomers</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Monosaccharides</td>
<td>Energy, raw materials, energy storage, structural compounds</td>
</tr>
<tr>
<td>Lipids</td>
<td>Glycerol, fatty</td>
<td>Energy storage, membranes, steroids, hormones</td>
</tr>
<tr>
<td></td>
<td>acids, steroids</td>
<td></td>
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<tr>
<td>Proteins</td>
<td>Amino acids</td>
<td>Enzymes, transport, movement, receptors, defense, structure</td>
</tr>
<tr>
<td>Nucleic acids</td>
<td>Nucleotides</td>
<td>Heredity, code for amino acid sequence</td>
</tr>
</tbody>
</table>
**Glycolysis** breaks down carbohydrates like glucose for use in cellular respiration.

**Cellular respiration** is the process through which the body generates energy, or ATP.

**Lipids** are nonpolar macromolecules made from long carbon chains.
- Lipids can be **fats**, **phospholipids**, or **steroids**.
- **Fats** store large amounts of energy.
- **Phospholipids** compose cell membranes.
- **Steroids** are made of four connected carbon rings with functional groups attached.
Lipids can be saturated or unsaturated. Saturated lipids have a linear (straight) shape and only single bonds between carbons, while unsaturated lipids have a nonlinear shape and double or triple bonds.

Proteins are amino acid polymers that are essential to life. Amino acids have amino and carboxylic groups. They are made unique by the “R” group that is attached to carbon. “R” is like a variable in algebra class. It can have many values (structures). Function of the amino acid is determined by the structure and conformation of the “R” group.

Nucleic acids are polymers of nucleotides. Nucleotides are monomers that consist of pentose (the hexagon shape in the diagram) attached to a phosphate group (in red on diagram) and nitrogen base (in blue on diagram). Pentose can be deoxyribose (as in DNA or deoxyribose nucleic acid) or ribose (as in RNA or ribose nucleic acid). DNA and RNA are central to heredity and are made unique by the nitrogenous base that is attached.

Nitrogenous bases can be cytosine (C), thymine (T), uracil (U), adenine (A), or guanine (G).
3rd Idea: Enzymes are mostly macromolecule proteins that act as biological catalysts

- Catalysts increase the rate of a reaction without being changed by the reaction
- Substrates are the reactants on which enzymes (catalysts) work
- Rate of reaction in both directions is increased by the presence of specific enzymes.
- Active site refers to the part of an enzyme that interacts with a substrate

The rate of a reaction involving enzymes has to speed up at times and slow down at other times based on the needs of the organism.

- Use the outline above and video called “Biological Molecules” (https://udkeystone.wikispaces.com/Organic+Chemistry) to answer the review questions at the end of this section.

- Use the video called “Enzymes” (https://udkeystone.wikispaces.com/Organic+Chemistry) to answer the questions
- The process of turning enzymes on occurs through Regulation or Activation
  - Regulation means the body only produces the enzyme when it is needed
  - Activation means the enzyme is present, but will not work until the body makes another chemical to turn the enzyme on
- Deactivation of enzymes occurs through Competitive or Allosteric inhibition
  - Competitive inhibition means another chemical bonds with and block the active site of the enzyme
  - Allosteric inhibition means another chemical bonds to the enzyme in a position away from the active site, but blocks or alters the active site as a result
4th Idea: Enzyme reaction rates are impacted by temperature, pH & substrate concentration

- **Temperature** is a measure of kinetic energy
  - Kinetic energy is the energy of motion. Higher temperature means faster moving particles.
  - The number of collisions between enzymes and substrates is increased if the particles move around faster (higher temperature)
  - Enzymes do not function well above or below the optimal temperature
  - The enzyme denatures, or breaks down, if the enzyme gets too hot

- **pH** measures acidity
  - Enzymes function best at the optimal pH level
  - If the conditions are too acidic (low pH) or too basic (high pH), the enzyme may denature

- **Concentration** is a measure of how many substrate molecules are present in a given volume.
  - Point of saturation is the concentration where the reaction rate is maximized, the active sites of the enzymes are all used adding more substrate does not increase the rate of reaction.
Use the outline above and video called “Enzymes” ([https://udkeystone.wikispaces.com/Organic+Chemistry](https://udkeystone.wikispaces.com/Organic+Chemistry)) to answer the questions on the next page.

**Practice Questions:**

1. Which statement correctly describes how carbon’s ability to form four bonds makes it uniquely suited to form macromolecules?
   - A. It forms short, simple carbon chains.
   - B. **It forms large, complex, diverse molecules.**
   - C. It forms covalent bonds with other carbon atoms.
   - D. It forms covalent bonds that can exist in a single plane.

2. The diagram shows a reaction that forms a polymer from two monomers. What is this type of reaction called?
   - A. glycolysis
   - B. hydrolysis
   - C. photosynthesis
   - D. dehydration synthesis

3. Carbohydrates and proteins are two types of macromolecules. Which functional characteristic of proteins distinguishes them from carbohydrates?
   - A. large amount of stored information
   - B. **ability to catalyze biochemical reactions**
   - C. efficient storage of usable chemical energy
   - D. tendency to make cell membranes hydrophobic

4. Substance A is converted to substance B in a metabolic reaction. Which statement **best** describes the role of an enzyme during this reaction?
   - A. It adjusts the pH of the reaction medium.
   - B. It provides energy to carry out the reaction.
   - C. It dissolves substance A in the reaction medium.
   - D. **It speeds up the reaction without being consumed.**

5. A scientist observes that, when the pH of the environment surrounding an enzyme is changed, the rate the enzyme catalyzes a reaction greatly decreases. Which statement **best** describes how a change in pH can affect an enzyme?
A. A pH change can cause the enzyme to change its shape.
B. A pH change can remove energy necessary to activate an enzyme.
C. A pH change can add new molecules to the structure of the enzyme.
D. A pH change can cause an enzyme to react with a different substrate.

6. Whenever biological organic compounds, such as proteins and carbohydrates, are broken down or synthesized...
   A. a phase change of matter results.
   B. thermal expansion occurs.
   C. sunlight is required.
   D. energy is absorbed or released.

7. Why does an enzyme function as a catalyst in a reaction?
   A. It creates the right pH needed for the reaction.
   B. It decreases the amount of energy needed for the reaction.
   C. It provides the extra energy needed for the reaction.
   D. It maintains the proper temperature needed for the reaction.

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Examine the structural formula below.

8. Which of the following biomolecules is best represented by this formula?
   A. nucleic acid
   B. protein
   C. carbohydrate
   D. lipid
9. Proteins are a major part of every living cell and have many different functions within each cell. Carbohydrates also perform numerous roles in living things.

**Part A:** Describe the general composition of a protein molecule.

A Proteins is a polymer of amino acid molecules. The amino acids are joined by dehydration synthesis which forms peptide bonds. C, H, N, S, and O are typical atoms that compose amino acids.

**Part B:** Describe how the structures of proteins differ from the structures of carbohydrates

• Proteins are made up of the elements C, H, O, and N while carbohydrates only contain C, H, and O (elemental ratio of these three is 1:2:1)

• Carbohydrates do not contain peptide bonds formed during dehydration synthesis (also known as a condensation reaction)

  The amino acids contain amino and carboxyl groups. Primary, secondary, tertiary, and quaternary structures of a protein molecule are necessary for the protein to function correctly. Interactions occur between amino and carboxyl groups of amino acids.

  Carbohydrates are composed of C, H, and O. Monosaccharides are the building blocks of carbohydrates. Two monosaccharides form a disaccharide. Many monosaccharides form a polysaccharide, such as starch, cellulose, or chitin.

**Part C:** Describe how the functions of proteins differ from the functions of carbohydrates

Proteins function as enzymes, antibodies, and structural components.

Carbohydrates function in short-term energy storage (starch, glycogen) or structural components (chitin, cellulose, glycogen).