**Biochemistry Student Objectives**

**<u>Enduring understanding 2.A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.</u>**

**Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.**

a. Molecules and atoms from the environment are necessary to build new molecules.

*Evidence of student learning is a demonstrated understanding of each of the following:*

1. Carbon moves from the environment to organisms where it is used to build carbohydrates, proteins, lipids or nucleic acids. Carbon is used in storage compounds and cell formation in all organisms.
2. Nitrogen moves from the environment to organisms where it is used in building proteins and nucleic acids.
3. Phosphorus moves from the environment to organisms where it is used in nucleic acids and certain lipids.

student objectives:

4. Living systems depend on properties of water that result from its polarity and hydrogen bonding.

*To demonstrate understanding of this concept, be able to explain water's:*

- Cohesion
- Adhesion
- High specific heat capacity
- Universal solvent supports reactions
- Heat of vaporization
- Heat of fusion
- thermal conductivity

**student objectives:**

- **why is matter necessary for biological systems?**
- **explain the uses of carbon, hydrogen, oxygen, nitrogen, phosphorous and sulfur in biological systems.**
- **Diagram the exchange of matter between organisms and the environment.**
- **what function does nitrogen serve in proteins? In nucleic acids?**
- **what function does phosphorus serve in nucleic acids? In phospholipids?**
- **Why do biological systems need water?**
- **How does the structure of a water molecule relate to its function(s)?**
- **How does the polarity of water lead to the emergence of unique properties in liquid water?**

**<u>Enduring understanding 4.A: Interactions within biological systems lead to complex properties.</u>**

**Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.**

a. Structure and function of polymers are derived from the way their monomers are assembled.

*Evidence of student learning is a demonstrated understanding of each of the following:*

1. In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate and a nitrogen base (adenine, thymine, guanine, cytosine or uracil). DNA and RNA differ in function and differ slightly in structure, and these structural differences account for the differing functions.
2. In proteins, the specific order of amino acids in a polypeptide (primary structure) interacts with the environment to determine the overall shape of the protein, which also involves secondary tertiary and quaternary structure and, thus, its function. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic and ionic), and the interactions of these R groups determine structure and function of that region of the protein.
3. In general, lipids are nonpolar; however, phospholipids exhibit structural properties, with polar regions that interact with other polar molecules such as water, and with nonpolar regions where differences in saturation determine the structure and function of lipids.
4. Carbohydrates are composed of sugar monomers whose structures and bonding with each other by dehydration synthesis determine the properties and functions of the molecules. Illustrative examples include: cellulose versus starch.

b. Directionality influences structure and function of the polymer.

*Evidence of student learning is a demonstrated understanding of each of the following:*

1. Nucleic acids have ends, defined by the 3' and 5' carbons of the sugar in the nucleotide, that determine the direction in which complementary nucleotides are added during DNA synthesis and the direction in which transcription occurs (from 5' to 3').

2. Proteins have an amino (NH2) end and a carboxyl (COOH) end, and consist of a linear sequence of amino acids connected by the formation of peptide bonds by dehydration synthesis between the amino and carboxyl groups of adjacent monomers.
3. The nature of the bonding between carbohydrate subunits determines their relative orientation in the carbohydrate, which then determines the secondary structure of the carbohydrate.

**student objectives:**

- **Compare the synthesis and decomposition of biological macromolecules.**
- **Where does the energy needed to drive the synthesis of biological macromolecules come from?**
- **How does the structure of <polysaccharides, proteins, nucleic acids> influence the function of those molecules?**
- **How does the structure of DNA contribute to it's roles in protein synthesis and heritability?**
- **Why is DNA a good molecule for information storage?**
- **How do the differences in the structure of DNA and RNA contribute to the difference in the functions of those molecules?**
- **Explain how the sequence of amino acids in a protein determines each level of that protein's structure.**
- **Explain how the conditions of the environment that a protein is in affect the structure and function of that protein.**
- **Explain how the structure of lipids determines the polarity of the molecule.**
- **If the chemistry of water occurs in aqueous solution, why are lipids useful in biological systems?**
- **Why is starch easily digested by animals, while cellulose isn't?**
- **Explain how directionality influences structure and function of the following polymer:**
    1. **Nucleic acids**
    2. **Proteins**
    3. **Carbohydrates**

Learning Objectives:

- The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties.
- The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.
- The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.