Unit: Biochemistry

- *Organic Molecules in organisms*
- *Properties of water*

- *KEY CONCEPTS: structure determines function, interactions provide essential cellular processes, variation creates wider range of function*
- *KEY EXAMPLES: nitrogen cycle, carbon cycle, water cycle, protein structure and function*
- *KEY MATH SKILLS: pH equation, dilution equation*

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

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.

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. Phosphorus moves from the environment to organisms where it is used in nucleic acids and certain lipids.

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

Enduring understanding 4.A: Interactions within biological systems lead to complex properties.

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.

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. [See also **1.D.1, 2.A.3, 3.A.1**]

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. [See also **1.D.1, 2.A.3, 2.B.1**]

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. [See also **1.D.1, 2.A.3, 2. B.1**]

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.

b. Directionality influences structure and function of the polymer.

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'). [See also **3.A.1**]

2. Proteins have an amino (NH_2) 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.

Can You Questions:

1. Discuss how the properties of water affect living systems?
2. Compare and contrast covalent bonding and ionic bonding?
3. Explain the processes of hydrogen bonding?
4. Explain the structure and function of a variety of carbohydrates, lipids, proteins and nucleic acids?
5. Explain how variation in molecules allows cells to have a wide range of functions?

1. A glass of orange juice with a pH of 4 has a hydroxide ion concentration of

   A) 4.0
   B) 1×10^{-10}
   C) 1×10^{-4}
   D) 10%
   E) 10

2. Water sustains life on Earth by all of the following properties EXCEPT

   A) Low density of its solid form due to hydrogen bonding.
   B) Ability to act as a versatile solvent due to the polarity of H_2O molecule
   C) Neutral pH from the equal concentrations of H^+ and OH^- ions
   D) Capillary action from cohesion and adhesion
   E) low surface tension from double covalent bonds

3. Proteins control body chemistry in all of the following ways EXCEPT

   A) serving as transport molecules such as hemoglobins
   B) protecting our bodies against foreign pathogens in the form of antibodies.
   C) specifying the amount of blood in the body
   D) serving as transport molecules such as myoglobins
   E) catalyzing chemical reactions in biological systems

4. Which of the following is *directly* responsible for water being liquid at room temperature?

   A) Covalent bonds are weaker than hydrogen bonds
   B) Water is a universal solvent
   C) Hydrogen bonds link water molecules together
   D) Water has a high heat capacity
   E) Water is stable due to strong covalent bonds

5. Which of the following molecules is correctly paired with its function?

   A) glycogen – energy storage in plants
   B) cellulose – main component of insect exoskeletons
   C) chitin – withstands turgor pressure in Fungi cell walls
   D) amylose - energy reserve stored in animal liver
   E) lignin - main component in Moneran cell walls

6. The following relationships between the structure and its defining feature are correct EXCEPT

   A) Primary structure – amino acid sequence
   B) Tertiary structure – bonding between radical groups
   C) Secondary structure – β pleated sheet
   D) Quaternary structure – hydrophobic interactions
   E) Enzyme-substrate complex – conformation of active site

7. Base your answer to the following question on During the winter Lake Michigan freezes over trapping the living organisms under a sheet of solid ice. As the temperature drops the hydrogen bonds between water molecules get locked into a crystalline lattice.

   Which of the following can be attributed to the fact that the bottom of the lake doesn't freeze solid?

   A) The organisms' metabolic activity produces enough heat to prevent solidification.
   B) The solutes distributed in the lake have a higher freezing point.
   C) Water expands as it solidifies making ice water less dense than liquid water.
   D) Hydrogen bonds are constantly breaking and reforming.
   E) The hydration shell surround the ice prevents it from extending past the surface.

1. C
2. E
3. C
4. C
5. C
6. D
7. C