**UNIT 1-Chemistry of Life**

**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**

***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. 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.   
  
To foster student understanding of this concept, instructors can choose an illustrative example such as:   
 • Cohesion   
 • Adhesion   
 • High specific heat capacity   
 • Universal solvent supports reactions   
 • Heat of vaporization   
 • Heat of fusion   
 • Water's thermal conductivity

LO 2.8 The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products. [See **SP 4.1**]

LO 2.9 The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. [See **SP 1.1, 1.4**]

**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**

Enduring understanding 3.A: Heritable information provides for continuity of life.

***Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.*** a. Genetic information is transmitted from one generation to the next through DNA or RNA.   
 *Evidence of student learning is a demonstrated understanding of each of the following:*   
 1. Genetic information is stored in and passed to subsequent generations through DNA   
 molecules and, in some cases, RNA molecules.   
 2. Noneukaryotic organisms have circular chromosomes, while eukaryotic organisms have   
 multiple linear chromosomes, although in biology there are exceptions to this rule.   
 3. Prokaryotes, viruses and eukaryotes can contain plasmids, which are small extra-  
 chromosomal, double-stranded circular DNA molecules.

b. DNA and RNA molecules have structural similarities and differences that define function.   
 [See also **4.A.1**]   
 *Evidence of student learning is a demonstrated understanding of each of the following:* 1. Both have three components — sugar, phosphate and a nitrogenous base — which   
 form nucleotide units that are connected by covalent bonds to form a linear molecule   
 with 3' and 5' ends, with the nitrogenous bases perpendicular to the sugar-phosphate   
 backbone.  
 2. The basic structural differences include:   
 i. DNA contains deoxyribose (RNA contains ribose).   
 ii. RNA contains uracil in lieu of thymine in DNA  
 iii. DNA is usually double stranded, RNA is usually single stranded  
 iv. The two DNA strands in double-stranded DNA are antiparallel in directionality  
 3. Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through   
 evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with   
 guanine (C-G).  
 i. Purines (G and A) have a double ring structure.  
 ii. Pyrimidines (C, T and U) have a single ring structure.   
 4. The sequence of the RNA bases, together with the structure of the RNA molecule,   
 determines RNA function  
 i. mRNA carries information from the DNA to the ribosome.  
 ii. tRNA molecules bind specific amino acids and allow information in the mRNA to be   
 translated to a linear peptide sequence   
 iii. rRNA molecules are functional building blocks of ribosomes.   
 iv. The role of RNAi includes regulation of gene expression at the level of mRNA   
 transcription

Learning Objectives:

**LO 3.1** The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information. [See **SP 6.5**]

**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**   
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.   
 *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. [See also **1.D.1, 2.A.3, 3.A.1**]   
 ✘✘ *The molecular structure of the specific nucleotides is beyond the scope of the course and of the AP Exam.* 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**]   
✘✘ *The molecular structure specific amino acids is beyond the scope of the course and of the AP Exam.* 3. In general, lipids are non-polar; however, phospholipids exhibit structural properties, with   
 polar regions that interact with other polar molecules such as water, and with non-polar   
 regions where differences in saturation determine the structure and function of lipids. [  
 See also **1.D.1, 2.A.3, 2. B.1**]   
✘✘ *The molecular structure of specific lipids is beyond the scope of course and the AP Exam.* 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.   
✘✘ *The molecular structure of specific carbohydrate polymers is beyond the scope of the course and the AP Exam.*

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

Learning Objectives:   
**LO 4.1** The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [See **SP 7.1**]  **LO 4.2** 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. [See **SP 1.3**]

**LO 4.3** 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. [See **SP 6.1, 6.4**]