Unit 1: Chemistry of Life (*3 weeks*)

Chapters:

- 2 – The Chemical Context of Life (pg. 28–43)
- 3 – Water and the Fitness of the Environment (pg. 44–55)
- 4 – Carbon and the Molecular Diversity of Life (pg. 56–65)
- 5 – The Structure and Function of Large Biological Molecules (pg. 66–91)
- 8 – An introduction to metabolism (153-161)

AP College Board Investigation:

- Investigation 13: Enzyme Activity

Big Ideas: 2, 3, 4

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

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

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring Understanding	Standard(s)				Section(s)
SYI-1	Living systems are organized in a hierarchy of structural levels that interact.				Section(s): 3.1, 3.2, 3.3
	Learning Objective		**Essential Knowledge**	**Science Practice**	
				2.A Describe characteristics of a biological concept, process, or model represented visually.	
	SYI-1.A	Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.	SYI-1.A.1	The subcomponents of biological molecules and their sequence determine the properties of that molecule.	
			SYI-1.A.2	Living systems depend on properties of water that result from its polarity and hydrogen bonding.	
			SYI-1.A.3	The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.	
ENE-1	The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules				Section(s): 4.1, 4.2, 4.3, 2.1, 2.2, 2.3
	Learning Objective		**Essential Knowledge**	**Science Practice**	
				2.A Describe characteristics of a biological concept, process, or model represented visually.	
	ENE-1.A	Describe the composition of macromolecules required by living organisms.	ENE-1.A.1	Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	
			ENE-1.A.2	Atoms and molecules from the environment are necessary to build new molecules— a. Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Carbon is used in storage compounds and cell formation in all organisms. b. Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.	
SYI-1	Living systems are organized in a hierarchy of structural levels that interact.				
	Learning Objective		**Essential Knowledge**	**Science Practice**	Section(s): 5.1, 5.2, 5.3, 5.4, 5.5
				2.A Describe characteristics of a biological concept,	

			process, or model represented visually.	
SYI-1.B	Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.	SYI-1.B.1	Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.	
		SYI-1.B.2	Structure and function of polymers are derived from the way their monomers are assembled— a. 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 structure and function. b. In proteins, the specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. Amino acids have directionality, with an amino (NH2) terminus and a carboxyl (COOH) terminus. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, or ionic), and the interactions of these R groups determine structure and function of that region of the protein. c. Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules. d. Lipids are nonpolar macromolecules— i. Differences in saturation determine the structure and function of lipids. ii. Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions that are often hydrophobic	
SYI-1.C	Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.	SYI-1.C.1	Directionality of the subcomponents influences structure and function of the polymer— a. Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3’ hydroxyl and 5’ phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3’ end of the growing strand, resulting in the formation of a covalent bond between nucleotides. b. DNA is structured as an antiparallel double helix, with each strand running in opposite 5’ to 3’ orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds. c. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain. d. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the	

				overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein. e. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched	
IST-1	Heritable information provides for continuity of life.				Section(s): 5.5
	Learning Objectives		**Essential Knowledge**	**Science Practice(s)**	
				2.A Describe characteristics of a biological concept, process, or model represented visually.	
	IST-1.A	Describe the structural similarities and differences between DNA and RNA.	IST-1.A.1	DNA and RNA molecules have structural similarities and differences related to their function— a. Both DNA and RNA have three components—sugar, a phosphate group, and a nitrogenous base—that form nucleotide units that are connected by covalent bonds to form a linear molecule with 5’ and 3’ ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone. b. The basic structural differences between DNA and RNA include the following: i. DNA contains deoxyribose and RNA contains ribose. ii. RNA contains uracil and DNA contains thymine. iii. DNA is usually double stranded; RNA is usually single stranded. iv. The two DNA strands in double-stranded DNA are antiparallel in directionality.	
ENE-1	The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.				Section(s): 8.4, 8.5
	Learning Objective		**Essential Knowledge**	**Scientific Practice(s)**	
				1.B Explain biological concepts and/or processes.	
	ENE-1.D	Describe the properties of enzymes.	ENE-1.D.1	The structure of enzymes includes the active site that specifically interacts with substrate molecules.	
			ENE-1.D.2	For an enzyme-mediated chemical reaction to occur, the shape and charge of the substrate must be compatible with the active site of the enzyme.	
	Learning Objective		**Essential Knowledge**	**Scientific Practice(s)**	
				3.B State the null and alternative hypotheses, or predict the results of an experiment. 3.C Identify experimental procedures that are aligned to the question, including	

				a. Identifying dependent and independent variables. b. Identifying appropriate controls. c. Justifying appropriate controls.
ENE-1.E	Explain how enzymes affect the rate of biological reactions.	ENE-1.E.1	The structure and function of enzymes contribute to the regulation of biological processes— a. Enzymes are biological catalysts that facilitate chemical reactions in cells by lowering the activation energy.	
Learning Objective		**Essential Knowledge**		**Scientific Practice(s)**
				6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a. Biological concepts or processes. b. A visual representation of a biological concept, process, or model. c. Data.
ENE-1.F	Explain how changes to the structure of an enzyme may affect its function.	ENE-1.F.1	Change to the molecular structure of a component in an enzymatic system may result in a change of the function or efficiency of the system— a. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions. b. Environmental temperatures and pH outside the optimal range for a given enzyme will cause changes to its structure, altering the efficiency with which it catalyzes reactions.	
		ENE-1.F.2	In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity.	
ENE-1.G	Explain how the cellular environment affects enzyme activity	ENE-1.G.1	Environmental pH can alter the efficiency of enzyme activity, including through disruption of hydrogen bonds that provide enzyme structure. **RELEVANT EQUATION** $pH = -\log[H^+]$ Exclusion Statement: understand the underlying concepts and applications of this equation, but not performing calculations with this equation	
		ENE-1.G.2	The relative concentrations of substrates and products determine how efficiently an enzymatic reaction proceeds.	
		ENE-1.G.3	Higher environmental temperatures increase the speed of movement of molecules in a solution, increasing the frequency of collisions between enzymes and substrates and therefore increasing the rate of reaction.	
		ENE-1G.4	Competitive inhibitor molecules can bind reversibly or irreversibly to the active site of the enzyme.	

				Noncompetitive inhibitors can bind allosteric sites, changing the activity of the enzyme.	