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| **2.1.U1** | **Molecular biology explains living processes in terms of the chemical substances involved.**   * Define “molecular biology.” * Compare the benefits of a reductionist vs. systems approach to studying biology. * Recognize common functional groups. * Draw skeletal molecular structures from full structure diagrams |
| **2.1.U2** | **Carbon atoms can form four covalent bonds allowing a diversity of stable compounds to exist.**   * Outline the number and type of bond carbon can form with other atoms. |

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| **2.1.U3** | **Life is based on carbon compounds including carbohydrates, lipids proteins and nucleic acids.**   * List the four major classes of carbon compounds used by living organisms. |
| **2.1.U4** | **Metabolism is the web of all the enzyme-catalyzed reactions in a cell or organism.**   * Define metabolism and catalysis. * State the role of enzymes in metabolism. |

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| **2.1.U5** | **Anabolism is the synthesis of complex molecules from simpler molecules including the formation of macromolecules from monomers by condensation reactions.**   * Define anabolism, monomer and polymer. * Describe condensation (dehydration synthesis) reactions. * Using simple shapes to represent monomers, diagram a condensation reaction. |
| **2.1.U6** | **Catabolism is the breakdown of complex molecules into simpler molecules including the hydrolysis of macromolecules into monomers.**   * Define catabolism. * Contrast anabolism and catabolism. * Describe hydrolysis reactions. * Using simple shapes to represent monomers, diagram a hydrolysis reaction. |

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| **2.1.A1** | | **Urea as an example of a compound that is produced by living organisms but can also be artificially synthesized.**   * Draw the molecular structure of urea. * Describe how urea can be synthesized by living and artificial mechanisms. |
| **2.1.S1** | **Drawing molecular diagrams of glucose, ribose, a saturated fatty acid and a generalized amino acid.**   * Draw the molecular diagram of ribose. * Draw the molecular diagram of alpha-glucose. * Draw the molecular diagram of a saturated fatty acid. * Identify the carboxyl and methyl groups on a fatty acid. * Draw the generalized structure of an amino acid. * Label the amine group, carboxyl group, alpha carbon and R group on an amino acid. | |

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| **2.1.S2** | | **Identification of biochemical such as sugars, lipids, or amino acids from molecular drawings.**   * Identify the four major classes of carbon compounds used by living organisms from given diagrams (examples will include D-ribose, alpha glucose, beta glucose, trigylcerides, phospholipids and steroids). * State the generalized chemical formula of the carbohydrates. * Identify the following carbohydrates from molecular drawings:  D-ribose, alpha glucose, beta glucose, cellulose, glycogen, amylose starch and amylopectin starch. * Compare the relative amount of oxygen atoms in lipids to the amount in carbohydrates. * Identify the following lipids from molecular drawings:  triglycerides, phospholipids and steroids. | |
| **2.1** **NOS** | **Falsification of theories- the artificial synthesis of urea helped to falsify vitalism.**   * Define vitalism. * Explain the role of urea in the falsification of vitalism. | | |
| **2.2.U1** | | | **Water molecules are polar and hydrogen bonds form between them.**   * Describe the structure of an atom (in terms of protons, neutrons and electrons). * Contrast ion with atom. * Define anion and cation. * Contrast covalent, ionic and hydrogen bonds. * Write the molecular formula for water and draw the atomic structure of the molecule. * Describe the cause and effect of the polar nature of water. * Describe where and how water is able to form hydrogen bonds. |
| **2.2.U2** | | | **Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water.**   * Contrast adhesion with cohesion. * Outline an example of the cohesive property of water being of benefit to life. * Outline an example of the adhesive property of water being of benefit to life. * Explain three thermal properties of water that are useful to living organisms. * Outline a benefit to life of water's high specific heat capacity. * Outline a benefit to life of water's high latent heat of vaporization. * Outline a benefit to life of water's high boiling point. * Explain why is water such a good solvent. * List the types of molecules that water will dissolve. |

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| **2.2.U3** | **Substances can be hydrophilic or hydrophobic**.   * State that polar and ionic molecules are hydrophilic. * State that non-polar, non-ionic molecules are hydrophobic. * Given a diagram of a molecular structure, determine if the molecule is hydrophilic or hydrophobic. |
| **2.2.A1** | **Comparison of the thermal properties of water with those of methane.**   * Compare the physical properties of methane and water. * Explain why water and methane have different thermal properties based on their molecular structures. |

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| **2.2.A2** | **Use of water as a coolant in sweat.**   * Explain sweating as a mechanism to cool the body. |
| **2.2.A3** | **Modes of transport of glucose, amino acids, cholesterol, fats. oxygen, and sodium in blood in relations to their solubility in water.**   * State if the following molecules are hydrophobic or hydrophilic:  glucose, amino acids, cholesterol, fats, oxygen, and sodium chloride. * Outline the mechanism of transport in the blood of the following molecules:  glucose, amino acids, cholesterol, fats, oxygen, and sodium chloride. |

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| **2.2.** **NOS** | **Use of theories to explain natural phenomena- the theory that hydrogen bonds form between water molecules explain the properties of water.**   * State why scientists cannot prove without a doubt that hydrogen bonds exist between water molecules. | |
| **2.3.U1** | | **Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers.**   * Define monosaccharide, disaccharide and polysaccharide. * List three examples of monosaccharides. * List three examples of disaccharides. * List three examples of polysaccharides. * Use molecular diagrams to draw the formation of maltose from two glucose monomers. * Explain a condensation reaction connecting two monosaccharides in the formation of a disaccharide. |
| **2.3.U2** | | **Fatty acids can be saturated, monounsaturated and polyunsaturated.**   * Describe the differences between saturated and unsaturated (mono- or poly-) fatty acids. |

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| **2.3.U3** | **Unsaturated fatty acids can be cis or trans isomers.**   * Describe the differences between cis- and trans- fatty acids. |
| **2.3.U4** | **Triglycerides are formed by condensation from three fatty acids and one glycerol.**   * Outline the difference between fats and oils. * Explain a condensation reaction connecting fatty acids and glycerol to form a triglyceride.. * State two functions of triglycerides. |

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| **2.3.A1** | **Structure and function of cellulose and starch in plants and glycogen in humans.**   * State the structural difference between alpha and beta glucose. * Contrast the structure and functions of cellulose, amylose, amylopectin and glycogen. |
| **2.3.A2** | **Scientific evidence for health risks of trans fat and saturated fatty acids.**   * Discuss the relationship between saturated fatty acid  and trans-unsaturated fat intake and rates of coronary heart disease. |

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| **2.3.A3** | **Lipids are more suitable for long term energy storage in humans than carbohydrates.**   * Explain the energy storage of lipids compared to that of carbohydrates. |
| **2.3.A4** | **Evaluation of evidence and the methods used to obtain the evidence for health claims made about lipids.**   * Define evaluation in respect to evidence from and methods of research. * Outline the manner in which the implications of research can be assessed. * Outline the manner in which the limitations of research can be assessed. * Evaluate a given health claim made about lipids. |

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| **2.3.S1** | **Use of molecular visualization software to compare cellulose, starch and glycogen.**   * Demonstrate use of JMol to view molecular structures, including changing image size, rotating the image and changing the style of the molecular model. * Identify carbon, hydrogen and oxygen atoms by color. |
| **2.3.S2** | **Determination of body mass index by calculation or use of a nomogram.**   * Calculate BMI using the formula. * Determine BMI using a nomogram. * Outline effects of a BMI that is too high or too low. |

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| **2.3.** **NOS** | **Evaluating claims- health claims made about lipids in diets need to be assessed.**   * Describe how the effect of lipids on health can be assessed scientifically. | |
| **2.4.U1** | | **Amino Acids are linked together by condensation to form polypeptides.**   * Describe polypeptide chain formation in terms of the formation of peptide bonds and condensation reactions. * Determine the number of peptide bonds given the number of amino acids in a polypeptide. * Define dipeptide, oligopeptides and polypeptide. |
| **2.4.U2** | | **There are 20 different amino acids in polypeptides synthesized on ribosomes.**   * State the number of amino acids used by living organisms to make polypeptides. * Given an image of an amino acid, classify the amino acid chemical properties based on R group properties. * Outline the role vitamin C plays in the conversion of proline to hydroxyproline. |

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| **2.4.U3** | **Amino Acids can be linked together in any sequence giving a huge range of possible polypeptides.**   * Calculate the possible number of amino acid sequences given n number of amino acids. |
| **2.4.U4** | **The amino acid sequence of polypeptides is coded for by genes.**   * Outline the relationship between genes and polypeptides. |

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| **2.4.U5** | **A protein may consist of a single polypeptide or more than one polypeptide linked together.**   * Outline the structure and function of three example proteins composed of two or more polypeptides linked together. |
| **2.4.U6** | **The amino acid sequence determines the three-dimensional conformation of a protein.**   * Contrast the structure of globular proteins with the structure of fibrous proteins. * Describe the structure of membrane bound globular proteins. |

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| **2.4.U7** | **Living organisms synthesize many different proteins with a wide range of functions.**   * Contrast the generalized function of globular proteins with generalized function of fibrous proteins. * List ten functions of proteins in a cell or organism. * Describe the function of enzyme proteins. * Describe the function of hormone proteins. * Describe the function of immunoglobulin proteins. * Describe the function of pigment proteins. * Describe the function of structural proteins. |
| **2.4.U8** | **Every individual has a unique proteome.**   * Define proteome. * Contrast proteome with genome. |

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| **2.4.A1** | **Rubisco, insulin immunoglobulins, rhodopsin, collagen and spider silk as examples of the range of protein functions.**   * State the function of each of the following proteins:  rubisco, insulin, immunoglobulin, rhodopsin. collagen, spider silk, actin, myosin, casein, hemoglobin, acetylcholine receptor, oxytocin, prolactin, ferritin, billirubin, fibrinogen, transferrin and albumin. |
| **2.4.A2** | **Denaturation of proteins by heat or by deviation of pH from the optimum.**   * Define denaturation. * Outline the effect of heat and pH on protein structure. |

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| **2.4.S1** | | **Drawing molecular diagrams to show the formation of a peptide bond.**   * Draw peptide bond formation in a condensation reactions. | |
| **2.4.** **NOS** | **Looking for patterns, trends, and discrepancies- most but not all organisms assemble proteins from the same amino acids.**   * Explain the trend of organisms assembly of polypeptides from the same amino acids. * Describe a discrepancy of the trend of all organisms using the same amino acids to assemble polypeptides. | | |
| **2.5.U1** | | | **Enzymes have an active site to which specific substrates bind.**   * State the relationship between enzyme substrate and enzyme product. * Explain the relationship between enzyme structure and enzyme specificity, including the role of the active site. |
| **2.5.U2** | | | **Enzyme catalysis involves molecular motion and the collision of substrates with the active site.**   * Outline the three stages of enzyme activity. * Explain the role of random collisions in the binding of the substrate with the enzyme active site. * Describe the induced fit model of enzyme action. |

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| **2.5.U3** | **Temperature, pH and substrate concentration affect the rate of activity of enzymes.**   * Explain how temperature affects the rate of enzyme activity. * Draw a graph of depicting the effect of temperature on the rate of enzyme activity. * Explain how pH affects the rate of enzyme activity. * Draw a graph of depicting the effect of pH on the rate of enzyme activity. * Identify the optimum temperature or pH for enzyme activity on a graph. * Explain how substrate concentration affects the rate of enzyme activity. * Draw a graph of depicting the effect of substrate concentration on the rate of enzyme activity. |
| **2.5.U4** | **Enzymes are denatured.**   * State the effect of denaturation on enzyme structure and function. |

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| **2.5.U5** | **Immobilized enzymes are widely used in industry.**   * List industries that use commercially useful enzymes. * Explain how and why industrial enzymes are often immobilized. |
| **2.5.A1** | **Methods of production of lactose-free milk and its advantages.**   * State the source of the lactase enzyme used in food processing. * State the reaction catalyzed by lactase. * Outline four reasons for using lactase in food processing. |

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| **2.5.S1** | **Design of experiments to test the effect of temperature, pH, and substrate concentration on the activity of enzymes.**   * Identify and manipulated, responding and controlled variables in descriptions of experiments testing the activity of enzymes. |
| **2.5.S2** | **Experimental investigation of a factor affecting enzyme activity.** **(Practical 3)**   * Describe three techniques for measuring the activity of an example enzyme. |

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| **2.5.** **NOS** | **Experimental design-accurate, quantitative measurements in enzyme experiments require replicates to ensure reliability.**   * Define quantitative and qualitative. * Determine measurement uncertainty of a measurement tool. * Explain the need for repeated measurements (multiple trials) in experimental design. * Explain the need to controlled variables in experimental design. |