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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
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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| **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.
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