PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Honors Biology

Curriculum Writing Committee:

Nicholas Irwin and Amanda Pope

Grade Level: 9

Date of Board Approval: _____

Course Weighting: Honors Biology

Major Assessments	45%
Skills Application	30%
Skills Practice	20%
Participation	5%

Curriculum Map

Overview:
This course aligns to the PA STEELS standards, covering content including: the Nature of Science and Basic Biological Principles; Biochemistry; Cellular Differentiation; Cell Structure and Function; Energy Transfer and Chemical Reactions; Reproduction and Inheritance, including DNA and Mendelian Genetics; Evolutionary Principles; and Ecology. Each unit underscores the role of biology in the life of the student and will present relevant scientific phenomena and necessitate application of scientific practices. Laboratory classes are designed to promote student problem-solving, mathematical applications, and deep analytical skills. Honors Biology aligns with many aspects of content and application seen in Advanced Placement Biology, and as such, covers significantly more material at a faster pace than in Biology. Students are expected to be consistent, academically mature learners, who are willing to work in a collaborative environment. Students are required to take the Keystone Biology Exam at the completion of the course.

Time/Credit for the Course: One full year, meeting daily for ~46 minutes/ 1 credit

Goals:

- **Marking Period 1 (45 days) -** Students are able to review and apply…
    - **Unit 1: Chemistry of Life and Natural Selection - 35 Days**
        - Introduction to Natural Selection
        - Organismal and Group Behavior
        - Structure of atoms, sub-atomic particles, and bonding characteristics
        - Structure of water and hydrogen bonding
        - Elements of life
        - Introduction to macromolecules, dehydration synthesis, and hydrolysis
        - Carbohydrates
        - Lipids

        - Proteins
        - Nucleic acids

    - **Unit 2: Cell Structure and Function- 10 Days**
        - Fungi Kingdom Diversity
        - Protist Kingdom Diversity
        - Plant Kingdom Diversity
        - Animal Kingdom Diversity
        - Cell Diversity, Componentry, Structure, and Size
        - Plasma Membrane Structure and Permeability

- **Marking Period 2 (45 days) -** Students are able to review and apply…
    - **Unit 2 Continued: Cell Structure and Function- 10 Days**
        - Cell Plasma Membrane Structure and Permeability
        - Membrane Transport - Active and Passive Transport Mechanisms
        - Tonicity and Osmoregulation
        - Endosymbiotic Theory

    - **Unit 3: Cellular Energetics - 20 Days**
        - Protein structure and Enzyme function
        - Environmental Impacts on Enzyme Function
        - ATP and cellular energy
        - Photosynthesis
        - Cellular respiration

    - **Unit 4: Cell Division and Cell Division Controls - 15 Days**
        - Asexual and Sexual Reproduction models
        - Prokaryotic Binary Fission and Eukaryotic Mitosis
        - Cell Cycle Stages
        - Controls of the cell cycle and cancer
        - Meiosis and Fertilization as mechanisms for Genetic Variation
        - Chromosome Analysis and Chromosome Mutations
        - NonDisjunction
        - Biotechnology: Stem Cells and Cloning

- **Marking Period 3 (45 days) -** Students are able to review and apply…
    - **Unit 5: DNA and Protein Synthesis - 15 Days**
        - Critical Experiments to conclude DNA as the genetic material
        - Structure of DNA
        - Mechanism of Semi-Conservative Replication
        - Mechanism of Protein Synthesis through Transcription and Translation
        - Comparison of Prokaryotic and Eukaryotic Protein Synthesis
        - Point Mutations
        - Types of Questions and Bioethics
        - Biotechnology: Gene Modification and CRISPR

- **Unit 6 : Heredity -15 Days**
  - Genetics Terminology
  - Inheritance patterns and probability
  - Blood typing
  - Pedigree Analysis
  - Biotechnology: Genetic Testing

- **Unit 7: Evolutionary Principles and Natural Selection- 15 Days**
  - Evolution as a Scientific Law and Scientific Theory
  - Darwin's contributions to Natural Selection
  - Evidences of Evolution (Fossils, anatomy, biogeography, embryology, molecular DNA)
  - Phylogenetic Trees/Cladograms as models of Common Ancestry

- **Marking Period 4 (45 days) -** Students are able to review and apply…
  - **Unit 7 Continued: Evolutionary Principles and Natural Selection - 10 Days**
    - Extinction and Extirpation
    - Biological Species Concept, Reproductive Barriers, and mechanisms of Speciation
    - Adaptations and Biodiversity

  - **Unit 8: Ecology - 25 Days**
    - Levels of Ecological Study
    - Population Growth Curves and Limiting Factors
    - Community Interactions
    - Trophic Interactions
    - Biogeochemical Cycling
    - Terrestrial and Aquatic Biomes
    - Learned and Innate Behaviors
    - Current Threats to Biological Diversity, Ecosystem Health, and the Biosphere

  - **Unit 9: Environmental Literacy and Sustainability- 10 Days**
    - Investigate local areas for conservation and plans for sustainability in the community
    - Plan and collaborate with local resources to analyze human impacts on systems and resources

Big Ideas:

- **Structure and Function:** Organisms have characteristic structures that enable functions and behaviors that allow them to grow, reproduce, and die.
- **Growth and Development of Organisms:** The characteristic structures, functions and behaviors of organisms change in predictable ways as they progress through their life cycle.

- **Organization for Matter and Energy Flow in Organisms:** The structures, functions, and behaviors of organisms allow them to obtain, use, transport, and remove the matter and energy needed to live.
- **Interdependent Relationships in Ecosystems:** Ecosystems are complex systems that include both living (biotic) and non-living (abiotic) components that interact with each other.
- **Cycles of Matter and Energy Transfer in Ecosystems:** The cycling of matter and the flow of energy within ecosystems occur through interactions among different organisms and between organisms and the physical environment.
- **Ecosystem Dynamics, Functioning, and Resilience:** As the environment and populations of species change, there are resulting changes in ecosystems.
- **Social Interactions and Group Behavior:** Many species live in groups, increasing the chances of survival for individuals and their relatives.
- **Inheritance of Traits:** Offspring resemble, but are not identical to, their parents due to traits being passed from one generation to the next via genes.
- **Variation of Traits:** Variation among individuals of the same species can be explained by both genetic and environmental factors.
- **Evidence of Common Ancestry and Diversity:** Comparisons between species provide evidence that they evolved from common ancestors, explaining the similarities and differences between species.
- **Natural Selection:** In any environment, individuals with particular traits may be more likely than others to survive and produce offspring.
- **Adaptation:** When the environment changes, some individuals in a population may have traits that provide a reproductive advantage which over many generations can change the makeup of a population.

Textbook and Supplemental Resources:

- **Primary Textbook Name:** *Inspire Biology*
    - **Textbook ISBN:** 978-0-07-688434-6
    - **Textbook Publisher/Year of Publication:** McGraw-Hill Education, 2020

- **Supplemental Resources:**
    - Lab Hamster Website
    - OpenSciEd Instructional Materials for Grades 9-12

Curriculum Plan

Unit 1: Biochemistry (35 Days)

- **Standards**
    - 3.1.9-12.A Students who demonstrate understanding can construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
        - **Clarifying Statement:**
            - Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.
        - **Assessment Boundary:**
            - Assessment does not include deriving mathematical equations to make comparisons.

    - 3.1.9-12.F: Students who demonstrate understanding can construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
        - **Clarifying Statement:**
            - Emphasis is on using evidence from models and simulations to support explanations.
        - **Assessment Boundary:**
            - Assessment does not include the details of specific chemical reactions or identification of macromolecules.

    - 3.1.9-12.O Students who demonstrate understanding can evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
        - **Clarifying Statement:**
            - Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.
        - **Assessment Boundary:**
            - N/A

- 3.1.9-12.P Students who demonstrate understanding can ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
  - **Clarifying Statement:**
    - N/A
  - **Assessment Boundary:**
    - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

- 3.1.9-12.R Students who demonstrate understanding can apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
  - **Clarifying Statement:**
    - Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.
  - **Assessment Boundary:**
    - Assessment does not include Hardy-Weinberg calculations.

- 3.1.9-12.T Students who demonstrate understanding can construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
  - **Clarifying Statement:**
    - Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.
  - **Assessment Boundary:**
    - Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

- 3.1.9-12.U Students who demonstrate understanding can apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
  - **Clarifying Statement:**
    - Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species.

Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

- **Assessment Boundary:**
  - Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

- 3.1.9-12 W Students who demonstrate understanding can construct an explanation based on evidence for how natural selection leads to adaptation of populations.
  - **Clarifying Statement:**
    - Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.
  - **Assessment Boundary:**
    - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Constructing Explanations and Designing Solutions ● Engaging in Argument From Evidence ● Asking Questions and Defining Problems ● Analyzing and Interpreting Data	● Interdependent Relationships in Ecosystems ● Organization for Matter and Energy Flow in Organisms ● Social Interactions and Group Behavior ● Structure and Function ● Inheritance of Traits ● Natural Selection ● Adaptation ● Variation of Traits	● Scale Proportion and Quantity ● Energy and Matter ● Cause and Effect ● Patterns

Anchoring Phenomenon:

- Survivorship of Mouse in American Southwest

Objectives:

1. Determine and construct the appropriate type of graph to depict quantitative and qualitative data (DOK 4)
2. Identify dependent variable, independent variable, and controlled variables in a scientific controlled experiment (DOK 2)
3. Explain the meaning of standard deviation to indicate spread in a data set (DOK 3)
4. Cite evidence of adaptations in nature (DOK 3)
5. Compare and contrast positive and negative feedback mechanisms (DOK 4)
6. Define fitness in the context of success of passing on one's DNA (DOK 1)

7. Describe how genetics plays a role in evolutionary change (DOK 1)
8. Make connections about mutations and genetic variation in a population (DOK 4)
9. Identify that genetic recombination in sexual reproduction plays a role in evolution (DOK 1)
10. Summarize the processes that influenced the survival or extinction of a species (DOK 2)
11. Review the Characteristics of life and modern taxonomy (DOK 1)
12. Compare and Contrast Taxonomic Domains and Eukaryotic Kingdoms (DOK 2)
13. Identify and distinguish between the three subatomic particles found in atoms (DOK 1, 2)
14. Describe the properties of polar and nonpolar covalent bonds and identify examples of each based on bonding rules (DOK 3)
15. Differentiate structure and properties of covalent from ionic from hydrogen bonds (DOK 3)
16. Evaluate why different bonds affect the properties of a molecule (DOK 3)
17. Identify the parts of a chemical reaction, including reactants, products, appropriate chemical notation and the use of coefficients for balanced chemical formulas (DOK 1)
18. Identify patterns about the unique properties of water and the molecular basis behind these properties (DOK 2)
19. Compare acidic solutions and basic solutions and explain the molecular basis for these properties (DOK 3)
20. Relate the properties of carbon to its significance in many different structural and functional characteristics of living things (DOK 2)
21. Identify the general structure and functions of carbohydrates (DOK1)
22. Identify the general structure and functions of lipids (DOK1)
23. Identify the general structure and functions of nucleic acids (DOK1)
24. Identify the general structure and functions of proteins (DOK1)
25. Compare, contrast, and make a prediction about the structures and functions of each of the four groups of macromolecules (DOK 3)
26. Describe why the structure of a protein influences the function of the protein (DOK 2)
27. Predict the effect on protein function when protein structure is altered (DOK 3)

Core Activities and Corresponding Instructional Methods:

- Collect data from an online simulation and compile class data. Analyze and identify elements of an experimental design
- Complete a Driving Question Board based on the indicated unit phenomenon.
- Investigate Positive and Negative Feedback Mechanisms
- Complete Cornell Notes on content including: Natural Selection, Properties of Water, Types of Bonds, Period Table and subatomic particles, Elements of life, Structure and Function of Macromolecules, Carbohydrates, Lipids, Nucleic Acids, and Proteins.
- Draw electron configurations and depict types of bonds using atomic number, atomic mass, and electronegativity
- Use paper models to compare and contrast organic macromolecules
- Perform a Hygroscopic Seeds Lab to investigate the impact of macromolecules on water transfer in humid environments
- Observe a demonstration or simulation to see impacts of changes in pH and an increase in temperature on protein structure and function (Possible resource: https://sites.google.com/site/biologydarkow/enzymes/lactase-enzyme-simulation)

- Work in groups to create a model to depict all aspects of the curriculum to describe mechanisms to support pocket mouse survivorship in the American Southwest

Correspondent Vocabulary:

- Hypothesis, standard deviation, error bars, natural selection, competition, survival, reproduction, phenotypes, genetic variation, biotic factors, abiotic factors, evolution, genetic variation, adaptations, heritability, population, environment, fitness, atom, proton, neutron, electron, bond, molecule, ionic bond, polar covalent bond, non-polar covalent bond, polarity, hydrogen bonding, cohesion, adhesion, surface tension, heat capacity, hydrophilic/hydrophobic, density, macromolecules, carbohydrate, lipid, protein, nucleic acids, monomer, polymer, dehydration synthesis, hydrolysis, mono/di/poly saccharide, saturated/unsaturated triglyceride fat, phospholipid, cell membrane, steroids, cholesterol, amino acid, peptide bond, polypeptide chain, structure/function, nucleotide, deoxyribose, double helix, antiparallel, ribose, adenine, cytosine, guanine, uracil, thymine

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool (CDT)

- **Formative:**
  - Summer Work Assignment: Experimental Design and Graphing Skills
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities
  - Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
  - Summer Work Assignment: Experimental Design and Graphing Skills
  - Lab Exercise: Properties of Macromolecules Lab (Example: Hygroscopic Seed Lab)
  - Quiz Content (as agreed upon by PLC): Subatomic Particles, Bonds and Water, Macromolecules Structure and Function
  - Model: Survivor-American Southwest
  - Common Assessment(s) Unit 1- Basic Biological Principals, Inorganic Chemistry, Organic Chemistry
    - Question types include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
  - Cornell Notes correspondent to Lab Hamster Website

    - Left Side Processing
    - Biology POGIL practice
    - YouTube video reviews
    - Model design feedback

- **Extensions:**
    - Application and analysis of standard deviations and standard error of the mean
    - Perform Alka Seltzer Lab or Diet Pepsi lab to explore controlled experimental design, placebo effect
    - Create Johnstone's Triangle to depict characteristics of water molecules
    - Explore Ocean Acidification
    - Research proteins on the Protein Data base: (https://cdn.rcsb.org/pdb101/molecular-machinery/)
    - Review Enzymatic Function and levels of protein structure

Unit 2: Cells (20 Days)

- **Standards:**
    - 3.1.9-12.B: Students who demonstrate understanding can develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
        - **Clarifying Statement:**
            - Emphasis is on functions at the organism system level, such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.
        - **Assessment Boundary:**
            - Assessment does not include interactions and functions at the molecular or chemical reaction levels.

    - 3.1.9-12.C: Students who demonstrate understanding can plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
        - **Clarifying Statement:**
            - Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.
        - **Assessment Boundary:**
            - Assessment does not include the cellular processes involved in the feedback mechanism.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models ● Planning and Carrying Out Investigations	● Structure and Function ● Organization for Matter and Energy Flow in Organisms	● Systems and System Models ● Stability and Change ● Energy and Matter

Anchoring Phenomenon:

- Three Parent Children and the Endosymbiotic Theory
- Bruce Lee: Death by Nutrition or Distilled Water in IV Case Study

Objectives:

- State the three parts of the Cell Theory (All living things are made of cells; cells are the basic structure and function of living things; all cells come from pre-existing cells) and be able to apply each part to an example in nature (DOK 1, 4)

- List and arrange the cellular organization of living things (cells→tissues→organs→ organ systems→organism) (DOK 1)
- Make connections of diversity and specialization of cells to real-life examples (DOK 4)
- Differentiate between the variety of cells that exist in the 3 domains of life (DOK 3)
- Compare and contrast prokaryotic and eukaryotic cells (DOK 2)
- List organelles found in eukaryotic cells (DOK 1)
- Classify structural features of eukaryotic cell organelle and relate the structural features with the organelle's function (DOK 2)
- Describe the pathway, including relationship and function of each portion of the endomembrane system, used to generate, modify and distribute proteins in and out of the cell (DOK 3)
- Compare and contrast major features and organelles of plant and animal cells (DOK 2)
- Identify structure and function of components in the cell membrane (DOK 1)
- Predict the ability of a molecule to passively cross a cell membrane based on general features and types of bonds (DOK 4)
- Distinguish between Active and Passive Transport and describe examples of each (DOK 2)
- Apply the terms Hypotonic, Hypertonic, and Isotonic to determine the net movement of water into and out of cells (DOK 2)
- Apply knowledge of concentration gradients in order to explain the mechanisms by which materials move across the cell membrane (DOK 4)
- Recall the energy requirements that apply to different types of cell transport (DOK 1)
- Evaluate the mechanism of homeostasis through cell signaling of insulin in the human body (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Learn about the Driving Phenomenon and create a Driving Question Board to investigate
- Complete Cornell Notes on content including: Cell Structure, Cell Size, Plasma Membrane, Membrane Permeability, Membrane Transport, Tonicity and Osmoregulation, Cell Compartmentalization
- Use agar cubes to observe the effect of the Surface Area : Volume ratio on efficiency to diffuse materials through a cell
- Utilize Compound Light Microscopes to visualize cells. Learn the features and functions of a light microscope for appropriate use. View prepared slides and create wet-mount slides of cells from onion skin.
- Utilize Compound Light Microscope to view and identify different samples of algae
- Use the learn.genetics.utah.edu website's Mystery Cell activity to predict cell types based on structures, embedded proteins and organelle functions
- Perform animal dissections to illustrate the relationship between cells, tissues, organs, and organ systems
- Perform diffusion and osmosis labs to demonstrate and measure cellular transport with eggs or dialysis tubing.
- Perform a lab to generate and graph data to determine solute concentrations of unknown solutions based on osmotic flow

Correspondent Vocabulary:

- Cell, Cell Theory, DNA, Chromosome, Prokaryote, Eukaryote, Nucleus, Nucleoid Region, Chromosome, Cell Membrane, Cytoplasm, Cytosol, Organelle, Endomembrane system, Vacuole, Lysosome, Cytoskeleton, Centriole, Ribosome, Rough Endoplasmic Reticulum, Smooth Endoplasmic Reticulum, Golgi Apparatus/bodies, *Scientific* Theory, Endosymbiotic Theory, Chloroplast, Mitochondria, Cell Wall, Phospholipid Bilayer, Amphipathic, Fluid Mosaic Model, Receptor Protein, Channel Protein, Glycoprotein/Glycolipid, Selectively Permeable, Permeable solute, Non-permeable solute, Passive Transport, Diffusion, Facilitated Diffusion, Osmosis, Aquaporin, Isotonic, Hypertonic, Hypotonic, Animal Cell Lysis, Turgid, Flaccid, Plant cell Plasmolysis, Active Transport, Protein Pump, Endocytosis, Exocytosis, Cell Signaling

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool

- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities, Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
  - Lab Exercises: Cell Size lab, Microscope Lab, Water transport, Homeostasis Investigation
  - Quiz Content (as agreed upon by PLC): Cell Types, Transport and Cell Membrane Permeability
  - Model: Three Parent baby or Death By Nutrition
  - Common Assessment Unit 2
    - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
  - Cornell Notes correspondent to Lab Hamster Website
  - Left Side Processing
  - Biology POGIL practice
  - YouTube video reviews
  - Model design feedback

- **Extensions:**

- Readings on the Endosymbiotic Theory
- Explore simulation of diffusion with pHet website (https://phet.colorado.edu/sims/html/diffusion/latest/diffusion_all.html)
- Calculation of Water Potential and use of data to determine water potential of unknown cells
- Application of Osmolarity to health and homeostasis

Unit 3: Cellular Energetics (20 Days)

- **Standards:**
    - 3.1.9-12.C: Students who demonstrate understanding can plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
        - **Clarifying Statement:**
            - Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.
        - **Assessment Boundary:**
            - Assessment does not include the cellular processes involved in the feedback mechanism.

    - 3.1.9-12.E Students who demonstrate understanding can use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
        - **Clarifying Statement:**
            - Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.
        - **Assessment Boundary:**
            - Assessment does not include specific biochemical steps.

    - 3.1.9-12.F: Students who demonstrate understanding can construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
        - **Clarifying Statement:**
            - Emphasis is on using evidence from models and simulations to support explanations.
        - **Assessment Boundary:**
            - Assessment does not include the details of specific chemical reactions or identification of macromolecules.

    - 3.1.9-12.G Students who demonstrate understanding can use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
        - **Clarifying Statement:**
            - Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.
        - **Assessment Boundary:**
            - Assessment should not include identification of the steps or specific processes involved in cellular respiration.

- 3.1.9-12.K Students who demonstrate understanding can develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
  - **Clarifying Statement:**
    - Examples of models could include simulations and mathematical models.
  - **Assessment Boundary:**
    - Assessment does not include the specific chemical steps of photosynthesis and respiration.

- 3.1.9-12.J Students who demonstrate understanding can construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
  - **Clarifying Statement:**
    - Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.
  - **Assessment Boundary:**
    - Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models ● Planning and Carrying out Investigations	● Organization for Matter and Energy Flow in Organisms ● Structure and Function ● Cycles of Matter and Energy Transfer in Ecosystems ● Energy in Chemical Processes	● Energy and Matter ● Stability and Change ● Systems and System Models

Anchoring Phenomenon:
- Mission to Mars
- Iguanas falling from trees in cold temperatures

Objectives:
- State and apply the First and Second Laws of Thermodynamics to biological systems (DOK 1, 4)
- State the properties of endergonic and exergonic reactions (DOK1)
- Predict if a reaction is exergonic or endergonic and connect the ideas of spontaneous, nonspontaneous, anabolic, catabolic, dehydration synthesis, and hydrolysis to this concept (DOK4)
- Identify the structure of ATP and explain its role in cellular work (DOK2)
- Explain the effect of enzymes in lowering activation energy to catalyze reactions (DOK2)
- Predict the effect of environmental factors on enzyme dynamics (DOK 4)

- Identify the movement of Hydrogen atoms as indicators of reduction-oxidation (redox) reactions in photosynthesis and cellular respiration to determine which reactants are converted into which products (DOK 2)
- Recognize that light and pigments are necessary components of photosynthesis (DOK 1)
- Identify and explain the role of electron carrier molecules in photosynthesis (DOK 1, 3)
- Write the chemical equation for photosynthesis, including both reactants and products (DOK 1)
- Distinguish between the light-dependent reactions and the light-independent reactions/Calvin Cycle in photosynthesis (DOK 2)
- Draw and label the general structure of a chloroplast (DOK 1)
- Compare the different factors that affect the rate at which photosynthesis occurs (DOK 3)
- Apply concepts of autotrophy and heterotrophy to energy demands and biochemical energetic reactions (DOK 3)
- Label a cross-section of a leaf and distinguish which tissues are involved in photosynthesis (DOK 1, 2)
- Explain the general purpose of cell respiration (DOK 1)
- Write the chemical equation for cellular respiration, including reactants and products (DOK 1)
- Draw and label the general structure of a mitochondrion (DOK 1)
- Recognize what happens during glycolysis (DOK 1)
- Summarize what happens during the Krebs cycle (DOK 2)
- Recognize how high-energy electrons are used by the electron transport chain (DOK 1)
- Explain the mechanism of ATP synthase as it uses an electrochemical gradient to generate ATP cellular energy (DOK 3)
- Compare and contrast aerobic and anaerobic respiration (DOK 2)
- Describe different types of fermentation (alcohol fermentation and lactic acid fermentation) (DOK 1)
- Analyze the net production of ATP that is generated by both anaerobic and fermentation (DOK 4)
- Predict and evaluate the influence of toxins, inhibitors, and treatments that affect cell respiration mechanisms or concentrations of red blood cell (DOK 4)
- Assess the relationship that exists in ecosystems between the processes of photosynthesis and cellular respiration (DOK 3)
- Identify which types of cells undergo photosynthesis and cell respiration (DOK 1)
- Connect mechanisms of enzymatic reactions to their effect on energy-related reactions (DOK 4)
- Apply concepts learned when studying biochemistry to the transformations that occur between molecules in photosynthesis and cellular respiration (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Watch videos on Building a Mars Base Habitat (Example Videos: Building a Marsbase and NASA's Deep Food Space Challenge)
- Complete Cornell Notes on content including: Proteins Structure and Function, Enzyme Structure, Environmental Impacts on Enzymatic Functions, Cellular Energy, Photosynthesis, Cellular Respiration

- Explore the Molecular Database to identify structure and function of cellular proteins (https://cdn.rcsb.org/pdb101/molecular-machinery/)
- Perform computer simulations (https://www.biologysimulations.com/enzymes or https://sites.google.com/site/biologydarkow/enzymes) to determine the effect of environmental conditions on enzymatic activity
- Perform Yeast Sphere lab or Yeast and Balloon lab to observe fermentation and environmental impacts on rate of fermentation
- Perform a pigment chromatography lab to separate and identify pigments found in green plants

Correspondent Vocabulary:

- Chemical Reaction, Reactant, Product, Endergonic, Exergonic, Anabolic, Catabolic, Non-Spontaneous, Spontaneous, Activation Energy, Enzyme, Catalyst, Substrate, Active Site, Inhibitor, Denature, Adenosine Triphosphate/ATP, Adenosine DiphosphateADP, Phosphorylation, Autotroph, Heterotroph, Photosynthesis, Leaf Guard Cell, Stomate/Stomata, Pigment, Chlorophyll, Chloroplast, Thylakoid, Stroma, Electron Carrier, NADP+, Light-dependent reaction, Light-Independent reactions/Calvin Cycle, Photosystem, Electron Transport Chain, Electrochemical gradient, ATP Synthase, Phosphorylate/Phosphorylation, Calorie, Cellular Respiration, Aerobic, Anaerobic, Glycolysis, Mitochondria, Matrix of the Mitochondria, Synthesize, NAD+/ NADH, FAD+/FADH, Krebs Cycle, Electron Transport Chain, ATP Synthase, Oxidative Phosphorylation, Electrochemical gradient of H+, Fermentation, Alcoholic Fermentation, Lactic Acid Fermentation

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool (CDT)

- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities, Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
  - Lab Exercises: Enzymatic Simulations, Yeast Fermentation, Pigment Chromatography
  - Quiz Content (as agreed upon by PLC): Enzymatic Function and ATP, Cellular Respiration, Photosynthesis
  - Model: Life on Mars, Cold Iguanas Falling from Trees

    - Common Assessment Unit 3
        - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
    - Cornell Notes correspondent to Lab Hamster Website
    - Left Side Processing
    - Biology POGIL practice
    - YouTube video reviews
    - Model design feedback

- **Extensions:**
    - Complete the Toothpickase Lab to collect and analyze data on a kinesthetic depiction of enzymatic activity
    - Practice rate calculation
    - Use of https://sites.google.com/site/biologydarkow/enzymes website to differentiate between human enzymes based on optimal conditions and products
    - Exploration of Impact of Carbon Monoxide on Cellular Respiration
    - Research on Fermented Foods
    - Use of https://sites.google.com/site/biologydarkow/metabolism to investigate models of cellular respiration and photosynthesis
    - Incorporate aspects of Open Sci Ed B.2

Unit 4: Cell Division and Cell Division Controls (15 Days)

- **Standard:**
  - 3.1.9-12.D Students who demonstrate understanding can use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
    - **Clarifying Statement:**
      - N/A
    - **Assessment Boundary:**
      - Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

  - 3.1.9-12.P Students who demonstrate understanding can ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
    - **Clarifying Statement:**
      - N/A
    - **Assessment Boundary:**
      - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

  - 3.1.9-12.Q Students who demonstrate understanding can make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
    - **Clarifying Statement:**
      - Emphasis is on using data to support arguments for the way variation occurs.
    - **Assessment Boundary:**
      - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

  - 3.5.9-12 GG Students who demonstrate understanding can evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and economic landscapes throughout history.
    - **Clarifying Statement:**
      - Communication, agriculture, and transportation, for example, have evolved out of the political, economic, and social interests and values of the times.
    - **Assessment Boundary:**
      - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models ● Asking questions and defining problems	● Structure and Function ● Inheritance of Traits ● Growth and Development of Organisms ● Defining & Delimiting Engineering Problems	● Systems and System Models ● Cause and Effect ● Making and Doing ● Attention to Ethics

Anchoring Phenomenon:

- Vegetative Propagation - Grow Banana Tree From a Banana
- Cancer Cells Unit from Open Sci Ed

Objectives:

- Recognize that cell size is limited because of growth, DNA overload, and surface to volume ratio (DOK 1)
- Identify different forms of DNA and how it should appear at different stages of the cell cycle (molecular, chromatin, chromosome) (DOK 1)
- Explain the role of DNA and chromosomes in cell division (DOK 1)
- Summarize the stages of the cell cycle (DOK 2)
- Describe the specific events of the three phases of interphase (DOK 2)
- Recognize that DNA must be copied before cell division can occur (DOK 1)
- Describe the specific events of the four phases of mitosis (DOK 2)
- Describe the process of cytokinesis (DOK 1)
- Distinguish between cytokinesis in animal cells and in plant cells (DOK 2)
- Cite evidence of how the cell cycle is regulated (DOK 1)
- Identify three specific cell cycle checkpoints and what each is checking for (DOK 2)
- Distinguish between cancer cells and healthy cells (DOK 2)
- Relate the onset of cancer to the control of the cell cycle (DOK 2)
- Identify the role of apoptosis in body cell maintenance and protection against cancer (DOK 2)
- Differentiate between diploid (2n) and haploid (n) cells (DOK 3)
- Differentiate between asexual and sexual reproduction and evaluate evolutionary advantages of each (DOK 3)
- Compare and contrast a somatic cell and a gamete (DOK 2)
- Summarize the events of meiosis (DOK 2)
- Describe the processes of independent assortment and crossing over (DOK 2)
- Compare and contrast meiosis and mitosis (DOK 3)
- Identify three specific events in meiosis and fertilization that contribute to genetic variation in offspring (DOK 3)
- Provide examples to illustrate and evaluate the benefit of variation in a population (DOK 4)
- Create and analyze a karyotype in order to recognize chromosomal defects that may occur during meiosis as a result of nondisjunction and examples of specific chromosomal aneuploidy disorders (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Create a driving question board on the content indicated by the unit phenomenon
- Complete Cornell Notes on content including: Feedback, Cell Cycle, Regulation of the Cell Cycle, Meiosis and Variation
- Learn about role of p53 in cell cycle regulation and play a Nobel Prize Cell Cycle game to identify the three checkpoints in cell division
- Perform a flower dissection to identify reproductive structures and the role of pollen and eggs in angiosperm plant reproduction
- Complete an analyze a Karyotype using the University of Arizona website to determine chromosomal abnormalities

Correspondent Vocabulary:

- Cell division, Asexual reproduction, Sexual Reproduction, Chromosome, Chromatin, Cell cycle, Interphase, G1 Phase (interphase), S Phase (interphase), G2 phase (interphase), Centromere, Chromatid, Centriole, Mitosis, Prophase (mitosis), Metaphase (mitosis), Anaphase (mitosis), Telophase (mitosis), Cytokinesis, Cyclin, Growth Factors, Apoptosis, Cancer, Tumor, Embryo, Differentiation, Totipotent, Multipotent, Stem Cell, Aneuploid, Monosomy, Trisomy, Homologous Chromosome, Diploid, Haploid, "2n" , "n" , Meiosis, Tetrad, Crossing over, Independent /Random Assortment during Metaphase I, Zygote, Genome, Karyotype, Autosome, Sex Chromosome(s), Nondisjunction, Chromosomal mutations, Deletion Chromosome mutation, Addition Chromosome mutation, Inversion chromosome mutation, Translocation Chromosome mutation

Assessments:

- **Diagnostic:**
    - Introduction of the Phenomenon and driving question board
    - Teacher questioning and observation
    - Classroom Diagnostic Tool

- **Formative:**
    - Teacher observations
    - Questioning techniques
    - Define vocabulary words for this unit
    - Group activities
    - Think/Pair/Share vocal activities
    - Homework – Example problems from the textbook
    - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
    - Lab Exercises: Modeling Mitosis and Meiosis, Observation of Mitosis slides of Onion Root Tip and Whitefish Blastula
    - Quiz Content (as agreed upon by PLC): Mitosis and Cell Cycle Checkpoints, Meiosis and Variation
    - Common Assessment Unit 4

        - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
    - Cornell Notes correspondent to Lab Hamster Website
    - Left Side Processing
    - Biology POGIL practice
    - YouTube video reviews
    - Model design feedback

- **Extensions:**
    - Review types of cancer to determine causes, impacts, and treatments
    - Learn about Henrietta Lacks' cancer cells use in biomedical research
    - Utilize the NOVA RNA lab to see the functionality of RNA in cells (https://www.pbs.org/wgbh/nova/labs/lab/rna/)
    - Incorporate aspects of Open Sci Ed B.3

Unit 5: DNA and Gene Expression (15 Days)

- **Standards:**
    - 3.1.9-12.A Students who demonstrate understanding can construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
        - **Clarifying Statement:**
            - Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.
        - **Assessment Boundary:**
            - Assessment does not include deriving mathematical equations to make comparisons.

    - 3.1.9-12.P Students who demonstrate understanding can ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
        - **Clarifying Statement:**
            - N/A
        - **Assessment Boundary:**
            - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

    - 3.1.9-12.Q Students who demonstrate understanding can make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
        - **Clarifying Statement:**
            - Emphasis is on using data to support arguments for the way variation occurs.
        - **Assessment Boundary:**
            - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

    - 3.5.9-12 GG Students who demonstrate understanding can evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and economic landscapes throughout history.
        - **Clarifying Statement:**
            - Communication, agriculture, and transportation, for example, have evolved out of the political, economic, and social interests and values of the times.

        - **Assessment Boundary:**
            - N/A

    - 3.5.9-12 JJ Students who demonstrate understanding can identify and explain how the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes.
        - **Clarifying Statement:**
            - The Stone Age started with the development of stone tools used for hunting, cutting, and pounding vegetables and meat and progressed to the harnessing of fire for heating, cooking, and protection. The Bronze Age began with the discovery of copper and copper-based metals. The wide application of new agricultural technologies such as the sickle, plow, windmill, and irrigation enabled farmers to grow more food. Sustained technological advancement caused many people to migrate from farms to developing towns and cities. Other influential developments in this age included weaving machines and the spinning wheel, which advanced the making of cloth. The invention of gunpowder and guns was an improvement over previous weapons for both hunting and protection.
        - **Assessment Boundary:**
            - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Ask questions that arise from examining models or a theory to clarify relationships. ● Engaging in Argument From Evidence ● Obtaining, Evaluating, and Communicating Information	● Structure and Function ● Inheritance of Traits ● Variation of Trait ● Defining & Delimiting Engineering Problems	● Cause and Effect ● Making and Doing ● Attention to Ethics

Anchoring Phenomenon:

- CRISPR and the Future of Human Evolution

Objectives:

- Create a Driving Question Board that addresses the expression of genetic traits (DOK 4)
- Describe the characteristics of DNA that allow it to be used as the hereditary material (DOK 2)
- Describe the mechanisms by which genetic information is copied for transmission between generations (DOK 2)

- Describe the mechanisms by which genetic information flows from DNA to RNA to Protein (DOK 3)
- Explain how the phenotype of an organism is determined by its genotype (DOK 2)
- Explain how the location of regulatory sequences relates to their function (DOK 3)
- Explain that variable gene expression may turn genes on or off (DOK 3)
- Explain how environmental factors may influence gene expression (DOK 3)
- Explain the effects of mutations (DOK 2)
- Describe the various types of mutations (DOK 2)
- Explain the use of genetic engineering techniques in analyzing or manipulating DNA (DOK 3)

Core Activities and Corresponding Instructional Methods:

- Watch video on future human ancestry and evolution / genetic engineering tools (CRISPR and the future of gene editing)
- Create a driving question board on the content indicated by the unit phenomenon
- Complete Cornell Notes on content including: DNA, RNA, Proteins, Mutations, Gene editing, Gene expression, Biotechnology, and Genetic engineering
- Create models of DNA structure
- Complete investigatory lab on bacterial identification
- Watch simulations on how DNA mutations can lead to changes in specific protein amino acid sequence and protein function (How is DNA Used to Make Proteins?)
- Complete a DNA extraction lab
- Practice the process of transcription and translation to observe how DNA codes for the amino acid sequence of a protein
- Utilize the HHMI CRISPR interactive to investigate new technology

Correspondent Vocabulary:

- Chromosome, Chromatin, Double Helix, Antiparallel, DNA Semi-Conservative Replication, Helicase, Primase, DNA Polymerase, Okazaki Fragment, Ligase, Leading Strand, Lagging Strand, Point Mutation, Insertion Mutation, Deletion Mutation, Frame Shift Mutation, Substitution Mutation, Silent Mutation, Nonsense Mutation, Missense Mutation, Protein, Protein Synthes, Transcription, RNA Polymerase, Translation, rRNA, tRNA, mRNA,Codon, AntiCodon, Amino Acid, Polypeptide Chain, Nitrogenous Base, Clone, Genetically Modified Organism

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool

- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit

    - Group activities
    - Think/Pair/Share vocal activities
    - Homework – Example problems from the textbook
    - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
    - Lab Exercise: DNA Extraction lab (ex: DNA extraction from yeast or fruit)
    - Quiz Content (as agreed upon by PLC): DNA Structure and function, Protein synthesis and mutations, Genetic Inheritance Modeling
    - Genetic engineering research project/presentation
    - Common Assessment Unit 5
        - Questions to include multiple choice, fill in the blank, CER, and free response
    -
- **Correctives:**
    - Cornell Notes correspondent to Lab Hamster Website
    - Left Side Processing
    - Biology POGIL practice
    - Youtube video reviews
    - Model design feedback

- **Extensions:**
    - Researching new DNA technologies and science breakthroughs that in different scientific disciplines that are related to DNA
    - Describe and research different professional careers that utilize DNA science

Unit 6: Mendelian Genetics (15 Days)

- **Standards:**
  - 3.1.9-12Q Students who demonstrate understanding can make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
    - **Clarifying Statement:**
      - Emphasis is on using data to support arguments for the way variation occurs.
    - **Assessment Boundary:**
      - Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

  - 3.1.9-12.T Students who demonstrate understanding can construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
    - **Clarifying Statement:**
      - Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.
    - **Assessment Boundary:**
      - Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

  - 3.5.9-12 GG Students who demonstrate understanding can evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and economic landscapes throughout history.
    - **Clarifying Statement:**
      - Communication, agriculture, and transportation, for example, have evolved out of the political, economic, and social interests and values of the times.

    - **Assessment Boundary:**
      - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Engaging in Argument	● Variation of Traits	● Cause and Effect

from Evidence ● Constructing Explanations and Designing Solutions	● Natural Selection ● Adaptation ● Defining & Delimiting Engineering Problems	● Making and Doing ● Attention to Ethics

Anchoring Phenomenon:

- Duchenne Muscular Dystrophy Inquiry Hub Landing Page - Unit 2 Genetics: How Can Science Help Make Our Lives Better? iHub Biology
- TED Talk: Life Saving Secrets in your baby's DNA (Robert C. Green: The Life-saving Secrets in Your Baby's DNA)

Objectives:

- Apply concepts from DNA and cell division to the understanding of heredity (DOK 4)
- Describe geneticist Gregor Mendel's studies and conclusions about inheritance and how Mendel's principles apply to all organisms (DOK 1)
- Recall what happens during segregation in meiosis and the principle of independent assortment, genetic recombination, and gene linkage as they apply to chromosome distribution in sex cells (DOK 3)
- Display how geneticists use the principles of probability to predict genetic crosses by setting up and analyzing Punnett Squares (DOK 2, 4)
- Explain the differences between Mendelian (complete dominance) and non-Mendelian (codominance, incomplete dominance, sex-linked traits) and predict offspring genotypes and phenotypes based on parent genotype (DOK 4)
- Define codominance and apply the ABO blood typing system as a model of codominance and apply the concepts of immune response to determine safe transfusions (DOK 1, 4)
- Predict the multiplicative effects of inheritance of multiple different traits at the same time (dihybrid inheritance patterns.) (DOK 3)
- Identify examples of applied genetics such as selective breeding, hybridization, inbreeding, and test crosses (DOK 1)
- Recognize patterns of inheritance of human traits by analyzing pedigree charts (DOK 4)
- Cite evidence for the causes of genetic disorders—distinguish between small changes in DNA; errors occurring in meiosis; and chromosomal abnormalities (DOK 2, 3)
- Show the cause and effect relationship between gene expression and the environment (DOK 2)
- Analyze a pedigree chart to better understand how geneticists can study inheritance patterns (DOK 4)
- Cite evidence for the causes of genetic disorders—distinguish between small changes in DNA; errors occurring in meiosis; and chromosomal abnormalities (DOK 2, 3)
- Explain epigenetics and how it affects gene expression (DOK2)
- Determine if genes are linked (on the same chromosome) (DOK3)
- Identify examples of biotechnology and genetic engineering (DOK 1)
- Evaluate and apply ethical reasoning to the effect of new biotechnologies (such as CRISPR/Cas 9) in society (DOK4)
- Connect examples of biotechnology, genetic engineering, gene splicing to the students' understanding of the principles of DNA and how it can be applied to techniques for gene therapy and genetically modified organisms (DOK 4)

- Compare types of questions to determine the nature of an ethical question (DOK 2)
- Apply ethical reasoning to evaluate new biotechnological applications (DOK4)

Core Activities and Corresponding Instructional Methods:

- Watch a video depicting Muscular Dystrophy Phenotypes
- Create a driving question board on the content indicated by the unit phenomenon
- Perform Punnett Squares to predict probabilities of inheritance for different genetic inheritance patterns
- Analyze Pedigrees to determine mode of inheritance and probabilities of inheritance
- Use the Learn Genetics website to use Pigeons as models for inheritance
- Perform digital lab to determine blood type and appropriate transfusions (https://educationalgames.nobelprize.org/educational/medicine/bloodtypinggame/)
- Complete Cornell Notes on content including: Mendelian Genetics, NonMendelian Genetics, Chromosomal Inheritance

Correspondent Vocabulary:

- Trait, Gene, Allele, Diploid, Homologous Chromosome, Homozygous/True-Breeding, Heterozygous/Hybrid, Dominant Gene, Recessive Gene, Phenotype, Genotype. Punnett Square, Test Cross, Complete Dominance, Incomplete Dominance, Co-Dominance, Sex-linked Trait, Multiple Trait Inheritance, Blood Type, Antigen, Transfusion, Pedigree, Mode of Inheritance, Single-Gene Trait, Polygenic Trait, Linked Genes, Recombinant Chromosome, CRISPR-Cas9, Gene Editing

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool

- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities
  - Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
  - Bioengineering and Gene Editing Research
  - Quiz Content (as agreed upon by the PLC): DNA Structure and Function, Protein Synthesis and Point Mutations, Pedigree Analysis
  - Common Assessment Unit 6
    - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
    - Cornell Notes correspondent to Lab Hamster Website
    - Left Side Processing
    - Biology POGIL practice
    - YouTube video reviews
    - Model design feedback

- **Extensions:**
    - Utilize the Fly Lab to analyze inheritance patterns in *Drosophila melanogaster*

Unit 7: Natural Selection and Evolution (25 Days)

- **Standards:**
    - 3.1.9-12.S Students can communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
        - **Clarifying Statement:**
            - Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.
        - **Assessment Boundary:**
            - N/A

    - 3.1.9-12.R Students who demonstrate understanding can apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
        - **Clarifying Statement:**
            - Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.
        - **Assessment Boundary:**
            - Assessment does not include Hardy-Weinberg calculations.

    - 3.1.9-12.T Students can construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
        - **Clarifying Statement:**
            - Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.
        - **Assessment Boundary:**
            - Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

    - 3.1.9-12.U Students who demonstrate understanding can apply concepts of statistics and probability to support explanations that organisms with an

advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

- **Clarifying Statement:**
  - Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.
- **Assessment Boundary:**
  - Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.

- 3.1.9-12.W Students who demonstrate understanding can construct an explanation based on evidence for how natural selection leads to adaptation of populations.
  - **Clarifying Statement:**
    - Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.
  - **Assessment Boundary:**
    - N/A

- 3.1.9-12.X Students who demonstrate understanding can evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

  - **Clarifying Statement:**
    - Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

  - **Assessment Boundary:**
    - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Constructing Explanations and Designing Solutions ● Obtaining, Evaluating, and Communicating Information ● Science Models, Laws, Mechanisms, and Theories	● Variation of Traits ● Evidence of Common Ancestry and Diversity ● Natural Selection ● Adaptation	● Scale Proportion and Quantity ● Science is a Human Endeavor ● Cause and Effect ● Patterns ● Scientific Knowledge Assumes an Order and

Explain Natural Phenomena ● Analyzing and Interpreting Data ● Engaging in Argument From Evidence		Consistency in Natural Systems

Anchoring Phenomenon:

- Bacterial Evolution - Time Lapse Video
- Tuberculosis as an Infectious Killer

Objectives:

- Create a Driving Question Board that addresses the inheritance of genetic traits (DOK 4)
- Describe the causes of natural selection and its effect on populations (DOK 2)
- Describe the importance of phenotypic variation on a population (DOK 2)
- Explain how humans can affect diversity within a population (DOK 3)
- Explain how the phenotype of an organism is determined by its genotype (DOK 2)
- Explain how random occurrences affect the genetic makeup of a population (DOK 3)
- Explain the impacts of the population in any of the conditions for Hardy-Weinberg are not met (DOK 3)
- Describe the conditions under which allele and genotype frequencies will change in populations (DOK 2)
- Describe the types of data that provide evidence for evolution (DOK 2)
- Explain how evolution is an ongoing process in all living organisms (DOK 3)
- Describe the types of evidence that can be used to infer evolutionary relationships (DOK 2)
- Explain how phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness (DOK 3)
- Describe the conditions under which new species may arise (DOK 2)
- Describe the rate of evolution and speciation under different ecological conditions (DOK 2)
- Describe factors that lead to the extinction of a population (DOK 2)
- Describe the scientific evidence that provides support for models of the origin of life on Earth (DOK 2)
- Discuss the concepts and processes that direct the process of evolution (DOK 3)

Core Activities and Corresponding Instructional Methods:

- Watch video on tuberculosis and infectious disease
- Complete the Rock Pocket Dots lab and analyze data
- Complete simulation on artificial selection and genetic drift (7.3 & 7.4 Genetic Drift Simulation)
- Utilize the NOVA Evolution Lab on Phylogenetic Trees/Cladograms/Speciation
- Complete Cornell Notes on content including: Natural Selection, Artificial Selection, Population Genetics, Evidence of Evolution, Common Ancestry, Phylogeny, Speciation

Correspondent Vocabulary:

- Scientific Law, Scientific Theory, Law of Evolution, Theory of Evolution, Geology, Fossil, Artificial Selection, Evolutionary Fitness, Adaptation, Common Descent/Common Ancestor, Biogeography. Homologous Structure, Vestigial Structure, Analogous Structure, Embryology, Molecular Biology, Natural Selection, Sexual Selection, Gene Flow, Genetic drift, Bottleneck Effect, Founder Effect, Allele Frequency, Directional Selection, Stabilizing Selection, Disruptive Selection, Biological Species Concept, Speciation, Reproductive Isolation, Pre-zygotic Reproductive Barrier, Post-zygotic Reproductive Barrier, Gradualism, Punctuated Equilibrium, Hybrid, Allopatric Speciation, Sympatric Speciation

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tool

- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities
  - Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets, Formative Quizzes

- **Summative:**
  - Lab Exercise: Phenotype Testing of PTC for Allele Frequency Calculations
  - Quiz Content (as agreed upon by PLC): Natural Selection and Darwin, MicroEvolution and Sources of Allele Frequency Change, Speciation and
  - Common Assessment Unit 7
    - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
  - Cornell Notes correspondent to Lab Hamster Website
  - Left Side Processing
  - Biology POGIL practice
  - Youtube video reviews
  - Model design feedback

- **Extensions:**
  - Investigation of Alfred Russell Wallace as an addition developer of the Theory of Natural Selection by watching HHMI Making of a Theory

- Watch video clips from Your Inner Fish, Reptile and Monkey docuseries
- Utilize Cornell Bird Lab to explore concepts of Speciation and Selection
  - Speciation: An Illustrated Introduction
  - Natural Selection & Sexual Selection: An Illustrated Introduction
- Incorporate aspects of Open Sci Ed B.4 and B.5

Unit 8: Ecology (25 Days)

- **Standards:**
    - 3.1.9-12.H Students who demonstrate understanding can use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
        - **Clarifying Statement:**
            - Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen, and nitrogen being conserved as they move through an ecosystem.
        - **Assessment Boundary:**
            - Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.

    - 3.1.9-12.I Students who demonstrate understanding can use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
        - **Clarifying Statement:**
            - Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.
        - **Assessment Boundary:**
            - Assessment does not include deriving mathematical equations to make comparisons.

    - 3.1.9-12.K Students who demonstrate understanding can develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
        - **Clarifying Statement:**
            - Examples of models could include simulations and mathematical models.
        - **Assessment Boundary:**
            - Assessment does not include the specific chemical steps of photosynthesis and respiration.

    - 3.1.9-12.L Students who demonstrate understanding can use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
        - **Clarifying Statement:**

        - Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.
    - **Assessment Boundary:**
        - Assessment is limited to provided data.

- 3.1.9-12.M Students who demonstrate understanding can evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
    - **Clarifying Statement:**
        - Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.
    - **Assessment Boundary:**
        - N/A

- 3.1.9-12.N Students who demonstrate understanding can design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
    - **Clarifying Statement:**
        - Examples of human activities can include urbanization, building dams, and dissemination of invasive species.
    - **Assessment Boundary:**
        - N/A

- 3.1.9-12.O Students who demonstrate understanding can evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
    - **Clarifying Statement:**
        - Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.
    - **Assessment Boundary:**
        - N/A

- 3.1.9-12V Students who demonstrate understanding can create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
    - **Clarifying Statement:**

- Students who demonstrate understanding can create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

- **Assessment Boundary:**
  - N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Engaging in Argument from Evidence ● Scientific Knowledge is Open to Revision in Light of New Evidence ● Using Mathematical and Computational Thinking ● Developing and Using Models ● Constructing Explanations and Designing Solutions	● Ecosystem Dynamics, Functioning, and Resilience ● Cycles of Matter and Energy Transfer in Ecosystems ● Interdependent Relationships in Ecosystems ● Adaptations ● Biodiversity and Humans ● Energy in Chemical Processes ● Biodiversity and Humans ● Developing Possible Solutions ● Social Interactions and Group Behavior	● Stability and Change ● Energy and Matter ● Scale Proportion and Quantity ● Systems and System Models ● Cause and Effect

Anchoring Phenomenon:

- The Wolves and Moose on Isle Royale of Lake Superior

Objectives:

- Explain how the behavioral and physiological response of an organism is related to changes in internal or external environment (DOK 4)
- Identify how organisms respond to changes in their environment through behavioral and physiological mechanisms (DOK 1)
- Describe how organisms respond to changes in their environment through behavioral and physiological mechanisms (DOK 3)
- Identify and describe how organisms exchange information with one another in response to internal and external cues, which can change behavior (DOK 2, 4)
- Explain how the flow energy can lead to different limiting factors of populations (DOK 4)
- Define and model different graphical representations of population growth curves and reproductive strategies of organisms (DOK 1, 4)
- Identify different symbiotic relationships shared in community interactions between different populations of organisms (DOK 3)
- Create models of different climates and describe how populations are adapted to each of the different biomes they live in (DOK 1)
- Recognize how the behavioral responses of organisms affect their overall fitness and may contribute to the success of a population(DOK 4)
- Describe the strategies organisms use to acquire and use energy (DOK 2, 3)

- Calculate the flow of energy through an ecosystem based on tropic levels and energy pyramids (DOK 2)
- Model ecosystem energy flow utilizing food webs and food chains of an ecosystem (DOK 3)
- Explain how population density affects the number of individuals in a population based upon the limiting factors of an ecosystem and community dynamics (interactions) (DOK 2, 3)
- Define the levels of ecology (DOK 1)
- Compare and contrast the different biomes based upon climate and population diversity (DOK 3)
- Identify and describe positive and negative human impacts on different biomes and ecosystems(DOK 1,2)
- Evaluate different human projects (locally, statewide, and globally) that positively benefit populations and their environments (DOK 3)
- Explain how invasive (nonnative) species affect ecosystems through human activities (DOK 3)

Core Activities and Corresponding Instructional Methods:

- Watch YouTube videos such as Return of the Pack: Wolves' Restoration on Isle Royale!
- Create a driving question board on the content indicated by the unit phenomenon
- Investigate population, community, and ecosystem interactions in Isle Royale as conservation efforts occur
- Complete Cornell Notes on content including: Responses to the environment, Energy flow through ecosystems, Population ecology, Effect of density of populations, Community ecology, Biodiversity, Disruptions to ecosystems
- Explore population dynamics graphs and specific community interactions (such as the Old Grey Man, Blood Suckers, and Ravel Influence) on Isle Royale
- Learn about the 30 by 30 executive order, "America the Beautiful" and explore specific conservation sites in the United States
- Prepare for the Keystone Biology Exam

Correspondent Vocabulary:

- Species, Population, Community, Ecosystem, Biome, Biosphere, Biotic Factor, Abiotic Factor, Autotroph, Primary Producer, Photosynthesis, Phytoplankton, Chemosynthesis, Heterotroph, Zooplankton, Consumer, Carnivore, Herbivore, Scavenger, Omnivore, Predation, Decomposer, Detritivore, Food chain, Food web, Trophic level, Ecological pyramid, Biomass, Niche, Keystone Species, Symbiosis, Mutualism, Commensalism, Parasitism, Population density, Immigration/Emigration, Logistic Growth, Exponential Growth, Boom and Bust growth curve, Carrying capacity, Limiting Factor, Density Dependent Limiting Factor, Density Independent Limiting Factor, Renewable Resource, on-renewable Resource, Biological magnification, Invasive Species, Biodiversity, Primary ecological succession, Secondary ecological succession, Pioneer Species, Biogeochemical cycle, Water Cycle, Carbon Cycle, Nitrogen Cycle, Nitrogen Fixation, Nutrient, Limiting Nutrient

Assessments:

- **Diagnostic:**
  - Introduction of the Phenomenon and driving question board
  - Teacher questioning and observation
  - Classroom Diagnostic Tools
  -
- **Formative:**
  - Teacher observations
  - Questioning techniques
  - Define vocabulary words for this unit
  - Group activities
  - Think/Pair/Share vocal activities
  - Homework – Example problems from the textbook
  - CER, Enter/Exit tickets

- **Summative:**
  - Quiz Content (as agreed upon by PLC): Energy of ecosystems, Population dynamics and community interactions, Human impacts on ecosystems
  - Common Assessment Unit 8
    - Questions to include multiple choice, fill in the blank, CER, and free response

- **Correctives:**
  - Cornell Notes correspondent to Lab Hamster Website
  - Left Side Processing
  - Biology POGIL practice
  - YouTube video reviews
  - Model design feedback

- **Extensions:**
  - Explore the NOVA Polar Lab
  - Calculate Ecological Footprint to determine resource use
  - Incorporate aspects of Open Sci Ed B.1 and B.2

Unit 9: Environmental Literacy and Sustainability Capstone (10 Days)

- **Standards**
  - **3.4.9-12.A -** Analyze how human activities, technologies, and policies impact environmental and agricultural systems.
    - **Clarifying Statement:** Emphasis is on cause-and-effect relationships between human actions and environmental outcomes, including both intended and unintended consequences.
    - **Assessment Boundary:** N/A

  - **3.4.9-12.B -** Evaluate how human decisions influence environmental systems, including tradeoffs among economic, social, and ecological factors.
    - **Clarifying Statement:** Emphasis is on analyzing competing interests and outcomes when decisions affect sustainability.
    - **Assessment Boundary:** Limited to analysis of provided scenarios or datasets; not full policy design.

  - **3.4.9-12.C -** Analyze how natural systems provide ecosystem services and how those services are impacted by human activity.
    - **Clarifying Statement:** Emphasis is on identifying services such as water purification, pollination, and climate regulation, and how they are altered by human use.
    - **Assessment Boundary:** Focus on relationships and impacts; not required to quantify economic value.

  - **3.4.9-12.D -** Evaluate how resource use and management practices affect sustainability of environmental systems.
    - **Clarifying Statement:** Emphasis is on long-term impacts of resource consumption and sustainable vs. unsustainable practices.
    - **Assessment Boundary:** Evaluation based on provided data or case studies; not full lifecycle analysis.

  - **3.4.9-12.E -** Analyze how cultural, economic, and political perspectives influence environmental decisions.
    - **Clarifying Statement:** Emphasis is on comparing stakeholder viewpoints and how values shape decisions.
    - **Assessment Boundary:** Focus on analysis of perspectives, not resolution of large-scale policy conflicts.

  - **3.4.9-12.F -** Design or propose solutions that reduce environmental impacts and promote sustainability.
    - **Clarifying Statement:** Emphasis is on applying scientific knowledge and evidence to develop feasible solutions.
    - **Assessment Boundary:** Solutions may be conceptual or model-based; implementation is not required.

- **3.4.9-12.G -** Evaluate how environmental laws, policies, and resource management practices contribute to sustainability.
  - **Clarifying Statement:** Emphasis is on how regulations and management strategies affect environmental systems across land, water, and biodiversity.
  - **Assessment Boundary:** N/A

- **3.4.9-12.H -** Design, evaluate, and refine solutions to complex environmental problems using evidence and tradeoff analysis.
  - **Clarifying Statement:** Emphasis is on improving solutions by considering constraints, unintended consequences, and multiple criteria.
  - **Assessment Boundary:** N/A

- **3.4.9-12.I -** Apply systems thinking to evaluate environmental issues and predict outcomes of human actions.
  - **Clarifying Statement:** Emphasis is on understanding interactions within environmental systems and predicting long-term impacts.
  - **Assessment Boundary:** Limited to reasoning using models, scenarios, or provided data; not full predictive modeling.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Asking Questions and Defining Problems ● Developing and Using Models ● Analyzing and Interpreting Data ● Using Mathematics and Computational Thinking ● Constructing Explanations ● Engaging in Argument from Evidence ● Obtaining, Evaluating, and Communicating Information ● Designing Solutions	● Human Impacts on Earth Systems ● Sustainability and Resource Management ● Ecosystem Services and Biodiversity ● Environmental Decision-Making ● Systems Thinking and Interconnectedness ● Engineering Design and Solutions	● Cause and Effect ● Systems and System Models ● Stability and Change ● Patterns ● Influence of Science, Engineering, and Technology on Society and the Natural World

Anchoring Phenomena

- Impact of human activities on ecosystems locally and globally, requiring informed decisions to promote sustainability

Objectives:

- Identify and describe a real-world environmental issue affecting ecosystems or human populations. (DOK 1)

- Analyze data related to environmental changes, resource use, or biodiversity loss. (DOK 2)
- Explain how human activities influence ecosystem stability and sustainability. (DOK 3)
- Evaluate potential solutions to environmental problems using scientific evidence and reasoning. (DOK 4)
- Develop and defend a proposed solution that reduces environmental impact or promotes sustainability. (DOK 4)
- Communicate findings and recommendations using scientific arguments supported by data. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Introduce project and provide choice of environmental topics (local or global) using guided brainstorming and issue exploration. Possible topics for student choice:
    - **Delaware River Water Quality -** Investigate nutrient levels, turbidity, or pollution sources in the Delaware River and evaluate impacts on aquatic ecosystems and drinking water.
    - **Runoff and Stormwater in Milford Borough -** Analyze how roads, parking lots, and development contribute to stormwater runoff and propose green infrastructure solutions (rain gardens, permeable pavement).
    - **Harmful Algal Blooms in Local Lakes and Reservoirs -** Study conditions that lead to algal blooms (e.g., Lake Wallenpaupack watershed) and evaluate impacts on recreation, wildlife, and water quality.
    - **Effects of Septic Systems on Groundwater Quality -** Investigate how residential septic systems in rural Pike County may contribute to nutrient loading and groundwater contamination.
    - **Delaware River Basin Flooding and Land Use -** Analyze how land use changes (development, deforestation) influence flood frequency and severity along the Delaware River.
    - **Habitat Fragmentation in Pike County Forests -** Examine how roads, development, and land clearing impact wildlife movement and biodiversity in forest ecosystems.
    - **Black Bear–Human Interactions in Pike County -** Investigate increasing bear sightings near residential areas and evaluate how human behavior, waste management, and habitat changes influence these interactions.
    - **Invasive Species in the Delaware River Basin -** Study species such as Japanese knotweed, zebra mussels, or spotted lanternfly and evaluate their ecological and economic impacts.
    - **Trout Stream Health and Cold-Water Fisheries -** Assess how temperature changes, runoff, and habitat degradation affect native trout populations in local streams.
    - **Impact of Road Salt on Local Waterways -** Analyze how winter road treatment affects salinity levels in streams and impacts aquatic life.
    - **Climate Change Impacts in Northeastern PA -** Investigate changes in temperature, precipitation, or seasonal patterns and how they affect ecosystems, wildlife, and human communities.

- **Wetland Loss and Ecosystem Services -** Evaluate the role of wetlands in water filtration, flood control, and biodiversity, and analyze impacts of wetland loss in the region.
- **Agricultural Runoff in the Delaware River Watershed -** Examine how farming practices contribute to nutrient loading and propose best management practices.
- **Air Quality and Transportation in Rural Communities -** Investigate local air pollution sources (traffic, heating, seasonal burning) and impacts on human and environmental health.
- **Tourism and Environmental Impact in the Delaware Water Gap Region -** Evaluate how recreation (hiking, boating, camping) impacts ecosystems and propose sustainable management strategies.
- **Forest Management and Carbon Storage in Pike County -** Analyze how forest conservation or logging practices influence carbon sequestration and climate mitigation.
- **Microplastics in Freshwater Systems -** Investigate presence and sources of microplastics in the Delaware River or nearby streams.
- **Renewable Energy Opportunities in Pike County -** Evaluate feasibility and environmental impact of solar, hydro, or wind energy in the region.
- **Residential Subdivision Growth in Pike County -** Analyze how increasing housing development impacts forests, wildlife corridors, and water runoff; propose land-use or zoning solutions.
- **Urban Sprawl vs. Conservation in Pennsylvania -** Compare developed vs. protected areas and evaluate tradeoffs between economic growth and ecosystem preservation.
- **Habitat Fragmentation from Road Expansion -** Investigate how highways and roads divide ecosystems and impact species movement; design mitigation strategies (wildlife crossings, zoning).
- **Deforestation and Land Conversion -** Examine rainforest or regional forest loss and evaluate impacts on biodiversity, climate, and local communities.
- **Local Food Systems vs. Industrial Agriculture**
  Compare environmental impacts of local farms vs. large-scale agriculture; evaluate sustainability and food security.
- **Nutrient Runoff and Fertilizer Use -** Analyze how fertilizers contribute to water pollution (local or Chesapeake Bay connections) and propose management strategies.
- **Sustainable Farming Practices -** Evaluate no-till farming, crop rotation, or regenerative agriculture and their impact on soil health and carbon storage.
- **Global Food Production and Climate Change -** Investigate how agriculture contributes to greenhouse gas emissions and explore sustainable alternatives.
- **Transportation Patterns in Rural vs. Urban Areas -** Compare environmental impacts of commuting, fuel use, and infrastructure; propose sustainable transportation options.
- **Tourism and Travel Impacts (Delaware Water Gap / National Parks) -** Evaluate environmental effects of recreation and propose sustainable tourism strategies.

    - **Electric Vehicles vs. Gas-Powered Vehicles -** Analyze lifecycle impacts (production, energy source, emissions) and evaluate tradeoffs.
    - **Global Air Travel and Carbon Emissions -** Investigate aviation's role in climate change and propose mitigation strategies.
    - **Household Waste and Recycling Effectiveness in PA -** Analyze waste streams and evaluate how effective recycling programs actually are.
    - **Plastic Pollution in Freshwater Systems -** Investigate sources and impacts of plastic and microplastics locally or globally.
    - **Food Waste in the United States -** Examine how much food is wasted and propose solutions to reduce waste at local or national levels.
    - **E-Waste and Technology Disposal -** Investigate how electronic waste is handled and its environmental and human health impacts.
    - **Household Waste and Recycling Effectiveness in PA -** Analyze waste streams and evaluate how effective recycling programs actually are.
    - **Plastic Pollution in Freshwater Systems -** Investigate sources and impacts of plastic and microplastics locally or globally.
    - **Food Waste in the United States -** Examine how much food is wasted and propose solutions to reduce waste at local or national levels.
    - **E-Waste and Technology Disposal -** Investigate how electronic waste is handled and its environmental and human health impacts.
    - **Climate Change Impacts in Pennsylvania -** Analyze regional changes in temperature, precipitation, and ecosystems.
    - **Sea Level Rise and Coastal Communities -** Investigate impacts and adaptation strategies.
    - **Extreme Weather and Infrastructure Resilience -** Evaluate how communities prepare for floods, storms, or drought.
    - **Climate Change Impacts in Pennsylvania -** Analyze regional changes in temperature, precipitation, and ecosystems.
    - **Sea Level Rise and Coastal Communities -** Investigate impacts and adaptation strategies.
    - **Extreme Weather and Infrastructure Resilience -** Evaluate how communities prepare for floods, storms, or drought.
    - **Species Decline and Conservation Efforts in PA -** Investigate local endangered species and evaluate conservation strategies.
    - **Global Biodiversity Loss -** Analyze causes and propose solutions to slow or reverse trends.
    - **Reintroduction or Wildlife Management Programs -** Evaluate success and unintended consequences.
- Students select a topic and develop a driving question using teacher conferencing and proposal templates.
- Conduct research using curated articles, datasets, and reports; students practice obtaining and evaluating information.
- Analyze environmental data (graphs, maps, case studies) using data interpretation and systems thinking.
- Develop a system model showing interactions between human activity and environmental systems.

- Participate in direct instruction on sustainability frameworks and evaluating solutions.
- Construct a solution or action plan addressing the identified issue using engineering design and CER reasoning.
- Engage in peer critique and revision cycles using structured feedback protocols.
- Create a final product (presentation, report, infographic, or proposal) using scientific communication strategies.
- Present solutions to peers (or authentic audience if possible) using argument from evidence.

Assessments:

- **Diagnostic:**
    - Initial proposal and background knowledge discussion

- **Formative:**
    - Research checkpoints
    - Data analysis tasks
    - Model drafts
    - Peer feedback sessions

- **Summative**:
    - Final project (solution and evidence-based justification)
    - Presentation or defense

- **Correctives**:
    - Interpreting environmental data (graphs, trends, cause-effect)
    - Connecting human actions to ecosystem outcomes
    - Distinguishing between short-term fixes vs. sustainable solutions
    - Strengthening CER (Claim–Evidence–Reasoning)

- **Extensions**:
    - Implement a real-world action project (school or community-based)
    - Develop a grant-style proposal for environmental improvement
    - Interface with local stakeholders, community organizations, or agencies (DEP, DCNR, PEEQ, Grey Towers, PAFBC, PAGC, National Park Service, USDA, etc.)