PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Biology

Curriculum Writing Committee:

Patrick Ingulli and Andrew Rupp

Grade Level: 9

Date of Board Approval: _____

Course Weighting: Biology

Major Assessment	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 support application of scientific practices. Laboratory classes are designed to stimulate student interest and encourage problem-solving and student-led discovery. 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 will be able to …**
    - **Unit 1: Ecosystem Interactions - 28 Days**
        - Develop and use a model based on evidence to explain why wildebeest migrate.
        - Use mathematics and computational thinking to explain how limiting factors such as food have impacted the wildebeest population over time including carrying capacity.
        - Use a model to generate evidence to explain how group behavior explains interactions between wildebeest and their predators.
        - Obtain and communicate information about other components of the system in a complex model that can be used to predict future outcomes.
        - Evaluate the potential outcomes of a proposed road through the Serengeti ecosystem including the criteria prioritized by different interest holders.
        - Apply all the ecosystems and conservation ideas developed in the context of the Serengeti to evaluate conservation efforts in the US.

        - Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
        - Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
        - Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
        - 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
        - Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

    - **Unit 2: Matter and Energy - 17 Days**
        - Develop, use, and revise a model of the matter and energy flow in zombie fire systems so that they can apply this model to other carbon sinks and on a greater scale.
        - Construct an explanation for how there was enough matter and energy in the peat/permafrost system for a zombie fire to burn under ice.
        - Plan and carry out investigations to identify changes in matter and energy under different conditions in the system.
        - Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
        - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

- **Marking Period 2 (45 days) - Students will be able to …**
    - **Unit 2: Ecosystems: Matter and Energy - 15 Days**
        - Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
        - 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.
        - 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 the new compounds are formed resulting in a net transfer of energy.

- Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

- **Unit 3: Inheritance & Variation of Traits - 30 Days**
  - Develop a model and ask questions to explain and predict the factors of cancer and the possible protective effects from p53.
  - Construct an explanation based on evidence about how mutations occur and the role of p53 in their repair.
  - Use a model to illustrate the relationships between DNA structure and the structure and function of p53.
  - Use a computer simulation as evidence to develop and revise a model that predicts how the rate of cell division affects the likelihood of cancer.
  - Develop and use multiple models to explain how the inheritance of p53 alleles and other gene alleles can cause cancer in multiple generations of a family through new combinations of alleles.
  - 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.
  - 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
  - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms
  - Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
  - Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
  - 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
  - Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

- **Marking Period 3 (45 days) - Students will be able to …**
    - **Unit 4: Natural Selection & Evolution of Populations - 28 Days**
        - Ask and answer questions about how urbanization may cause changes in nonhuman populations.
        - Develop and revise models for how various selection pressures could cause nonhuman populations to evolve.
        - Analyze data collected by published scientists and apply this evidence to support their explanations.
        - Write and revise explanations for how genetic variations can lead to differential reproductive success and changes in populations.
        - Apply their knowledge of evolution by natural selection to explain why small, fragmented populations can be more vulnerable to change than large populations.
        - Evaluate and discuss how well proposed designs for the urbanization of a real city meet criteria for protecting biodiversity and the needs of all inhabitants of the area.
        - 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.
        - 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.
        - Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
        - 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.

    - **Unit 5: Common Ancestry and Speciation - 17 Days**
        - Develop and revise models to explain and predict the interactions of Arctic bear populations with their environment.
        - Construct and evaluate arguments using evidence.
        - Evaluate competing solutions to prevent extinction.
        - Find patterns in data at different scales that affect the survival of Arctic bears as the climate changes.
        - Develop and revise models about the effect of climate change on the long-

term survival of Arctic bear populations.
        - Make, defend, and evaluate claims about the relationship between thermoregulation and bear behavior.
        - Infer mechanisms of bear speciation at scales that cannot be studied directly.
        - Construct and revise arguments about how brown and polar bears split from a common ancestor.
        - Construct and revise arguments about the causes of mass extinction events on Earth.
        - Integrate and evaluate information from multiple sources about ways to prevent the extinction of particular species.
        - Evaluate possible solutions for protecting polar bears from extinction.
        - Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
        - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
        - 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.
        - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

- **Marking Period 4 (45 days) - Students will be able to …**
    - **Unit 5: Common Ancestry and Speciation - 17 Days**
        - Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
        - 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 .
        - Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
        - 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.

    - **Unit 6: ESL Capstone Project- 28 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 which 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:** OpenSciEd Instructional Materials for Grades 9-12

Curriculum Plan

Unit 1: Ecosystem Interactions and Dynamics - 28 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 Boundaries:** 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 Boundaries:** Assessment does not include deriving mathematical equations to make comparisons.

    - 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 Boundaries:** 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 Boundaries:** 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 Boundaries:** 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 Boundaries:** N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Using Mathematics and Computational Thinking • Scientific Knowledge is Open to Revision in Light of New Evidence • Engaging in Argument From Evidence • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions	• Interdependent Relationships in Ecosystems • Ecosystem Dynamics, Functioning, and Resilience • Social Interactions and Group Behavior • Natural Selection • Adaptation	• Scale Proportion and Quantity • Stability and Change • Cause and Effect • Patterns • Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Anchoring Phenomena:

- "30 by 30" Initiative
- The Great Migration of the Serengeti
- Wildebeest Population Trends Over Time
- Predator–Prey Interactions
- Biodiversity Stability in the Serengeti
- Human Impacts & Conservation Decisions
- Conservation Case Study: American Prairie Preserve

Objectives:

- Identify and define limiting factors (food, space, predation) in ecosystems. (DOK 1)
- Organize and graph population and resource data to show trends in carrying capacity. (DOK 2)
- Construct explanations for changes in population size using mathematical evidence. (DOK 3)
- Predict future population changes in an ecosystem using models and justify predictions. (DOK 4)

- Describe how energy flows and matter cycles through an ecosystem (biomass and population relationships). (DOK 1)
- Analyze data from models to explain how energy availability affects populations. (DOK 2)
- Revise ecosystem models to connect food availability to ecosystem stability. (DOK 3)
- Evaluate human or natural disruptions on the flow of energy in an ecosystem and propose improvements. (DOK 4)
- Identify biodiversity and keystone species in the Serengeti ecosystem. (DOK 1)
- Compare data sets to determine the impacts of biodiversity on population stability. (DOK 2)
- Use computational models to support claims about ecosystem resilience. (DOK 3)
- Evaluate competing explanations of ecosystem change and defend the most supported claim. (DOK 4)
- Recall examples of group behavior, such as herding and cooperative hunting. (DOK 1)
- Interpret survival data to differentiate between group and individual behaviors. (DOK 2)
- Construct evidence-based arguments for how group behavior improves survival or reproduction. (DOK 3)
- Apply group behavior models to a new ecological system and argue whether the mechanism would change outcomes. (DOK 4)
- Identify human activities that affect ecosystems, such as roads and land use. (DOK 1)
- Compare conservation strategies using success criteria, including biodiversity, stability, and stakeholder needs. (DOK 2)
- Construct and revise explanations for conservation success using stakeholder evidence and ecosystem models. (DOK 3)
- Design and defend a conservation plan for a new ecosystem with prioritized criteria and trade-offs. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Open Sci. Ed Unit B.1
- Driving Question Board launch using Lesson 1 Slideshow “Why do ecosystems need protection?” and “30x30 Initiative: Conserving U.S. Land and Waters by 2030” article set; student questioning and categorization routines
- Initial ecosystem model creation using Lesson 1 “Initial Modeling Tool” followed by consensus modeling from Lesson 2
- Jigsaw reading routine using Lesson 2 article “History of Serengeti National Park and Ngorongoro Conservation Area” and “Serengeti Map: Migration Routes”
- Data sorting and graphing using Lesson 3 “Wildebeest Mortality Data Table” and video “What Kills Wildebeests?”
- Rainfall and resource mapping analysis using Lesson 4 maps “Rainfall in Serengeti: Wet & Dry Seasons” and “Grass Availability and Migration”
- Kinesthetic carrying capacity simulation using Lesson 5 “Carrying Capacity Simulation” cards/tokens and “Population vs. Food Data” recording sheet
- Transfer task on limiting factors and carrying capacity using Lesson 6 “Liwonde National Park Wild Dog Case Study” and “Limiting Factors Data Set: Pack Size” with gallery walk peer feedback

- Agent-based predator–prey simulation game using Lesson 7 “Predator–Prey Simulation Game Board” and reading “Group Behavior in Lions and Spotted Hyenas”
- Mechanism-based CER writing using Lesson 7 “Mechanism Graphic Organizer” and student notebook prompts explaining survival advantages of group behavior
- Computational biodiversity and resilience modeling using Lesson 8 “Serengeti Component Articles” and SageModeler template “Serengeti Interactions Model” with disturbance testing
- Stakeholder mapping using Lesson 9 “Serengeti Stakeholder Cards” to evaluate human–ecosystem interactions
- Evidence-based stakeholder debate analyzing Lesson 9 “Serengeti Road Proposal Scenario” and “Claim-Evidence-Reasoning Decision Matrix”
- Evaluation of conservation success using Lesson 1 “U.S. Conservation Profiles” and Lesson 10 “Criteria for Conservation Success Organizer”
- Gallery walk presentation and peer feedback using Lesson 10 “Conservation Profile Slides/Posters”
- Transfer evaluation and solution design using Lesson 11 “American Prairie Case Study Packet” and species cards (Bison, Black-footed Ferret, Prairie Dogs)
- Keystone-style data interpretation using teacher-created question sets aligned to STEELS standards and Lesson 3–8 data
- Final consensus ecosystem model creation using “Final Ecosystem Model Rubric” and DQB review protocol
- Performance assessment submission using “Performance Assessment: Serengeti Conservation Plan” and notebook submission rubric

Correspondent Vocabulary:

- Conservation, Conservation plan, Criteria, Constraints, Interest holder, Land use, Protected area, 30x30 Initiative, Trade-offs, Biodiversity, Keystone species, Ecosystem, Habitat, Resource availability, Stability, Resilience, Disturbance, System interactions, System model, Carrying capacity, Limiting factor, Competition, Predation, Population size, Mortality factors, Growth rate, Biomass, Group behavior, Herding, Cooperative hunting, Survival rate, Predator–prey interactions, Risk reduction, Survival advantage, Energy flow, Trophic level, Food source, Matter cycling, Resource cycling, Conservation of matter and energy, Algorithm, Computational simulation, Empirical evidence, Data representation, Mathematical representation, Rate of change, Trend analysis, Prediction, Natural resource management, Sustainability, Ecosystem services, Human impact, Evaluation, Analyze, Evaluate, Revise, Optimize, Criteria-based decision making, Claim-Evidence-Reasoning (CER)

Assessments:

- **Diagnostic:**
    - CDT
    - Initial Models
    - Student Work
    - Driving Question Board
    - Student Questions

- **Formative:**
    - Collected student work samples
    - Exit Tickets
    - Transfer Tasks
    - Claim Evidence Reasoning (CERs)
    - Quizzes (as determined by the collective team)
    - Peer Feedback

- **Summative:**
    - Unit 1: Ecosystem Interactions and Dynamics Common Assessment
    - Open Sci-Ed Transfer Task

- **Correctives:**
    - Energy Flow & Matter Cycling
    - Biodiversity Impacts
    - Stability vs. Change: Types of Disturbances
    - Conservation Criteria & Decision-Making
    - Probability and Group Behavior
    - Keystone-Style Data Interpretation Activities

- **Extensions:**
    - Create documentary-style video explaining the Serengeti as a complex system
    - Design an interactive ecosystem model for a younger grade level
    - Build predictive models of climate change impacts on migration routes
    - Conduct a research mini-review using peer-reviewed Serengeti ecology articles
    - Find a compelling connection between the Serengeti and one of Pennsylvania's State Parks or Forests
    - Compare wildebeest migration with Arctic caribou, Monarch butterflies, Salmon spawning and determine which resilience mechanisms are universal vs. species-specific

Unit 2: Ecosystems Matter and Energy - 32 days

- **Standards:**

- 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 Boundaries:** 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 Boundaries:** 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 Boundaries:** Assessment should not include identification of the steps or specific processes involved in cellular respiration.

- 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 Boundaries:** 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 Boundaries:** Assessment does not include deriving mathematical equations to make comparisons.

- 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 Boundaries:** Assessment does not include the specific chemical processes of either aerobic or anaerobic 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 Boundaries:** 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 Boundaries:** Assessment is limited to provided data.

- 3.1.9-12.M - 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 Boundaries:** 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 Boundaries: N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models ● Using Mathematics and Computational Thinking ● Analyzing and Interpreting Data ● Constructing Explanations ● Engaging in Argument from Evidence ● Obtaining, Evaluating, and Communicating Information	● Interdependent Relationships in Ecosystems ● Ecosystem Dynamics, Functioning, and Resilience ● Social Interactions and Group Behavior ● Natural Selection ● Adaptation	● Energy and Matter ● Systems and System Models ● Stability and Change ● Cause and Effect

Anchoring Phenomena:

- Arctic "zombie fires" that continue burning under snow
- Smoke emerging from frozen ground in Arctic regions
- Repeated burn scars appearing in the same locations over multiple years
- Peat soils storing large amounts of carbon that can burn underground
- Release of carbon dioxide from burning peat ecosystems
- Thawing permafrost exposing carbon-rich soils to fire
- Changes in carbon cycling influencing ecosystems and climate

Objectives:

- Identify producers, consumers, and decomposers and describe their roles in ecosystems. (DOK 1)
- Define trophic levels and distinguish between food chains and food webs. (DOK 1)
- Describe the difference between the flow of energy and the cycling of matter in ecosystems. (DOK 1)
- Identify carbon, oxygen, and nitrogen as atoms that are conserved as they move through ecosystems. (DOK 1)
- Interpret food webs and energy pyramids to explain how energy moves through trophic levels. (DOK 2)
- Use proportional reasoning to explain why energy and biomass decrease at higher trophic levels. (DOK 2)
- Classify reservoirs and processes involved in the carbon, oxygen, and nitrogen cycles. (DOK 2)
- Analyze graphs or data sets to determine how nutrient availability affects ecosystem productivity. (DOK 2)
- Construct explanations describing how carbon cycles through photosynthesis, respiration, decomposition, and combustion. (DOK 3)
- Explain how oxygen cycling is connected to photosynthesis, respiration, and ecosystem metabolism. (DOK 3)
- Explain how nitrogen availability influences plant growth and ecosystem productivity. (DOK 3)

- Use data and models to explain how matter cycling and energy transfer influence ecosystem carrying capacity. (DOK 3)
- Evaluate evidence showing how disruptions to nutrient cycles can affect ecosystem stability. (DOK 3)
- Evaluate competing explanations for changes in ecosystem productivity using scientific models and data. (DOK 4)
- Predict how altering carbon, oxygen, or nitrogen cycling could affect ecosystem structure and function. (DOK 4)
- Design and defend a strategy to reduce human impacts on biogeochemical cycles in an ecosystem. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Open Sci. Ed Unit B.2
- Launch investigation of Arctic "zombie fires" phenomenon using OpenSciEd B.2 introductory materials; students conduct Notice and Wonder routines and contribute questions to a Driving Question Board to frame the unit investigation.
- Construct initial ecosystem models explaining how matter and energy move through ecosystems using the OpenSciEd modeling routine; students share and critique models to identify gaps in understanding.
- Analyze food chains and food webs to identify trophic levels and energy pathways using guided data analysis and collaborative discussion.
- Investigate energy transfer between trophic levels through analysis of biomass and energy pyramid data; students apply mathematical reasoning and graph interpretation to explain decreasing energy availability.
- Revise ecosystem models to incorporate evidence about energy transfer efficiency and trophic structure using iterative model revision and peer critique protocols.
- Investigate plant growth data showing increases in plant mass to determine the source of biomass; students engage in evidence-based reasoning and small-group data analysis.
- Develop and analyze models of the carbon cycle using diagrams and simulations; students trace carbon atoms through processes such as photosynthesis, respiration, decomposition, and combustion.
- Conduct structured analysis of carbon reservoirs and fluxes using system diagrams and case studies; students apply systems thinking to understand how carbon moves through ecosystems and Earth systems.
- Compare and contrast energy flow and matter cycling through guided instruction and model-based reasoning to reinforce the distinction between conserved matter and dissipating energy.
- Investigate the oxygen cycle by connecting photosynthesis and respiration to ecosystem metabolism through diagram analysis and CER (Claim-Evidence-Reasoning) explanations.
- Analyze plant productivity and nutrient limitation data to explore the role of nitrogen cycling in ecosystems using data interpretation and collaborative problem solving.
- Construct and revise models of the nitrogen cycle, including processes such as nitrogen fixation, nitrification, assimilation, and denitrification using visual system modeling.
- Examine case studies of fertilizer runoff and eutrophication to investigate human impacts on nitrogen cycling using cause-and-effect analysis and evidence-based argumentation.

- Analyze ecological data from algal blooms and hypoxic zones to explain relationships between nutrient enrichment and oxygen depletion through graph interpretation and CER writing.
- Integrate carbon, oxygen, and nitrogen cycles into a comprehensive ecosystem system model through collaborative modeling and peer feedback.
- Evaluate how disruptions to nutrient cycles affect ecosystem stability and resilience through scenario analysis and evidence-based reasoning.
- Apply matter- and energy-cycle concepts to a novel ecosystem case study to predict how changes in resource availability or nutrient cycling affect ecosystem dynamics.
- Engage in structured academic discussions and argumentation from evidence to evaluate claims about ecosystem stability and change.
- Participate in targeted direct instruction on energy pyramids, trophic transfer efficiency, and proportional reasoning to strengthen quantitative reasoning related to energy flow.
- Participate in targeted direct instruction on conservation of matter in biogeochemical cycles, reinforcing how atoms move through biological and environmental processes.
- Conduct Keystone-style data interpretation practice analyzing graphs, tables, and diagrams related to energy transfer and nutrient cycling.
- Revise and finalize ecosystem models integrating matter cycling, energy flow, and human impacts through model-based explanation and synthesis activities.
- Complete a performance-based investigation or scenario analysis requiring students to explain ecosystem processes using models, data, and scientific reasoning.
- Reflect on learning through Driving Question Board synthesis and metacognitive discussion, connecting the anchoring phenomenon to the movement of matter and energy through ecosystems.

Correspondent Vocabulary:

- Biomass, Energy pyramid, Biomass pyramid, Energy flow, Chemical energy, Thermal energy, Matter cycling, Conservation of matter, Carbon cycle, Oxygen cycle, Nitrogen cycle, Biogeochemical cycle, Carbon reservoir, Carbon flux, Carbon dioxide, Nitrogen gas, Nitrogen fixation, Nitrification, Assimilation, Denitrification, Limiting nutrient, Nutrient availability, Ecosystem productivity, Metabolism, Fossil fuel combustion, Fertilizer runoff, Eutrophication, Hypoxia, Dead Zone

Assessments:

- **Diagnostic:**
  - CDT
  - Initial Models
  - Student Work
  - Driving Question Board
  - Student Questions

- **Formative:**
  - Collected student work samples
  - Exit Tickets
  - Transfer Tasks
  - Claim Evidence Reasoning (CERs)

    - Quizzes (as determined by the collective team)
    - Peer Feedback

- **Summative:**
    - Unit 2: Ecosystems Matter & Energy Common Assessment
    - Open Sci-Ed Transfer Task(s)

- **Correctives:**
    - Distinguishing between energy flow and matter cycling in ecosystems.
    - Interpreting and constructing energy pyramids and biomass pyramids.
    - Understanding why energy decreases at each trophic level and how this limits population size.
    - Applying proportional reasoning and graph interpretation to explain energy transfer and ecosystem productivity.
    - Identifying and explaining carbon reservoirs and carbon fluxes within the carbon cycle.
    - Tracing carbon atoms through photosynthesis, respiration, decomposition, and combustion.
    - Explaining the connection between photosynthesis, cellular respiration, and oxygen cycling.
    - Understanding processes in the nitrogen cycle including nitrogen fixation, nitrification, assimilation, and denitrification.
    - Interpreting data related to nutrient limitation and ecosystem productivity.
    - Analyzing how human activities alter biogeochemical cycles, including fossil fuel combustion and fertilizer runoff.
    - Explaining the causes and ecological consequences of eutrophication and hypoxia.
    - Evaluating ecosystem stability and change using evidence and ecological models.
    - Practicing Keystone-style data interpretation, including analysis of graphs, tables, and ecosystem diagrams.

- **Extensions:**
    - Investigate real-world datasets on global carbon cycling and climate change, analyzing trends in atmospheric CO_2 and discussing implications for ecosystem stability.
    - Conduct an independent case study on Arctic peat fires (“zombie fires”) to examine how thawing permafrost influences carbon release and global carbon cycles.
    - Analyze satellite imagery or scientific reports related to deforestation and carbon sequestration, evaluating how land-use changes affect carbon reservoirs.
    - Research the role of nitrogen-fixing organisms in agricultural ecosystems and evaluate how crop rotation and soil management influence nitrogen availability.
    - Develop a systems model predicting how changes in nutrient availability could alter productivity and biodiversity in a specific ecosystem.

- Evaluate a real environmental issue such as coastal dead zones, fertilizer runoff, or algal blooms, and propose evidence-based solutions to reduce ecosystem disruption.
- Design and present a public awareness infographic or presentation explaining how human activities influence matter cycling and energy flow in ecosystems.
- Compare how different ecosystems (e.g., rainforest, grassland, desert, tundra) cycle matter and energy, and explain how environmental conditions affect ecosystem productivity.
- Explore how climate change may alter biogeochemical cycles and predict possible ecological consequences using scientific models and data.

Unit 3: Inheritance and Variation of Traits - 30 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:** N/A
        - **Assessment Boundaries:** Assessment does not include the identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

    - 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 Boundaries:** 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 Boundaries:** Assessment does not include the cellular processes involved in the feedback mechanism.

    - 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 Boundaries:** 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 Boundaries:** 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 Boundaries:** 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 populations.
    - **Assessment Boundaries:** Assessment does not include Hardy-Weinberg calculations.

- 3.1.9-12.S - Students who demonstrate understanding can communicate through writing and/or in oral form that DNA coding is the universal and conserved genetic code for all living organisms.
    - **Clarifying Statement:** N/A
    - **Assessment Boundaries:** N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● 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	● Structure and Function ● Growth and Development of Organisms ● Inheritance of Traits ● Variation of Traits	● Cause and Effect ● Structure and Function ● Patterns ● Systems and System Models ● Stability and Change

Anchoring Phenomena:

- Some people develop cancer even when they appear healthy and have no known environmental exposure.
- Cancer occurs when cells lose control of the cell cycle and divide uncontrollably.
- Mutations in genes such as p53 are commonly found in cancer cells.
- Mutations can change DNA sequences and alter the proteins produced by cells.
- Changes in protein structure can affect how cells function and regulate growth.

- Cancer risk increases over time as mutations accumulate in cells.
- Some individuals inherit genetic mutations that increase their risk of developing cancer.
- Different individuals inherit different combinations of genes, resulting in variation in traits.
- Mutations and genetic recombination create variation within populations.
- Environmental factors such as radiation and chemicals can increase mutation rates.

Objectives:

- Describe the structure of DNA and explain how genetic information is stored in cells. (DOK 1)
- Identify the relationship between DNA, genes, and chromosomes. (DOK 1)
- Describe the process of DNA replication and its role in cell division. (DOK 2)
- Explain how cells regulate the cell cycle and maintain normal growth. (DOK 2)
- Describe how genes code for proteins and how proteins influence traits. (DOK 2)
- Identify different types of mutations and explain how they alter DNA sequences. (DOK 2)
- Analyze how mutations can change protein structure and affect cell function. (DOK 3)
- Use models to explain how gene expression leads to observable traits. (DOK 3)
- Analyze patterns of inheritance using pedigrees and probability models. (DOK 3)
- Use mathematical reasoning to predict the likelihood of inheriting specific traits or mutations. (DOK 3)
- Explain how inherited and acquired mutations contribute to cancer development. (DOK 3)
- Construct explanations describing how mutations create genetic variation within populations. (DOK 3)
- Evaluate evidence for how environmental factors influence mutation rates and trait variation. (DOK 4)
- Evaluate claims about genetic inheritance and disease risk using data, models, and scientific reasoning. (DOK 4)
- Develop and revise models explaining how changes in DNA can alter cell behavior and lead to cancer. (DOK 4)
- Predict how changes in genetic variation may influence populations over time. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Open Sci. Ed Unit B.3
- Launch investigation of the cancer anchoring phenomenon using OpenSciEd B.3 introductory case materials; students engage in Notice and Wonder routines and Driving Question Board development to frame questions about cancer, mutations, and inheritance.
- Construct initial models explaining how cells normally regulate growth and what may cause uncontrolled cell division using student-generated modeling and peer critique protocols.
- Analyze cancer incidence and case data to identify patterns in cancer occurrence using guided data analysis and collaborative discussion.
- Investigate the structure of DNA using diagrams and molecular models to identify nucleotides, base pairing, and double helix structure through model-based instruction and visualization strategies.

- Participate in targeted direct instruction on DNA structure and chromosome organization to clarify foundational concepts.
- Develop models explaining how DNA replication occurs prior to cell division using collaborative modeling and teacher-guided explanation.
- Analyze the cell cycle and checkpoints using diagrams and case examples of normal vs. cancer cells through systems modeling and cause-and-effect reasoning.
- Participate in targeted direct instruction on the cell cycle, mitosis, and cancer-related disruptions to address misconceptions.
- Investigate mutations by analyzing DNA sequence changes and predicting their effects on proteins using pattern recognition and CER writing.
- Conduct a simulation or activity modeling mutation occurrence during DNA replication using probability-based modeling and data collection.
- Participate in targeted direct instruction on types of mutations and their effects on protein structure and function.
- Develop models explaining how genes are expressed as proteins and how proteins influence traits using model-based reasoning and structured explanation.
- Analyze case studies involving the p53 tumor suppressor gene to explain how mutations affect cell regulation using evidence-based reasoning and data interpretation.
- Investigate inheritance patterns using pedigrees and family case studies related to genetic disease or cancer risk using pattern analysis and collaborative problem solving.
- Apply probability concepts and Punnett square analysis to predict inheritance of traits using mathematical reasoning and guided practice.
- Participate in targeted direct instruction on inheritance patterns, genotype vs. phenotype, and probability.
- Compare inherited mutations and acquired mutations through structured discussion and model revision activities.
- Investigate environmental mutagens and their role in increasing mutation rates using cause-and-effect analysis and data interpretation.
- Conduct a variation-focused activity examining how mutations and genetic recombination contribute to differences among individuals using data analysis and modeling.
- Participate in targeted direct instruction on sources of genetic variation (mutation + recombination) to reinforce connections to future evolution content.
- 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.
- Utilize Compound Light Microscope to view stages of mitosis in onion root tip and white fish blastula.
- Engage in argumentation activities evaluating claims about genetic inheritance, mutation, and cancer risk using structured argument from evidence protocols.
- Analyze real-world datasets related to genetic variation and disease risk using graph interpretation and trend analysis.
- Participate in Keystone-style practice interpreting genetic diagrams, pedigrees, and mutation data using test-aligned data analysis strategies.

- Revise and synthesize models connecting DNA structure, gene expression, mutation, inheritance, and cancer using iterative modeling and peer feedback.
- Complete a performance-based task explaining how changes in DNA influence traits and contribute to cancer development using models and evidence.
- Administer a summative assessment including data analysis, explanation, and application of inheritance and mutation concepts.
- Engage in structured reflection and Driving Question Board synthesis connecting the anchoring phenomenon to DNA, mutation, inheritance, and variation.

Correspondent Vocabulary:

- DNA, Gene, Chromosome, Nucleotide, Double helix, DNA replication, Mutation, Substitution mutation, Insertion mutation, Deletion mutation, Gene expression, Protein synthesis, Trait, Inherited trait, Genetic variation, Allele, Genotype, Phenotype, Dominant allele, Recessive allele, Probability, Punnett square, Pedigree, Inherited mutation, Acquired mutation, Tumor suppressor gene, p53 gene, Cell cycle, Cell division, Uncontrolled cell growth, Cancer, Environmental mutagen, Transcription, Translation, Gene expression, Protein, Amino acid, Codon, Meiosis, Genetic recombination, Crossing over, Independent assortment

Assessments:

- **Diagnostic**:
    - CDT
    - Initial Models
    - Student Work
    - Driving Question Board
    - Student Questions

- **Formative**:
    - Collected student work samples
    - Exit Tickets
    - Transfer Tasks
    - Claim Evidence Reasoning (CERs)
    - Quizzes (as determined by the collective team)
    - Peer Feedback

- **Summative**:
    - Unit 3: Inheritance and Variation of Traits Common Assessment
    - Open Sci-Ed Transfer Task(s)

- **Correctives**:
    - Distinguishing between DNA, genes, and chromosomes and understanding how they relate to one another.
    - Clarifying the structure of DNA and nucleotide base pairing.
    - Understanding the process and purpose of DNA replication before cell division.
    - Distinguishing between mitosis and uncontrolled cell division in cancer.
    - Explaining how genes encode proteins and how proteins influence traits.

- Identifying different types of mutations (substitution, insertion, deletion) and predicting how they affect DNA and proteins.
- Distinguishing between inherited mutations and acquired mutations.
- Interpreting pedigrees and inheritance patterns.
- Applying probability and Punnett square reasoning to predict inheritance of traits.
- Understanding the role of tumor suppressor genes such as p53 in regulating cell division.
- Explaining how mutations accumulate over time and increase cancer risk.
- Distinguishing between genotype and phenotype.
- Evaluating how environmental factors can increase mutation rates.
- Practicing Keystone-style data interpretation using genetic diagrams, mutation data, and inheritance models.

- **Extensions**:
  - Investigate the role of tumor suppressor genes (such as p53) and how mutations in these genes increase the likelihood of cancer development.
  - Analyze real-world cancer incidence datasets to identify patterns in cancer rates across different populations or age groups.
  - Research inherited cancer syndromes (e.g., Li-Fraumeni syndrome or BRCA mutations) and explain how inherited mutations influence disease risk.
  - Develop a model showing how specific mutations alter protein structure and function, and predict how these changes could influence cell behavior.
  - Investigate how environmental mutagens such as UV radiation, tobacco smoke, or chemical exposure increase mutation rates in cells.
  - Conduct a bioinformatics investigation comparing normal and mutated DNA sequences to identify how mutations alter gene function.
  - Evaluate modern cancer treatment strategies such as chemotherapy, radiation therapy, targeted therapy, or immunotherapy and explain how they affect rapidly dividing cells.
  - Explore the use of CRISPR gene-editing technology and evaluate potential benefits and ethical considerations related to correcting genetic mutations.
  - Research how genetic screening and early detection technologies are used to identify inherited disease risk in individuals and families.
  - Develop a public education infographic or presentation explaining how mutations, inheritance, and environmental factors interact to influence cancer risk.
  - Perform animal dissections to illustrate the relationship between cells, tissues, organs, and organ systems

Unit 4: Natural Selection & Evolution of Populations - 28 days

- **Standards:**
    - 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 Boundaries:** 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 Boundaries:** N/A

    - 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 species to increase in number, (2) heritable genetic variation, (3) competition for limited resources, and (4) proliferation of organisms better able to survive and reproduce.
        - **Clarifying Statement:** Emphasis is on using evidence to explain the factors driving evolution.
        - **Assessment Boundaries:** N/A

    - 3.1.9-12.U - Students who demonstrate understanding can apply concepts of statistics and probability to support explanations that organisms with advantageous heritable traits tend to increase in proportion to organisms lacking those traits.
        - **Clarifying Statement:** N/A
        - **Assessment Boundaries:** Assessment is limited to basic statistical and probability reasoning; not specific calculations.

    - 3.1.9-12.V - 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 explanations that link natural selection to population adaptation.
        - **Assessment Boundaries:** N/A

- 3.1.9-12.W - 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:** Examples of evidence include data, observations, and patterns in the fossil record and laboratory or field research.
    - **Assessment Boundaries:** N/A

- 3.1.9-12.X - 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:** Examples of human activity can include overfishing, industrial pollution, deforestation, and introduction of invasive species.
    - **Assessment Boundaries:** N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• 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	• Evidence of Common Ancestry and Diversity • Natural Selection • Adaptation • Biodiversity and Humans	• Cause and Effect • Patterns • Stability and Change • Systems and System Models • Energy and Matter

Anchoring Phenomena:

- In urban environments, some species (e.g., rats, plants, birds) show different traits compared to populations in non-urban areas.
- Certain urban populations develop traits that allow them to survive in environments with higher temperatures, pollution, or human activity.
- Populations exposed to repeated use of pesticides or chemicals in urban areas become resistant over time.
- Organisms living in cities often experience different environmental pressures than those in rural or natural ecosystems.
- Some individuals within a population survive and reproduce more successfully in urban environments than others.
- Over time, traits that provide advantages in urban environments become more common in those populations.
- Populations in different environments (urban vs. non-urban) can diverge in their traits due to different selection pressures.
- Human-driven environmental changes, such as urbanization, can influence how populations evolve.

- Populations of bacteria become resistant to antibiotics over time, even when the same medication is used repeatedly.
- The proportion of dark-colored peppered moths increased during the Industrial Revolution and later decreased as air pollution declined.
- Some insects develop resistance to pesticides after repeated exposure, making the chemicals less effective over time.
- Fossil records show that species have changed gradually over millions of years, with some organisms going extinct and others evolving into new forms.
- DNA comparisons reveal that different species share large portions of their genetic code, suggesting common ancestry.
- Populations of organisms living in different environments develop different traits that improve survival under local conditions.
- When environmental conditions change, some species survive and adapt while others decline or go extinct.
- Variation exists within populations, and individuals with certain traits are more likely to survive and reproduce in specific environments.

Objectives:

- Define natural selection and explain how it acts on variation within populations. (DOK 1)
- Identify sources of genetic variation within populations, including mutation and recombination. (DOK 1)
- Describe how environmental factors create selection pressures that influence survival and reproduction. (DOK 2)
- Interpret graphs and data showing changes in trait or allele frequency over time. (DOK 2)
- Use mathematical reasoning and probability to explain how advantageous traits increase in populations. (DOK 3)
- Construct explanations describing how natural selection leads to adaptation of populations. (DOK 3)
- Analyze evidence from fossils, comparative anatomy, and DNA to support claims of common ancestry. (DOK 3)
- Explain how environmental changes can lead to shifts in population traits, adaptation, or extinction. (DOK 3)
- Develop and use models to predict how populations will change under specific environmental pressures. (DOK 4)
- Evaluate claims about evolution using multiple sources of scientific evidence and reasoning. (DOK 4)
- Analyze how changes in environmental conditions influence the direction and rate of natural selection. (DOK 4)
- Evaluate the relationship between genetic variation and the long-term survival of populations. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Open Sci. Ed Unit B.4
- Launch unit with Urbanization or similar phenomenon using OpenSciEd B.4 materials; students engage in Notice and Wonder and Driving Question Board development focused on how populations change over time.

- Develop initial models explaining why some organisms survive and reproduce more than others using student-generated modeling and peer critique protocols.
- Analyze data sets showing variation within populations using guided data analysis and pattern recognition.
- Investigate sources of variation (mutation and recombination review from B.3) using model-based reasoning and connection to prior learning.
- Participate in targeted direct instruction on natural selection vocabulary and mechanisms (variation, selection pressure, fitness).
- Analyze case studies such as antibiotic resistance or pesticide resistance using cause-and-effect reasoning and CER writing.
- Interpret graphs showing changes in trait or allele frequency over time using mathematical reasoning and data interpretation.
- Participate in targeted direct instruction on interpreting evolutionary graphs and common misconceptions (fitness, individual vs population change).
- Develop models explaining how environmental pressures lead to differential survival using systems modeling and peer feedback.
- Investigate fossil evidence showing changes in organisms over time using evidence analysis and comparative reasoning.
- Analyze anatomical evidence (homologous structures) to support common ancestry using pattern recognition and model comparison.
- Analyze DNA sequence data to infer evolutionary relationships using data analysis and pattern identification.
- Participate in targeted direct instruction on types of evidence for evolution (fossils, anatomy, molecular data).
- Engage in argumentation activities evaluating claims about evolution using structured argument from evidence protocols.
- Analyze real-world datasets showing population shifts over time using graph interpretation and trend analysis.
- Participate in Keystone-style practice interpreting evolutionary diagrams, graphs, and data using test-aligned strategies.
- Investigate how environmental changes influence population survival using scenario-based modeling and prediction tasks.
- Participate in targeted direct instruction on adaptation vs. acclimation and selection pressure misconceptions.
- Develop and revise models explaining how natural selection leads to adaptation over generations using iterative modeling and synthesis.
- Analyze extinction events and environmental change scenarios using cause-and-effect reasoning and systems thinking.
- Conduct a performance-based task modeling how a population evolves under specific environmental conditions.
- Administer a summative assessment including data analysis, explanation, and application of natural selection concepts.
- Engage in Driving Question Board synthesis and reflection connecting variation, selection, evidence, and adaptation.

Correspondent Vocabulary:

- Evolution, Natural selection, Adaptation, Fitness, Selective pressure, Environmental pressure, Survival, Reproduction, Population, Species, Trait frequency, Allele frequency, Genetic variation, Advantageous trait, Disadvantageous trait, Common ancestry, Fossil record, Transitional fossil, Homologous structures, Analogous structures, Vestigial structures, Comparative anatomy, Embryology, Molecular evidence, DNA similarity, Extinction, Speciation, Environmental change, Population shift, Evolutionary change, Phylogenetic tree, Evolutionary relationship, Divergent evolution, Convergent evolution

Assessments:

- **Diagnostic:**
  - CDT
  - Initial Models
  - Student Work
  - Driving Question Board
  - Student Questions

- **Formative:**
  - Collected student work samples
  - Exit Tickets
  - Transfer Tasks
  - Claim Evidence Reasoning (CERs)
  - Quizzes (as determined by the collective team)
  - Peer Feedback

- **Summative:**
  - Unit 4: Natural Selection & Evolution of Populations Common Assessment
  - Open Sci-Ed Transfer Task(s)

- **Correctives**:
  - Distinguishing between evolution of populations vs. change in individuals.
  - Clarifying that natural selection acts on phenotypes, not directly on genes, and occurs through differential survival and reproduction.
  - Understanding that fitness refers to reproductive success, not strength, size, or speed.
  - Distinguishing between adaptation (genetic, population-level change) and acclimation (short-term individual response).
  - Interpreting graphs of trait or allele frequency over time, including identifying trends, rates of change, and direction of selection.
  - Applying basic probability and proportional reasoning to explain how advantageous traits increase in populations.
  - Identifying and explaining sources of variation (mutation and recombination) and their role in natural selection.
  - Distinguishing between random processes (mutation, genetic drift) and non-random processes (natural selection).

- Understanding how environmental pressures influence which traits are advantageous.
- Explaining how changes in environmental conditions can lead to adaptation, migration, or extinction.
- Interpreting and analyzing case studies of natural selection (e.g., antibiotic resistance, pesticide resistance, peppered moths).
- Identifying evidence for evolution including:
  - Fossil record and transitional fossils
  - Homologous vs. analogous structures
  - Vestigial structures
  - Comparative embryology
  - Molecular (DNA) similarities
- Distinguishing between homologous and analogous structures and what each indicates about evolutionary relationships.
- Interpreting phylogenetic trees and determining evolutionary relationships among species.
- Understanding how DNA and protein similarities provide evidence of common ancestry.
- Addressing misconceptions such as:
  - "Organisms evolve because they need to"
  - "Traits appear because organisms try to adapt"
  - "All individuals in a population change at the same time"
- Practicing Keystone-style data interpretation, including analysis of graphs, diagrams, and scenarios involving population change and evolutionary evidence.
- Constructing and revising models explaining how natural selection leads to adaptation over generations.
- Evaluating claims and arguments about evolution using evidence and scientific reasoning.

- **Extensions:**
  - Analyze a real dataset on antibiotic resistance (e.g., MRSA or TB); graph changes in resistance over time and construct a written explanation of how natural selection led to the observed pattern.
  - Use an online simulation (e.g., PhET Natural Selection or similar) to model how environmental changes affect trait frequency, then write a CER explaining the results.
  - Construct and defend a predictive model showing how a population would change if a new environmental pressure (e.g., climate change, predator introduction) is introduced.
  - Analyze genetic sequence data from multiple species to determine evolutionary relationships and construct a phylogenetic tree, then justify the relationships using evidence.
  - Investigate a case of pesticide resistance in insects, then design a management strategy that could slow the development of resistance.
  - Compare two different species that show convergent evolution (e.g., sharks vs. dolphins) and explain how similar environmental pressures led to similar traits.

- Evaluate fossil evidence from a specific lineage (e.g., horse evolution) and construct a timeline showing gradual changes in traits over time.
- Conduct a mini research investigation on a recent extinction event or endangered species, analyzing how environmental pressures contributed and predicting future outcomes.
- Develop a public-facing infographic or short presentation explaining a real-world example of natural selection (e.g., COVID variants, antibiotic resistance, climate adaptation).
- Model how climate change could shift species distributions and predict which traits would become advantageous in a changing environment.
- Analyze competing claims about evolution found in media or online sources and write a scientific rebuttal using evidence (fossil, anatomical, or molecular).
- Design and carry out a simple classroom selection simulation (e.g., "predator-prey" with colored objects) to collect data on survival rates and explain results using natural selection.

Unit 5: Common Ancestry and Speciation - 34 Days

- **Standards:**
  - 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 species to increase in number, (2) heritable genetic variation, (3) competition for limited resources, and (4) proliferation of organisms better able to survive and reproduce.
    - **Clarifying Statement:** Emphasis is on using evidence to explain the factors driving evolution.
    - **Assessment Boundaries:** N/A

  - 3.1.9-12.U - Students who demonstrate understanding can apply concepts of statistics and probability to support explanations that organisms with advantageous heritable traits tend to increase in proportion to organisms lacking those traits.
    - **Clarifying Statement:** N/A
    - **Assessment Boundaries:** Assessment is limited to basic statistical and probability reasoning; not specific calculations.

  - 3.1.9-12.W - 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:** Examples of evidence include data, observations, and patterns in the fossil record and laboratory or field research.
    - **Assessment Boundaries:** N/A

  - 3.1.9-12.X - 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:** Examples of human activity can include overfishing, industrial pollution, deforestation, and introduction of invasive species.
    - **Assessment Boundaries:** N/A

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Developing and Using Models • Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Constructing Explanations • Engaging in Argument from Evidence	• Evidence of Common Ancestry and Diversity • Natural Selection • Adaptation • Biodiversity and Humans	• Patterns • Cause and Effect • Stability and Change • Systems and System Models

• Obtaining, Evaluating, and Communicating Information		

Anchoring Phenomena:

- Brown bears have been increasingly sighted in Arctic regions where polar bears typically live.
- Polar bears and brown bears share many physical and genetic similarities but live in different environments.
- Hybrid "pizzly" or "grolar" bears have been identified, showing traits of both polar and brown bears.
- Fossil and genetic evidence suggest that polar bears evolved from brown bear ancestors relatively recently.
- Populations that become geographically isolated can develop different traits over time.
- Closely related species often share structures and DNA sequences, indicating common ancestry.
- Environmental changes can cause populations to move, interact, or become isolated, influencing evolution.
- Over long periods of time, populations can diverge enough to form new species.

Objectives:

- Describe the types of evidence used to support common ancestry, including fossils, anatomical structures, and DNA similarities. (DOK 1)
- Define speciation and explain how new species can arise from existing populations. (DOK 1)
- Describe how geographic isolation and environmental differences can lead to population divergence. (DOK 2)
- Interpret phylogenetic trees to determine evolutionary relationships among species. (DOK 2)
- Analyze data from fossil records, DNA sequences, and anatomical comparisons to identify patterns of common ancestry. (DOK 3)
- Use mathematical reasoning and data trends to explain how populations diverge over time. (DOK 3)
- Construct explanations describing how natural selection acting on variation can lead to speciation. (DOK 3)
- Explain how environmental changes can lead to isolation, divergence, or extinction of populations. (DOK 3)
- Develop and use models to predict how isolated populations may evolve into distinct species under different environmental conditions. (DOK 4)
- Evaluate claims about evolutionary relationships using multiple lines of evidence, including fossil, anatomical, and molecular data. (DOK 4)
- Analyze how environmental changes (e.g., climate change in the Arctic) influence species interactions, hybridization, and divergence. (DOK 4)
- Evaluate the role of genetic variation and environmental pressures in shaping biodiversity over time. (DOK 4)

Core Activities and Corresponding Instructional Methods:

- Open Sci. Ed Unit B.5
- Launch unit with Arctic bear phenomenon (polar bears, brown bears, and hybrids) using OpenSciEd B.5 materials; students engage in Notice and Wonder and Driving Question Board development focused on how species are related and how new species form.
- Develop initial models explaining relationships between polar bears and brown bears using student-generated modeling and peer critique protocols.
- Analyze data comparing physical traits and habitats of polar and brown bears using guided data analysis and pattern recognition.
- Investigate DNA sequence data comparing polar bears and brown bears to identify similarities and differences using data analysis and evidence-based reasoning.
- Participate in targeted direct instruction on types of evidence for common ancestry (fossils, homologous structures, DNA) (Standard T).
- Construct explanations using multiple lines of evidence to support claims about common ancestry using CER writing and argumentation protocols.
- Analyze fossil evidence showing changes in bear populations over time using temporal pattern analysis and model refinement.
- Interpret phylogenetic trees to determine evolutionary relationships using guided practice and model-based reasoning.
- Administer Quiz 1: Evidence for common ancestry (fossils, DNA, anatomy, phylogenetic trees).
- Investigate how geographic isolation (Arctic vs. non-Arctic environments) influences populations using scenario-based modeling and cause-and-effect reasoning.
- Develop models explaining how isolated populations diverge over time using systems modeling and peer feedback.
- Participate in targeted direct instruction on speciation mechanisms (isolation, divergence, reproductive isolation).
- Analyze how environmental pressures in Arctic environments influence trait selection using data interpretation and CER writing.
- Apply mathematical reasoning to examine how trait frequencies shift in diverging populations using graph analysis and proportional reasoning (Standard U).
- Investigate hybridization (pizzly/grolar bears) and what it reveals about species boundaries using evidence evaluation and discussion.
- Participate in targeted direct instruction on defining species and limitations of species classification.
- Engage in argumentation activities evaluating claims about whether polar bears and brown bears are separate species using structured argument from evidence protocols.
- Analyze real-world datasets related to climate change and Arctic habitat shifts using graph interpretation and trend analysis (Standard X).
- Participate in Keystone-style practice interpreting phylogenetic trees, evolutionary diagrams, and speciation scenarios using test-aligned strategies.
- Develop and revise models explaining how natural selection and environmental change lead to speciation using iterative modeling and synthesis (Standard W).
- Conduct a performance-based task predicting how a population will diverge under specific environmental conditions.

- Administer a summative assessment including data analysis, explanation, and application of speciation and common ancestry concepts.
- Engage in Driving Question Board synthesis and reflection connecting Arctic bears, common ancestry, and speciation.

Correspondent Vocabulary:

- Common ancestry, Speciation, Species, Population divergence, Reproductive isolation, Geographic isolation, Hybridization, Hybrid species, Phylogenetic tree, Evolutionary relationship, Lineage, Divergence, Evolutionary time scale, Fossil record, Transitional fossil, Comparative anatomy, Homologous structures, Analogous structures, Vestigial structures, Embryological development, Molecular evidence, DNA similarity, Biodiversity, Extinction, Environmental change, Selection pressure, Adaptive divergence

Assessments:

- **Diagnostic:**
  - CDT
  - Initial Models
  - Student Work
  - Driving Question Board
  - Student Questions

- **Formative:**
  - Collected student work samples
  - Exit Tickets
  - Transfer Tasks
  - Claim Evidence Reasoning (CERs)
  - Quizzes (as determined by the collective team)
  - Peer Feedback

- **Summative:**
  - Unit 5: Common Ancestry & Speciation Common Assessment
  - Open Sci-Ed Transfer Task(s)

- **Correctives:**
  - Distinguishing between common ancestry and similarity due to function (homologous vs. analogous structures).
  - Identifying and interpreting multiple lines of evidence for common ancestry, including:
    - Fossil record
    - DNA similarity
    - Comparative anatomy
    - Embryological development
  - Interpreting phylogenetic trees, including:
    - Determining common ancestors
    - Identifying closest relatives
    - Understanding branching patterns (not “more evolved” vs. “less evolved”)

- Understanding that evolution occurs in populations over time, not in individuals.
- Explaining how geographic isolation leads to population divergence.
- Distinguishing between different types of isolation:
  - Geographic
  - Reproductive
  - Behavioral (if briefly addressed)
- Clarifying how natural selection acting on variation leads to speciation over long timescales
- Interpreting data showing divergence in populations, including trait differences and genetic variation.
- Applying basic mathematical reasoning to explain how populations become genetically distinct over time.
- Understanding that hybridization can occur between closely related species and what it reveals about species boundaries.
- Addressing misconceptions such as:
  - "Species are completely separate with no overlap"
  - "New species form quickly"
  - "Evolution has a goal or direction"
- Explaining how environmental changes (e.g., Arctic warming) can:
  - Shift habitats
  - Cause population overlap or isolation
  - Influence speciation or extinction
- Distinguishing between adaptation within a population and divergence leading to new species.
- Practicing Keystone-style data interpretation, including:
  - Phylogenetic trees
  - Fossil timelines
  - DNA similarity charts
- Constructing and revising models explaining how one species can diverge into two over time.
- Evaluating claims about species relationships and evolution using multiple sources of evidence
- Prepare for Keystone Biology Exam

- **Extensions:**
  - Analyze a real dataset comparing polar bear and brown bear DNA sequences, calculate percent similarity, and construct a phylogenetic tree to justify evolutionary relationships.
  - Investigate documented cases of hybrid species (e.g., grolar bears, ligers, mule deer, or trout hybrids) and evaluate what these cases reveal about how species are defined.
  - Construct a predictive model showing how continued Arctic warming could influence the distribution, interaction, and divergence of bear populations over time.
  - Use fossil data from a specific lineage (e.g., bears, whales, or horses) to build a timeline illustrating gradual changes in traits and speciation events.

- Analyze and compare multiple phylogenetic trees built from different types of data (morphological vs. molecular) and evaluate why they may differ.
- Conduct a case study on adaptive radiation (e.g., Darwin's finches, cichlid fish) and explain how environmental variation led to rapid speciation.
- Model how geographic isolation (island formation, glacier movement, habitat fragmentation) could lead to speciation, then defend predictions using evidence.
- Evaluate a real-world scenario involving climate-driven species range shifts and predict whether populations are more likely to:
    - Adapt
    - Migrate
    - Go extinct
    - Speciate
- Develop a scientific argument (written or presentation) addressing the question: "Are polar bears and brown bears truly separate species?" using genetic, anatomical, and ecological evidence.
- Design and conduct a simulation (digital or physical) showing how populations diverge over time under different environmental pressures.

Unit 6: Environmental Literacy and Sustainability Capstone - 28 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

- Human activities are impacting 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.)