

**TOWNSHIP OF UNION PUBLIC SCHOOLS**



**SC 211 Honors Biology**

**Curriculum Guide**

**Revised December 18, 2018**

## **Mission Statement**

The mission of the Township of Union Public Schools is to build on the foundations of honesty, excellence, integrity, strong family, and community partnerships. We promote a supportive learning environment where every student is challenged, inspired, empowered, and respected as diverse learners. Through cultivation of students' intellectual curiosity, skills and knowledge, our students can achieve academically and socially, and contribute as responsible and productive citizens of our global community.

## **Philosophy Statement**

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is formulation of a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

## **References**

The following curriculum guide was adapted from the Next Generation Science Standards and the State of New Jersey Department of Education High School Biology Model Curriculum.

“Model Curriculum: HS Biology.” *Model Curriculum: HS Biology*. State of New Jersey. 2014. Web. 22 Apr. 2016.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. Web. 22 Apr. 2016.

## **Curriculum Unit Overview**

Unit 1- Interdependent Relationships in Ecosystems & Population Dynamics

Unit 2- Structure & Function

Unit 3- Matter and Energy in Organisms and Ecosystems

Unit 4- Inheritance and Variation of Traits

Unit 5- Natural Selection and Mechanisms of Evolution

Unit 6- Evidence of Evolution, Relationships and Common Ancestry

## Curriculum Pacing Guide – Honors Biology

<b><u>Unit Name</u></b>	<b><u>Estimated Number of Days</u></b>
Unit 1- Interdependent Relationships in Ecosystems & Population Dynamics	30
Unit 2- Structure & Function	30
Unit 3- Matter and Energy in Organisms and Ecosystems	30
Unit 4- Inheritance and Variation of Traits	45
Unit 5- Natural Selection and Mechanisms of Evolution	20
Unit 6- Evidence of Evolution, Relationships and Common Ancestry	25

# Honors Biology Course Description

The Honors Biology course is specifically designed for the student who has demonstrated exceptional ability in the sciences. The course challenges the student with a rigorous, in-depth study of Biology, stressing higher-level learning skills and critical thinking. Emphasis is on developing skills such as: designing experiments and investigative procedures, hypothesizing, observing, interpreting, data analysis, graphing, and inferring. Extensive open-ended laboratory and computer-based investigations are utilized, to foster inquiry and discovery skills.

## Course Proficiencies

*For all units, students will understand and follow all laboratory and safety rules, understand scientific explanations, generate scientific evidence through active investigations, reflect on scientific knowledge and participate productively in science.*

The honors biology student will explore the following unit topics that are aligned with the NGSS Disciplinary Core Ideas/ NJ Biology Model Curriculum Standards:

### Unit 1- Interdependent Relationships in Ecosystems & Population Dynamics

In this unit of study, students formulate answers to the question *"how and why do organisms interact with each other (biotic factors) and their environment (abiotic factors), and what affects these interactions?"* Secondary ideas include the interdependent relationships in ecosystems; dynamics of ecosystems; and functioning, resilience, and social interactions, including group behavior. Students use *mathematical reasoning* and *models* to make sense of carrying capacity, factors affecting biodiversity and populations, the cycling of matter and flow of energy through systems. Additionally, in this unit of study, *mathematical models* provide support for students' conceptual understanding of systems and students' ability to *design, evaluate, and refine solutions* for reducing the impact of human activities on the environment and maintaining biodiversity. The crosscutting concepts of *scale, proportion, and quantity* and *stability and change* are called out as organizing concepts for the disciplinary core ideas. Students are expected to use *mathematical reasoning* and *models* to demonstrate proficiency with the disciplinary core ideas.

### Unit 2- Structure & Function

Students formulate an answer to the question *"How do the structures of organisms enable life's functions?"* Students investigate explanations for the structure and functions of cells as the basic unit of life, of hierarchical organization of interacting organ systems, and of the role of specialized cells for maintenance and growth. The crosscutting concepts of *structure and function, matter and energy, and systems and system models* are called out as organizing concepts for the disciplinary core ideas. Students use *critical reading, modeling, and conducting investigations*. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

### Unit 3- Matter and Energy in Organisms and Ecosystems

In this unit of study, students *construct explanations* for the role of energy in the cycling of matter in organisms and ecosystems. They *apply mathematical concepts to develop evidence to support explanations* of the interactions of photosynthesis and cellular respiration, and they will *develop models to communicate these explanations*. Students also understand organisms' interactions with each other and their physical environment and how organisms obtain resources. Students utilize the crosscutting concepts of *matter and energy* and *systems, and system models* to make sense of ecosystem dynamics. Students are expected to use students *construct explanations* for the role of energy in the cycling of matter in organisms and ecosystems. They *apply mathematical concepts to develop evidence to support explanations* as they demonstrate their understanding of the disciplinary core ideas.

#### Unit 4- Inheritance and Variation of Traits

Students analyze data develop models to make sense of the relationship between DNA and chromosomes in the process of cellular division, which passes traits from one generation to the next. Students determine why individuals of the same species vary in how they look, function, and behave. Students develop *conceptual models* of the role of DNA in the unity of life on Earth and *use statistical models* to explain the importance of variation within populations for the survival and evolution of species. Ethical issues related to genetic modification of organisms and the nature of science are described. Students explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expressions. The crosscutting concepts of *structure and function, patterns, and cause and effect* are used as organizing concepts for the disciplinary core ideas. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

#### Unit 5- Natural Selection and Mechanisms of Evolution

Students *constructing explanations and designing solutions, analyzing and interpreting data, and engaging in argument from evidence investigate* to make sense of the relationship between the environment and natural selection. Students also develop an understanding of the factors causing natural selection of species over time. They also demonstrate and understandings of how multiple lines of evidence contribute to the strength of scientific theories of natural selection. The crosscutting concepts of *patterns and cause and effect* serve as a organizing concepts for the disciplinary core ideas. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

#### Unit 6- Evidence of Evolution, Relationships and Common Ancestry

Students construct explanations for the processes of natural selection and evolution and then communicate how multiple lines of evidence support these explanations. Students evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Additionally, students can apply concepts of probability to explain trends in population as those trends relate to advantageous heritable traits in a specific environment. Students demonstrate an understanding of these concepts by obtaining, evaluating, and communicating information and constructing explanations and designing solutions. The crosscutting concepts of *patterns and cause and effect* support the development of a deeper understanding.

## Unit 1 Summary

### Interdependent Relationships in Ecosystems & Population Dynamics

*How do organisms interact with the living and nonliving environments to obtain matter and energy?*

In this unit of study, students formulate answers to the question “how and why do organisms interact with each other (biotic factors) and their environment (abiotic factors), and what affects these interactions?” Secondary ideas include the interdependent relationships in ecosystems; dynamics of ecosystems; and functioning, resilience, and social interactions, including group behavior. Students use mathematical reasoning and models to make sense of carrying capacity, factors affecting biodiversity and populations, the cycling of matter and flow of energy through systems. The crosscutting concepts of scale, proportion, and quantity and stability and change are called out as organizing concepts for the disciplinary core ideas. Students are expected to use mathematical reasoning and models to demonstrate proficiency with the disciplinary core ideas.

#### Student Learning Objectives

Illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [LS2.A](#)

Graph real or simulated populations and analyze the trends to understand consumption patterns and resource availability, and make predictions as to what will happen to the population in the future. [LS2.A](#)

Provide evidence that the growth of populations are limited by access to resources, and how selective pressures may reduce the number of organisms or eliminate whole populations of organisms. [LS2.A](#)

**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**

*[Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]* ([HS-LS2-1](#))

**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** *[Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]* ([HS-LS2-2](#))

**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.** *[Clarification 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.]* ([HS-LS2-6](#))

**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** *[Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]* ([HS-LS2-7](#))

**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** *[Clarification 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. (HS-LS2-8)

Unit Sequence	
<b>Part A:</b> <i>When they relocate bears, wolves, or other predators, how do they know that they will survive?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support.</li> <li>These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.</li> <li>Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (the number of individuals) of species in any given ecosystem.</li> <li>The significance of carrying capacity in ecosystems is dependent on the scale proportion and quantity at which it occurs.</li> <li>Quantitative analysis can be used to compare and determine relationships among interdependent factors that affect the carrying capacity of ecosystems at different scales.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.</li> <li>Use quantitative analysis to compare relationships among interdependent factors and represent their effects on the carrying capacity of ecosystems at different scales.</li> </ul>
Unit Sequence	
<b>Part B:</b> <i>What limits the number and types of different organisms that live in one place?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.</li> <li>Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support.</li> <li>These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.</li> <li>Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite.</li> <li>This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.</li> <li>Use the concept of orders of magnitude to represent how factors affecting biodiversity and populations in ecosystems at one scale relate to those factors at another scale.</li> </ul>



<ul style="list-style-type: none"> <li>• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.</li> <li>• If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem.</li> <li>• Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.</li> <li>• Using the concept of orders of magnitude allows one to understand how a model of factors affecting biodiversity and populations in ecosystems at one scale relates to a model at another scale.</li> </ul>	
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**Unit Sequence**

**Part C: How can a one or two inch rise in sea level devastate an ecosystem?**

<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>• Much of science deals with constructing explanations of how things change and how they remain stable.</li> <li>• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.</li> <li>• If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem) as opposed to becoming a very different ecosystem.</li> <li>• Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.</li> <li>• Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Evaluate the claims, evidence, and reasoning that support the contention that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.</li> <li>• Construct explanations of how modest biological or physical changes versus extreme changes affect stability and change in ecosystems.</li> </ul>

**Connecting with English Language Arts/Literacy and Mathematics**

<p><i>English Language Arts/Literacy</i></p> <ul style="list-style-type: none"> <li>• Cite specific textual evidence to support analysis of science and technical texts supporting explanations of factors that affect carrying capacity of ecosystems at different scales, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.</li> <li>• Develop and write explanations of factors that affect carrying capacity of ecosystems at different scales by selecting the most significant and relevant facts,</li> </ul>
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extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

- Cite specific textual evidence to support how factors affect biodiversity and populations in ecosystems of different scale, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write explanatory texts based on scientific procedures/experiments to explain how different factors affect biodiversity and populations in ecosystems at different scales.
- Assess the extent to which the claim that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem, is supported by reasoning and evidence.
- Cite specific textual evidence to support claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address claims that 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 validity of evidence and reasoning that support claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

#### *Mathematics*

- Represent the factors that affect carrying capacity of ecosystems at different scales symbolically and manipulate the representing symbols. Make sense of quantities and relationships between different factors that affect carrying capacity of ecosystems at different scales.
- Use a mathematical model to describe factors that affect carrying capacity of ecosystems at different scales. Identify important quantities in factors that affect carrying capacity of ecosystems at different scales and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand how factors affect the carrying capacity of ecosystems at different scales. Choose and interpret units consistently in formulas to determine carrying capacity. Choose and interpret the scale and origin in graphs and data displays showing factors that affect carrying capacity of ecosystems at different scales.
- Define appropriate quantities for the purpose of descriptive modeling of factors that affect carrying capacity of ecosystems at different scales.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing factors that affect carrying capacity of ecosystems at different scales.
- Represent the factors that affect biodiversity and populations in ecosystems symbolically and manipulate the representing symbols. Make sense of quantities and relationships between different factors and their effects on biodiversity and populations in ecosystems.
- Use a mathematical model to describe the factors that affect biodiversity and populations in ecosystems. Identify important quantities in factors that affect biodiversity and populations in ecosystems and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand factors that affect biodiversity and populations in ecosystems.

- Choose and interpret units consistently in formulas to determine effects on biodiversity and populations in ecosystems. Choose and interpret the scale and the origin in graphs and data displays representing the factors that affect biodiversity and populations in ecosystems.
- Define appropriate quantities for the purpose of descriptive modeling of the factors that affect biodiversity and populations in ecosystems.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities of the factors that affect biodiversity and populations in ecosystems.
- Represent claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem symbolically and manipulate the representing symbols. Make sense of quantities and relationships between complex interactions in ecosystems and ways in which ecosystems remain stable and ways in which they change.
- Represent data relating to complex interactions in ecosystems and their effects on stability and change in ecosystems with plots on the real number line (graph).
- Understand statistics as a process for making inferences about complex interactions in ecosystems and organism population parameters based on a random sample from that population.
- Evaluate reports of complex interactions and their effects on stability and change in ecosystems based on data showing numbers and types of organisms in stable conditions and in changing conditions.

### Suggested Learning Activities

**Predator/Prey Relationships:** Students will construct and interpret graphs to correlate relationships between population sizes of predator and prey.

**Infectious Disease Lab:** Students will model spread of disease (density dependent factor) and the exponential growth of bacterial populations.

**Human Population Age Structure Study:** Students will compare age structure histograms to predict future trends for developing and developed countries.

**Live and Let Live Group Project:** Students will work in cooperative learning groups to develop a plan to accommodate an increase in human population while having a minimal impact on surrounding ecosystem.

**The Bean Game: Exploring Human Interactions with Natural Resources:** This activity explores the various influences of human consumption of natural resources over time. (use this as a primer for making a computational model).

**World In Balance Film:** Students will view film that reviews age structure trends within various countries.

**Population Growth – Exponential and Logistic Models vs. Complex Realities:** This analysis and discussion activity is designed to help students develop a solid understanding of the exponential and logistic models of population growth, including the biological processes that result in exponential or logistic population growth. Students learn about the simplifying assumptions built into the exponential and logistic models and explore how deviations from these assumptions can result in discrepancies between the predictions of these models and the actual trends in population size for natural populations.

**Changing Biological Communities – Disturbance and Succession:** Students use their understanding of the processes involved in succession to construct and evaluate

models of succession in abandoned farm fields. Students also analyze the effects on succession of climate and non-native invasive plants.

**Bye Bye Birdie:** Students will develop criteria that ecologists, wildlife managers, and public officials might use to make decisions about protecting endangered species, conduct research on an endangered species through the Internet and other sources, and then present their findings, showing how their species measures up against the chosen decision criteria.

### Methods of Assessment

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

### Appendix A: NGSS and Foundations for the Unit

**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**

*[Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.] (HS-LS2-1)*

**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** *[Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.] (HS-LS2-2)*

**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.** *[Clarification 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.] (HS-LS2-6)*

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><a href="#">Using Mathematics and Computational Thinking</a></p> <ul style="list-style-type: none"> <li>Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1)</li> <li>Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)</li> </ul>	<p><a href="#">LS2.A: Interdependent Relationships in Ecosystems</a></p> <ul style="list-style-type: none"> <li>Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce</li> </ul>	<p><a href="#">Scale, Proportion, and Quantity</a></p> <ul style="list-style-type: none"> <li>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)</li> <li>Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)</li> </ul>

<p><a href="#">Engaging in Argument from Evidence</a></p> <ul style="list-style-type: none"> <li>Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-6)</li> </ul>	<p>populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)</p> <p><a href="#">LS2.C: Ecosystem Dynamics, Functioning, and Resilience</a></p> <ul style="list-style-type: none"> <li>A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)</li> </ul>	<p><a href="#">Stability and Change</a></p> <ul style="list-style-type: none"> <li>Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6)</li> </ul>
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## Unit 2 Summary Structure and Function

### *How do the structures of organisms enable life's functions?*

Students formulate an answer to the question “*How do the structures of organisms enable life's functions?*” Students investigate explanations for the structure and functions of cells as the basic unit of life, of hierarchical organization of interacting organ systems, and of the role of specialized cells for maintenance and growth. The crosscutting concepts of *structure and function*, *matter and energy*, and *systems and system models* are called out as organizing concepts for the disciplinary core ideas. Students use *critical reading*, *modeling*, and *conducting investigations*. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

### Student Learning Objectives

Explain the connection between the sequence and the subcomponents of a biomolecule and its properties. *[Clarification Statement: Emphasis is on the general structural properties that define molecules. Examples include r-groups of amino acids, protein shapes, the nucleotide monomers of DNA and RNA, hydrophilic and hydrophobic regions.] [Assessment Boundary: Assessment does not include identification or the molecular sequence and structure of specific molecules]* ([LS1.A](#))

Create representations that explain how genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein. ([LS1.A](#))

**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.** *[Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]* ([HS-LS1-1](#))

Construct models that explain the movement of molecules across membranes with membrane structure and function. *[Clarification Statement: Emphasis is on the structure of cell membranes, which results in selective permeability; the movement of molecules across them via osmosis, diffusion and active transport maintains dynamic homeostasis.]* ([LS1.A](#))

**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** *[Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.]* ([HS-LS1-2](#))

Provide examples and explain how organisms use feedback systems to maintain their internal environments. ([LS1.A](#))

**Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** *[Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.]* ([HS-LS1-3](#))

**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** *[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]* ([HS-LS1-4](#))

Unit Sequence	
<b>Part A:</b> <i>How does the structure of DNA determine the structure of proteins, and what is the function of proteins?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>Systems of specialized cells within organisms help them perform the essential functions of life.</li> <li>All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.</li> <li>Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal their functions and/or solve a problem.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.</li> <li>Construct an explanation, based on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.</li> <li>Conduct a detailed examination of the structure and function of DNA.</li> </ul>
Unit Sequence	
<b>Part B:</b> <i>What do you mean they say that people are made of a system of systems?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.</li> <li>Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Develop and use a model based on evidence to illustrate hierarchical organization of interacting systems that provide specific functions within multicellular organism.</li> <li>Develop and use a model based on evidence to illustrate the interaction of functions at the organism system level.</li> <li>Develop and use a model based on evidence to illustrate the flow of matter and energy within and between systems of an organism at different scales.</li> </ul>

**Unit Sequence**

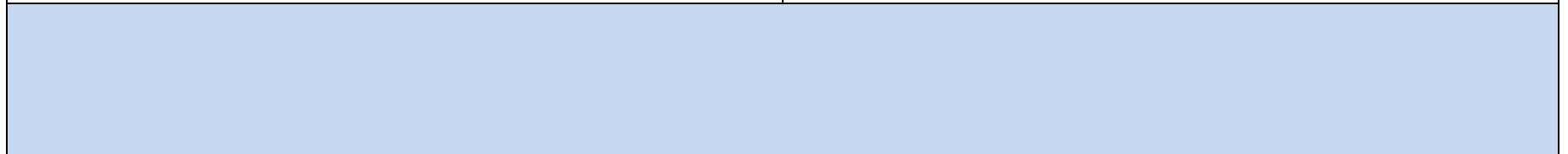
**Part C: How do feedback mechanisms maintain homeostasis?**

<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"><li>• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.</li><li>• Feedback mechanisms maintain a living system’s internal conditions within certain limits, and they mediate behaviors, allowing the system to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.</li><li>• Feedback (negative or positive) can stabilize or destabilize a system.</li></ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"><li>• Plan and conduct an investigation individually and collaboratively to produce evidence that feedback mechanisms (negative and positive) maintain homeostasis.</li><li>• In the planning of the investigation, decide on the types, amount, and accuracy of the data needed to produce reliable measurements, consider limitations on the precision of the data, and refine the design accordingly.</li></ul>

**Unit Sequence**

**Part D: Why aren’t all elephants the same size?**

<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"><li>• In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.</li><li>• The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells.<ul style="list-style-type: none"><li>• Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.</li></ul></li><li>• Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions, including energy, matter, and information flows, within and between systems at different scales.</li></ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"><li>• Use a model based on evidence to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.</li><li>• Use a model to illustrate the role of cellular division and differentiation in terms of energy, matter, and information flows within and between systems of cells/organisms.</li></ul>





## Connecting with English Language Arts/Literacy and Mathematics

### *English Language Arts/Literacy*

- Cite specific textual evidence that supports how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
  - Write an explanation that supports how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
- Draw evidence from informational texts to support how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
  - Make strategic use of digital media in presentations to enhance understanding of the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- Conduct short as well as more sustained research to determine how feedback mechanisms maintain homeostasis. Synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
  - Gather applicable information from multiple reliable sources to support claims that feedback mechanisms maintain homeostasis. Use advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
  - Make strategic use of digital media in presentations to enhance understanding of the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

### *Mathematics*

- Use a mathematical model to illustrate the role of cellular division and differentiation in producing and maintaining complex organisms. Identify important quantities in the role of cellular division and differentiation in producing and maintaining complex organisms and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Graph functions expressed symbolically showing the role of cellular division and differentiation in producing and maintaining complex organisms and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
  - Write a function that describes a relationship between the role of cellular division and differentiation and the production and maintenance of complex organisms.

## Suggested Learning Activities

**Building Macromolecules from Monomers:** Students will combine paper models of monomers for various macromolecules using knowledge of dehydration synthesis to create macromolecules.

**Understanding the Functions of Proteins and DNA:** Students learn about the functions of proteins and how different versions of a protein can result in a characteristic such as albinism or sickle cell anemia.

**Model of phospholipid bilayer:** Students will recognize structural components of fluid mosaic model.

**Introduction to Osmosis- Osmosis Egg Demonstration:** Students will predict cell response to a change in osmotic conditions.

**Osmosis in Onion Cell Lab:** Students will utilize microscope techniques to observe cell structures that regulate osmotic pressure to maintain homeostasis.

**Design your own dialysis diffusion lab?/ Diffusion Across a Selectively Permeable Membrane:** Students will design their own investigation using dialysis tubing, sugar and starch solutions to predict and observe the diffusion of water and other substances through the a selectively permeable membrane.

**Osmosis & Diffusion "In and Out of Cells" Web quest:** Students will use internet simulations to study active and passive transport.

**Modeling endocytosis and exocytosis:** Students will investigate the types of active transport in cells.

**Enzyme Liver Lab (Chemical Reactions and Catalysts in Living Organisms):** Students will observe the impact of temperature and pH on enzyme activity via. analysis of data.

**Enzymes Help Us Digest Food:** Students also analyze how lactase functions in the digestive system and how the digestive and circulatory systems cooperate to provide cells all over the body with molecules that provide the energy for cellular processes

**Structure and Function of Molecules and Cells:** Students analyze multiple examples of the relationship between structure and function in diverse proteins and eukaryotic cells. In addition, students learn that cells are dynamic structures with constant activity, students learn about emergent properties, and students engage in argument from evidence to evaluate three alternative claims concerning the relationship between structure and function.

**Amylase cracker demonstration:** Students will use sense of taste in recognizing specificity of digestive enzymes in the body.

**Murder Food Lab (macromolecule identification):** Students will apply various chemical tests to determine presence or absence of macromolecules of unknown sample.

**Cell Cycle and Mitosis Internet Activity:** Students will use an online web quest to identify stages of the cell cycle

**Ideal Cell Size Lab Investigation:** Students will use potato cubes to predict the rate of diffusion for a small and large cell. Students will measure the depth and rate of diffusion for a small and large cell (potato cube)

**Mitosis vs. Meiosis Pipe Cleaner Modeling Activity:** Students will use pipe cleaner chromosomes to model the processes of mitosis and meiosis

**Structure and Function of Cells, Organs and Organ Systems:** Students analyze multiple examples of the relationship between structure and function in diverse eukaryotic cells and in the digestive system. In addition, students learn that cells are dynamic structures with constant activity and they learn how body systems interact to accomplish important functions.

**Mitosis – How Each New Cell Gets a Complete Set of Genes:** students learn about the basic process of mitosis and use model chromosomes to simulate mitosis. Throughout, students respond to analysis and discussion questions to further develop their understanding of mitosis.

**Homeostasis and Negative Feedback – Concepts and Breathing Experiments:** Students carry out and analyze an experiment which investigates how rate and depth of breathing are affected by negative feedback regulation of blood levels of CO<sub>2</sub> and O<sub>2</sub>. Finally, students formulate a question concerning effects of exercise on breathing, design and carry out a relevant experiment, analyze and interpret their data, and relate their results to homeostasis during exercise

#### Methods of Assessment

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

#### Appendix A: NGSS and Foundations for the Unit

Explain the connection between the sequence and the subcomponents of a biomolecule and its properties. *[Clarification Statement: Emphasis is on the general structural properties that define molecules. Examples include r-groups of amino acids, protein shapes, the nucleotide monomers of DNA and RNA, hydrophilic and hydrophobic regions.] [Assessment Boundary: Assessment does not include identification or the molecular sequence and structure of specific molecules]* [\(LS1.A\)](#)

Create representations that explain how genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein. [\(LS1.A\)](#)

**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.** *[Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]* [\(HS-LS1-1\)](#)

Construct models that explain the movement of molecules across membranes with membrane structure and function. *[Clarification Statement: Emphasis is on the structure of cell membranes, which results in selective permeability; the movement of molecules across them via osmosis, diffusion and active transport maintains dynamic homeostasis.]* [\(LS1.A\)](#)

**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** *[Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural*

*stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.] (HS-LS1-2)*

Provide examples and explain how organisms use feedback systems to maintain their internal environments. (LS1.A)

**Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** *[Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.] (HS-LS1-3)*

**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** *[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.] (HS-LS1-4)*

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)</li> </ul> <p><b>Developing and Using Models</b></p> <ul style="list-style-type: none"> <li>Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)</li> </ul> <p><b>Planning and Carrying Out Investigations</b></p> <ul style="list-style-type: none"> <li>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and</li> </ul>	<p><b>LS1.A: Structure and Function</b></p> <ul style="list-style-type: none"> <li>Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)</li> <li>Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)</li> <li>Regions of DNA called genes determine the structure of proteins, which carry out the essential functions of life through systems of specialized cells. The sequence of genes contains instructions that code for proteins. (LS1.A)</li> <li>Systems of specialized cells within organisms help them perform the essential functions of</li> </ul>	<p><b>Systems and System Models</b></p> <ul style="list-style-type: none"> <li>Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2)</li> </ul> <p><b>Stability and Change</b></p> <ul style="list-style-type: none"> <li>Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)</li> </ul>

refine the design accordingly. (HS-LS1-3)	<p>life. (HS-LS1-1)</p> <ul style="list-style-type: none"> <li>Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism. (LS1.A)</li> </ul>	
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<b>Unit 3 Summary</b> <b>Matter and Energy in Organisms and Ecosystems</b>
<p style="text-align: center;"><i>How do matter and energy cycle through ecosystems?</i></p> <p>In this unit of study, students <i>construct explanations</i> for the role of energy in the cycling of matter in organisms and ecosystems. They <i>apply mathematical concepts to develop evidence to support explanations</i> of the interactions of photosynthesis and cellular respiration, and they will <i>develop models to communicate these explanations</i>. Students also understand organisms' interactions with each other and their physical environment and how organisms obtain resources. Students utilize the crosscutting concepts of <i>matter and energy</i> and <i>systems, and system models</i> to make sense of ecosystem dynamics. Students are expected to use students <i>construct explanations</i> for the role of energy in the cycling of matter in organisms and ecosystems. They <i>apply mathematical concepts to develop evidence to support explanations</i> as they demonstrate their understanding of the disciplinary core ideas.</p> <p>This unit is based on HS-LS1-5, HS-LS2-3, HS-LS2-4, and HS-LS2-5.</p>
<b>Student Learning Objectives</b>
<p><b>Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.</b> <i>[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]</i> <a href="#">(HS-LS1-5)</a></p>
<p><b>Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.</b> <i>[Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]</i> <a href="#">(HS-LS2-3)</a></p>
<p><b>Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.</b> <i>[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]</i> <a href="#">(HS-LS2-4)</a></p>
<p><b>Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</b> <i>[Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]</i> <a href="#">(HS-LS2-5)</a></p>

Unit Sequence	
<b>Part A:</b> <i>Why do astrobiologists look for water on planets and not oxygen when they search for life on other planets?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>• Energy drives the cycling of matter within and between systems.</li> <li>• Energy drives the cycling of matter within and between systems in aerobic and anaerobic conditions.</li> <li>• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Construct and revise an explanation for the cycling of matter and flow of energy in aerobic and anaerobic conditions, based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</li> <li>• Construct and revise an explanation for the cycling of matter and flow of energy in aerobic and anaerobic conditions, considering that most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.</li> </ul>
Unit Sequence	
<b>Part B:</b> <i>Why is there no such thing as a food chain?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>• Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.</li> <li>• At each link in an ecosystem, matter and energy are conserved.</li> <li>• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level.</li> <li>• Given this inefficiency, there are generally fewer organisms at higher levels of a food web.</li> <li>• Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded.</li> <li>• The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Support claims for the cycling of matter and flow of energy among organisms in an ecosystem using conceptual thinking and mathematical representations of phenomena.</li> <li>• Use a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and to show how matter and energy are conserved as matter cycles and energy flows through ecosystems.</li> <li>• Use a mathematical model to describe the conservation of atoms and molecules as they move through an ecosystem.</li> <li>• Use proportional reasoning to describe the cycling of matter and flow of energy through an ecosystem.</li> </ul>

## Unit Sequence

**Part C:** *How can the process of photosynthesis and respiration in a cell impact ALL of Earth's systems?*

### Concepts

- Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

### Formative Assessment

*Students who understand the concepts are able to:*

- Develop a model, based on evidence, to illustrate the roles of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere, showing the relationships among variables in systems and their components in the natural and designed world.
- Develop a model, based on evidence, to illustrate the roles of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere at different scales.

## Connecting with English Language Arts/Literacy and Mathematics

### *English Language Arts/Literacy*

- Cite specific textual evidence to support an explanation for the cycling of matter and flow of energy in aerobic and anaerobic conditions, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Develop and write an explanation, based on evidence, for the cycling of matter and flow of energy in aerobic and anaerobic conditions by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples.
- Develop and strengthen an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

### *Mathematics*

- Represent the cycling of matter and flow of energy among organisms in an ecosystem symbolically and manipulate the representing symbols. Make sense of quantities of and relationships between matter and energy as they cycle and flow through an ecosystem.
- Use a mathematical model to describe the cycling of matter and flow of energy among organisms in an ecosystem. Identify important quantities in the cycling of matter and flow of energy among organisms in an ecosystem and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret units consistently in formulas to determine the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret the scale and the origin in graphs and data displays representing the cycling of matter and flow of energy among organisms in an ecosystem.
- Define appropriate quantities to represent matter and energy for the purpose of descriptive modeling of their cycling and flow among organisms in ecosystems.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing matter cycles and energy flows among organisms

in ecosystems.

### Suggested Learning Activities

**Experiments in Photosynthesis Film:** Students will make predictions on plant response to various conditions pertaining to the reactants and products of photosynthesis.

**Photosynthesis Web- Quest:** Students will utilize internet resources to observe and make predictions on factors that affect the process of photosynthesis including light intensity, water availability and gas exchange.

**Photosynthesis Modeling Activity:** Students learn the chemical formula for photosynthesis by acting out plant's photosynthetic process including photosystem 2, photosystem 1, and the Calvin cycle. Great visual and kinesthetic activity.

**Where does a plant's mass come from?** This analysis and discussion activity helps students to understand that a large part of a plant's mass consists of water, most of the biomass comes from carbon dioxide, and minerals from the soil contribute only a tiny amount of the plant's mass. For example, students engage in analyzing and interpreting data and arguing from evidence.

**Plant Growth Puzzle:** This analysis and discussion activity presents a structured sequence of questions to challenge students to explain why a plant that sprouts and grows in the light has a greater biomass than the seed it came from, whereas a plant that sprouts and grows in the dark has less biomass than the seed it came from.

**Build a Paper Ecosystem:** Using biotic and abiotic factors, students will build a food web and energy pyramid using examples of producers, consumers, and decomposers.

**Surviving Winter in the Dust Bowl (Food Chains and Trophic Levels):** The lesson engages students in an argumentation cycle based on an engaging scenario in which their group is a farm family trying to survive a dust bowl winter with limited food and water resources. The family has a bull, a cow, and limited amounts of water and wheat. Students are presented with four options that include various combinations of eating or keeping the animals alive and eating the wheat. Within this scenario, the lesson provides data on nutritional requirements of cows and humans, along with nutritional contents of wheat, milk, and beef. Students then use this data to construct an argument for the best strategy to allow their family to survive. As they construct this argument, students build and apply knowledge of food chains, trophic levels, interdependence among organisms, and energy transfers within ecosystems.

**How does Energy Flow Through an Ecosystem? Virtual lab: Model Ecosystems:** Students will model the transfer of energy up a food chain via online simulation.

Link: [http://www.mhhe.com/biosci/genbio/virtual\\_labs/BL\\_02/BL\\_02.html](http://www.mhhe.com/biosci/genbio/virtual_labs/BL_02/BL_02.html)

**Food Webs, Energy Flow, Carbon Cycles and Trophic Pyramids:** Students construct a food web for Yellowstone National Park, including producers, primary consumers, secondary consumers, decomposers, and trophic omnivores. Then, students analyze a trophic cascade that resulted when wolves were re-introduced to Yellowstone.

**Cellular Respiration Activity:** Students will model the biochemistry behind cellular respiration by acting out the steps of cellular respiration.

**Exercise & Cellular Respiration Lab:** Students will compare rate of aerobic cellular respiration before and after physical activity to confirm the production of CO<sub>2</sub>



during aerobic respiration.

**Lactic Acid Fermentation in Human Muscle Cells Investigation:** Students will investigate the relationship between aerobic respiration, anaerobic respiration and muscle fatigue in living organisms.

**Of Microbes and Men:** Students will develop a model to show the relationships among nitrogen and the ecosystem including parts that are not observable but predict observable phenomena. They will then construct an explanation of the effects of the environmental and human factors on this cycle.

**How do Biological Organisms Use Energy?** This analysis and discussion activity helps students understand the basic principles of how biological organisms use energy, with a focus on the roles of ATP and cellular respiration. In addition, students apply the principles of conservation of energy and conservation of matter to avoid common errors and correct common misconceptions.

#### Methods of Assessment

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

#### Appendix A: NGSS and Foundations for the Unit

**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]* *[Assessment Boundary: Assessment does not include specific biochemical steps.]* [\(HS-LS1-5\)](#)

**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** *[Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.]* *[Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]* [\(HS-LS2-3\)](#)

**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** *[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.]* *[Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]* [\(HS-LS2-4\)](#)

**Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** *[Clarification Statement: Examples of models could include simulations and mathematical models.]* *[Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]* [\(HS-LS2-5\)](#)

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):



Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><u><b>Constructing Explanations and Designing Solutions</b></u></p> <ul style="list-style-type: none"> <li>Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS2-3)</li> </ul> <p><u><b>Using Mathematics and Computational Thinking</b></u></p> <ul style="list-style-type: none"> <li>Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4)</li> </ul> <p><u><b>Developing and Using Models</b></u></p> <ul style="list-style-type: none"> <li>Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS1-5),(HS-LS2-5)</li> </ul>	<p><u><b>LS1.C: Organization for Matter and Energy Flow in Organisms</b></u></p> <ul style="list-style-type: none"> <li>The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-1)</li> </ul> <p><u><b>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</b></u></p> <ul style="list-style-type: none"> <li>Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)</li> <li>Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)</li> <li>Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the</li> </ul>	<p><u><b>Energy and Matter</b></u></p> <ul style="list-style-type: none"> <li>Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-1)</li> <li>Energy drives the cycling of matter within and between systems. (HS-LS2-3)</li> <li>Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4)</li> </ul> <p><u><b>Systems and System Models</b></u></p> <ul style="list-style-type: none"> <li>Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)</li> </ul> <hr style="border-top: 1px dashed black;"/> <p style="text-align: center;"><b><i>Connections to Nature of Science</i></b></p> <p><b>Scientific Knowledge is Open to Revision in Light of New Evidence</b></p> <ul style="list-style-type: none"> <li>Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-3)</li> </ul>

	biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)	
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## Unit 4 Summary

### Inheritance and Variation of Traits

#### *How are characteristics from one generation related to the previous generation?*

Students analyze data develop models to make sense of the relationship between DNA and chromosomes in the process of cellular division, which passes traits from one generation to the next. Students determine why individuals of the same species vary in how they look, function, and behave. Students develop *conceptual models* of the role of DNA in the unity of life on Earth and *use statistical models* to explain the importance of variation within populations for the survival and evolution of species. Ethical issues related to genetic modification of organisms and the nature of science are described. Students explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expressions. The crosscutting concepts of *structure and function, patterns, and cause and effect* are used as organizing concepts for the disciplinary core ideas. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

#### Student Learning Objectives

**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** *[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]* ([HS-LS1-4](#))

Explain *how* the process of meiosis results in the passage of traits from parent to offspring, and how that results in increased genetic diversity necessary for evolution. *[Clarification Statement: The emphasis is on how meiosis results in genetic diversity, not the rote memorization of the steps of meiosis.]* ([LS1.B](#))

**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** *[Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]* ([HS-LS3-1](#))

Create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. ([LS3.B](#))

**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.** *[Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.]* *[Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]* ([HS-LS3-2](#))

**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** *[Clarification Statement: Emphasis on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.]* *[Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]* ([HS-LS3-3](#))

#### Unit Sequence

**Part A:** *Why can't two roses ever be identical?*

Concepts

Formative Assessment

<ul style="list-style-type: none"> <li>• All cells contain genetic information in the form of DNA molecules.</li> <li>• Genes are regions in the DNA that contain the instructions that code for the formation of proteins.</li> <li>• Each chromosome consists of a single, very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA.</li> <li>• The instructions for forming species' characteristics are carried in the DNA.</li> <li>• All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways.</li> <li>• Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have, as yet, no known function.</li> <li>• Empirical evidence is required to differentiate between cause and correlation and to make claims about the role of DNA and chromosomes in coding the instructions for the characteristic traits passed from parents to offspring.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Ask questions that arise from examining models or a theory to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parent to offspring.</li> <li>• Use empirical evidence to differentiate between cause and correlation and make claims about the role of DNA and chromosomes in coding the instructions for characteristics passed from parents to offspring.</li> </ul>
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**Unit Sequence**

**Part B: How does inheritable genetic variation occur?**

<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation.</li> <li>• Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.</li> <li>• Environmental factors can also cause mutations in genes, and viable mutations are inherited.</li> <li>• Environmental factors also affect expression of traits, and hence affect the probability of occurrence of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.</li> <li>• Empirical evidence is required to differentiate between cause and correlation and to make claims about inheritable genetic variations resulting</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Make and defend a claim based on evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.</li> <li>• Use data to support arguments for the ways inheritable genetic variation occurs.</li> <li>• Use empirical evidence to differentiate between cause and correlation and make claims about the ways inheritable genetic variation occurs.</li> </ul>

from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.	
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<b>Unit Sequence</b>
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<b>Part C:</b> <i>Can a zoologist predict the distribution of expressed traits in a population?</i>
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<b>Concepts</b>	<b>Formative Assessment</b>
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<ul style="list-style-type: none"> <li>• Environmental factors affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variations and distributions of traits observed depend on both genetic and environmental factors.</li> <li>• Algebraic thinking is used to examine scientific data and predict the distribution of traits in a population as they relate to the genetic and environmental factors (e.g., linear growth vs. exponential growth).</li> <li>• Technological advances have influenced the progress of science, and science has influenced advances in technology.</li> <li>• Science and engineering are influenced by society, and society is influenced by science and engineering.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Apply concepts of statistics and probability (including determining function fits to data, slope, intercepts, and correlation coefficient for linear fits) to explain the variation and distribution of expressed traits in a population.</li> <li>• Use mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.</li> <li>• Use algebraic thinking to examine scientific data on the variation and distribution of traits in a population and predict the effect of a change in probability of traits as it relates to genetic and environmental factors.</li> </ul>
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<b>Connecting with English Language Arts/Literacy and Mathematics</b>
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<p><i>English Language Arts/Literacy</i></p> <ul style="list-style-type: none"> <li>• Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.</li> <li>• Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.</li> <li>• Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.</li> <li>• Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.</li> </ul> <p><i>Mathematics</i></p> <ul style="list-style-type: none"> <li>• Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.</li> <li>• Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and</li> </ul>	
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relationships to describe and predict the variation and distribution of expressed traits in a population.

### Suggested Learning Resources

**Structure and Function: Stem Cell:** Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

**DNA Structure, Function and Replication:** To introduce students to key concepts about the structure, function and replication of DNA or to review these topics. This activity includes hands-on modeling of DNA replication.

**Modeling DNA Replication, Transcription and Translation Activities:** Model the process of protein synthesis utilizing the genetic codon chart to show how DNA determines the structure of proteins which determine physical characteristics in organisms.

**From Gene to Protein – Transcription and Translation:** Students also analyze how lactase functions in the digestive system and how the digestive and circulatory systems cooperate to provide cells all over the body with molecules that provide the energy for cellular processes

**DNA Mutations and Consequences Activity:** Students will witness the change a single point mutation in the DNA can have on a resulting protein.

**DNA Extraction Lab:** Through active investigation of extraction human cheek cells, students will understand the technique and applications of DNA extraction.

**Determining Structure of DNA Investigation:** Students will analyze given set of data to construct an argument about the molecular structure of DNA. Students will compare synthesized models to determine the validity of their argument.

**Karyotype & Pedigree STEM project:** Students will explore, explain, elaborate and evaluate karyotypes and pedigrees of human chromosomal disorder case studies.

**Probability Lab:** Students will be introduced to concepts of probability and inheritance by applying concepts of statistics to bead models.

**Genetics Activity:** Students will complete a coin toss genetics activity and an analysis of student data on the sex makeup of sibships, both of which help students understand the probabilistic nature of inheritance and Punnett square predictions

**Soap Opera Genetics – Genetics to Resolve Family Arguments:** Students explain the relevant biology to answer the probing questions of a skeptical father who wants to know how his baby could be albino when neither he nor his wife are albino. Students also analyze sex-linked inheritance.

**Genetic Engineering Challenge - How can scientists develop a type of Rice that could prevent vitamin A deficiency?** To challenge students to design a basic plan that could produce a genetically engineered rice plant that makes rice grains that contain pro-vitamin A

**Investigating Corn Genetics:** Students will collect and analyze data of corn kernel population and apply test cross methods in determining genotypes of P generation. Students will additionally complete a test cross based on two-trait (dihybrid) corn kernel analysis.

**Using Blood Tests to Identify Babies and Criminals:** Students will use knowledge of non-mendelian genetics and multiple alleles to determine identities of unknown individuals.

**Meiosis and Fertilization – Understanding How Genes Are Inherited:** Students use model chromosomes to simulate the processes of meiosis and fertilization. As they model meiosis and fertilization, students follow the alleles of three human genes from the parents' body cells through gametes to zygotes.

### Methods of Assessment

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

### Appendix A: NGSS and Foundations for the Unit

**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** *[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]* ([HS-LS1-4](#))

Explain *how* the process of meiosis results in the passage of traits from parent to offspring, and how that results in increased genetic diversity necessary for evolution. *[Clarification Statement: The emphasis is on how meiosis results in genetic diversity, not the rote memorization of the steps of meiosis.]*([LS1.B](#))

**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** *[Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]* ([HS-LS3-1](#))

Create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. ([LS3.B](#))

**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.** *[Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.]* *[Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]* ([HS-LS3-2](#))

**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** *[Clarification Statement: Emphasis on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.]* *[Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]* ([HS-LS3-3](#))

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Asking Questions and Defining Problems</b></p> <ul style="list-style-type: none"> <li>Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)</li> </ul> <p><b>Constructing Explanations and Designing Solutions</b></p>	<p><b>LS1.A: Structure and Function</b></p> <ul style="list-style-type: none"> <li>All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary to HS-LS3-1)</li> </ul>	<p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HLS3-1; HSL3-2)</li> </ul>



<ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)</li> </ul> <p><b>Engaging in Argument from Evidence</b></p> <ul style="list-style-type: none"> <li>Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)</li> <li>Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3)</li> <li>Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)</li> </ul>	<p><b>LS3.A: Inheritance of Traits</b></p> <ul style="list-style-type: none"> <li>Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways.</li> <li>Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)</li> </ul> <p><b>LS3.B: Variation of Traits</b></p> <ul style="list-style-type: none"> <li>In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)</li> <li>Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2; HS-LS3-3)</li> </ul>	<p><b>Scale, Proportion, and Quantity</b></p> <ul style="list-style-type: none"> <li>Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-LS3-3)</li> </ul>
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## Unit 5 Summary

### Natural Selection and Mechanisms of Evolution

#### ***How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms?***

Students *constructing explanations and designing solutions, analyzing and interpreting data, and engaging in argument from evidence* investigate to make sense of the relationship between the environment and natural selection. Students also develop an understanding of the factors causing natural selection of species over time. They also demonstrate and understandings of how multiple lines of evidence contribute to the strength of scientific theories of natural selection. The crosscutting concepts of *patterns* and *cause and effect* serve as organizing concepts for the disciplinary core ideas. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

This unit is based on Disciplinary Core Idea LS4.C (Adaptation), HS-LS4-4, HS-LS4-3, HS-LS4-5, and HS-LS2-8.

#### Student Learning Objectives

Make predictions about the effects of artificial selection on the genetic makeup of a population over time. ([LS4.C](#))

**Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** *[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]* ([HS-LS4-4](#))

**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.** *[Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]* *[Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]* ([HS-LS4-3](#))

**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.** *[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]* ([HS-LS4-5](#))

**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** *[Clarification 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.]* ([HS-LS2-8](#))

#### Unit Sequence

**Part A:** *How does natural selection lead to adaptations of populations?*

Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>• Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. <ul style="list-style-type: none"> <li>• Empirical evidence is required to differentiate between cause and correlation and make claims about how natural selection leads to adaptation of populations.</li> <li>• Empirical evidence is required to differentiate between cause and correlation and make claims about how specific biotic and abiotic differences in ecosystems contribute to change in gene frequency over time, leading to adaptation of populations.</li> </ul> </li> <li>• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review), and on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, for how natural selection leads to adaptation of populations.</li> <li>• Use data to differentiate between cause and correlation and to make claims about how specific biotic and abiotic differences in ecosystems contribute to change in gene frequency over time, leading to adaptation of populations.</li> </ul>
<b>Unit Sequence</b>	
<b>Part B:</b> <i>Why is it so important to take all of the antibiotics in a prescription if I feel better?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.</li> <li>• The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.</li> <li>• Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</li> <li>• Analyze shifts in numerical distribution of traits and, using these shifts as evidence, support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</li> <li>• Observe patterns at each of the scales at which a system is studied to provide evidence for causality in explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</li> </ul>

<ul style="list-style-type: none"> <li>Adaptation also means that the distribution of traits in a population can change when conditions change.</li> <li>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</li> </ul>	
<b>Unit Sequence</b>	
<b>Part C: How are species affected by changing environmental conditions?</b>	
<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline, and sometimes the extinction, of some species.</li> <li>Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and make 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.</li> </ul> </li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>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.</li> <li>Determine cause-and-effect relationships for how changes to the environment affect distribution or disappearance of traits in species.</li> <li>Use empirical evidence to differentiate between cause and correlation and to make 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.</li> </ul>
<b>Unit Sequence</b>	
<b>Part D: Why do some species live in groups and others are solitary?</b>	
<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and to make claims about the role of group behavior in individual and species' chances to survive and reproduce.</li> </ul> </li> <li>Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in the revision of an explanation about the role of group behavior on individual and</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. <ul style="list-style-type: none"> <li>Distinguish between group and individual behavior.</li> <li>Identify evidence supporting the outcome of group behavior.</li> </ul> </li> <li>Develop logical and reasonable arguments based on evidence to evaluate the role of group behavior on individual and species' chances to survive and</li> </ul>

species' chances to survive and reproduce.	reproduce.
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- Use empirical evidence to differentiate between cause and correlation and to make claims about the role of group behavior on individual and species' chances to survive and reproduce.

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts/Literacy*

- Cite specific textual evidence to support analysis of science and technical texts describing how natural selection leads to adaptation of populations, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write informative/explanatory texts describing how natural selection leads to adaptation of populations, including the narration of historical events, scientific procedures/experiments, or technical processes.
  - Draw evidence from informational texts to support analysis, reflection, and research about how natural selection leads to adaptation of populations.
- Cite specific textual evidence to support analysis of science and technical texts that provide explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write informative/explanatory texts about explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait, including the narration of historical events, scientific procedures/experiments, or technical processes.
- Draw evidence from information texts to support analysis, reflection, and research about organisms with an advantageous heritable trait and their proportional increase as compared to organisms lacking this trait.
- Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text 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, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- Draw evidence from information texts making 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 to support analysis, reflection, and research.
- Assess the extent to which the reasoning and evidence in a text support the author's claim about the role of group behavior on individual and species' chances to survive and reproduce.
- Cite specific textual evidence to support analysis of science and technical texts about the role of group behavior on individual and species' chances to survive and reproduce.
  - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address the role of group behavior on individual and species' chances to survive and reproduce.
  - Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text about the role of group behavior on individual and species' chances to survive and reproduce, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

### Mathematics

- Represent how natural selection leads to adaptation of populations symbolically, and manipulate the representing symbols. Make sense of quantities and relationships between specific biotic and abiotic differences in ecosystems and their contributions to a change in gene frequency over time that leads to adaptation of populations.
- Represent symbolically the proportional increase in organisms with an advantageous heritable trait as compared with organisms lacking this trait, and manipulate the representing symbols. Make sense of quantities and relationships between the proportional increase in organisms with an advantageous heritable trait as compared with the numbers of organisms lacking this trait.

### Suggested Learning Activities

**Peppered Moth Evolution:** Students explain how variation, selection, and time drive the process of evolution by collecting and analyzing data within peppered moth population. Students will construct graphical representations to visualize trend of change over time within population of moths.

**Evolution by Natural Selection:** Students develop their understanding of natural selection by analyzing specific examples and carrying out a simulation

**Using Molecular and Evolutionary Biology to Understand HIV/AIDS and Treatment:** To challenge students to apply their understanding of basic molecular and cellular biology and natural selection and interpret information presented in prose and diagrams in order to understand multiple aspects of the biology of HIV/AIDS and treatment.

**Evolution and Adaptations Lesson:** Students will analyze how the balance between the advantages and disadvantages of a characteristic (e.g. an animal's color) can vary in different circumstances, how phenotypic plasticity can be a heritable trait that can optimize fitness in a variable environment, and how natural selection can influence the amount of phenotypic plasticity in a population. This activity is designed to help high school students meet the Next Generation Science Standards and the Common

**The Ecology of Lyme Disease:** Students will analyze when and where human risk of Lyme disease is greatest, why rates of Lyme disease have increased in recent decades in the US, and ecological approaches to preventing Lyme disease.

**Desert Snakes (Mechanics of Evolution):** Students will generate argument using multiple lines of evidence presented via. text, data tables and photos to defend claim about physical similarities between snakes. Students will present and justify their claim to classmates.

**Monstrous Mutation Lab:** Students will simulate how mutations in DNA impact the fitness of an organism due to natural selection.

**Modeling the Process of Natural Selection:** Class will act as a varied population of living organisms that over time will change due to external and internal factors.

**Genetic Drift Activity:** Students will analyze shifts in numerical distribution of traits due to density independent factors.

## Methods of Assessment

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

## Appendix A: NGSS and Foundations for the Unit

Make predictions about the effects of artificial selection on the genetic makeup of a population over time. ([LS4.C](#))

**Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** *[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]* ([HS-LS4-4](#))

**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.** *[Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]* *[Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]* ([HS-LS4-3](#))

**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.** *[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]* ([HS-LS4-5](#))

**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** *[Clarification 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.]* ([HS-LS2-8](#))

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Analyzing and Interpreting Data</b></p> <ul style="list-style-type: none"> <li>Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.</li> <li>Apply concepts of statistics and probability</li> </ul>	<p><b>LS1.A: Structure and Function</b></p> <ul style="list-style-type: none"> <li>Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)</li> </ul> <p><b>LS4.B: Natural Selection</b></p>	<p><b>Cause and Effect</b></p> <p>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-4)</p> <p><b>Patterns</b></p> <p>Different patterns may be observed at each of the</p>

<p>(including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS4-3)</p> <p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS4-4)</li> </ul> <p><b>Engaging in Argument from Evidence</b></p> <ul style="list-style-type: none"> <li>Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)</li> </ul>	<ul style="list-style-type: none"> <li>Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-3)</li> <li>The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HSL4-3)</li> <li>Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)</li> </ul> <p><b>LS4.C: Adaptation</b></p> <ul style="list-style-type: none"> <li>Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-4)</li> </ul> <p><b>LS2.D: Social Interactions and Group Behavior</b></p> <ul style="list-style-type: none"> <li>Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HSL2-8)</li> </ul>	<p>scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-LS4-3)</p>
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## Unit 6 Summary

### Evidence of Evolution, Relationships and Common Ancestry

#### *What evidence shows that different species are related?*

Students construct explanations for the processes of natural selection and evolution and then communicate how multiple lines of evidence support these explanations. Students evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Additionally, students can apply concepts of probability to explain trends in population as those trends relate to advantageous heritable traits in a specific environment. Students demonstrate an understanding of these concepts by *obtaining, evaluating, and communicating information* and *constructing explanations and designing solutions*. The crosscutting concepts of patterns and cause and effect support the development of a deeper understanding.

#### Student Learning Objectives

Examine a group of related organisms using a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. ([LS4.A](#))

**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** *[Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]* ([HS-LS4-1](#))

**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.** *[Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.]* *[Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.]* ([HS-LS4-2](#))

#### Unit Sequence

**Part A:** *How can someone prove that birds and dinosaurs are related?*

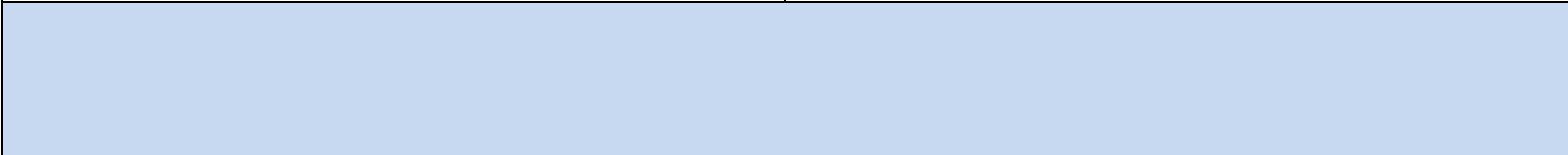
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.</li> <li>Genetic information provides evidence of evolution. DNA sequences vary</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>Communicate scientific information in multiple forms that common ancestry and biological evolution are supported by multiple lines of empirical evidence.</li> <li>Understand the role each line of evidence has relating to common ancestry and biological evolution.</li> <li>Observe patterns in multiple lines of empirical evidence at different scales</li> </ul>

<p>among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.</p> <ul style="list-style-type: none"> <li>• Different patterns in multiple lines of empirical evidence may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of common ancestry and biological evolution.</li> </ul>	<p>and provide evidence for causality in explanations of common ancestry and biological evolution.</p>
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**Unit Sequence**

**Part B: What is the relationship between natural selection and evolution?**

<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information— that is, trait variation—that leads to differences in performance among individuals.</li> <li>• Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment’s limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.</li> <li>• Empirical evidence is required to differentiate between cause and correlation and make claims about the process of evolution.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Construct an explanation, based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, 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.</li> <li>• Use empirical evidence to explain the influences of: (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, on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species.</li> </ul>



## Connecting with English Language Arts/Literacy and Mathematics

### *English Language Arts/Literacy*

- Cite specific textual evidence to support analysis of science and technical texts describing common ancestry and biological evolution, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  - Write informative/explanatory texts describing common ancestry and biological evolution, including the narration of historical events, scientific procedures/experiments, or technical processes.
  - Draw evidence from informational texts describing common ancestry and biological evolution to support analysis, reflection, and research.
- Present claims and findings about common ancestry and biological evolution, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

### *Mathematics*

- Represent evidence that common ancestry and biological evolution are supported by multiple lines of empirical evidence symbolically, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict common ancestry and biological evolution.

## Suggested Learning Activities

**Anatomical Evidence of Evolution Investigation:** Students investigate evidence for evolution by analyzing fossil evidence, structural evidence, and genetic evidence in support of common ancestry among living things.

**How could complex eyes have evolved?** Students analyze evidence from comparative anatomy, mathematical modeling, and molecular biology. This evidence suggests a likely sequence of steps in the evolution of the human eye and the octopus eye.

**Construction of Cladograms:** Students will interpret cladograms and synthesize cladograms to identify shared characteristics and make inferences about the evolutionary history of the group.

**Geologic Time Web Quest:** Students will use various online sources to study the history of life on Earth and major life forms that existed during each era.

**Evolutionary Relationships in Mammals:** Students will compare amino acid sequences, homologous structures and photographs of various animals to make a claim that incorporates phylogeny between mammal species.

**Methods of Assessment**

-Do Now, Exit Tickets, Question and Answer techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental Cumulative Assessments, Lab performance and analysis, Classwork & Homework reinforcement techniques, Discussion

**Appendix A: NGSS and Foundations for the Unit**

**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** *[Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]* **(HS-LS4-1)**

**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.** *[Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of a ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.]* *[Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.]* **(HS-LS4-2)**

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Obtaining, Evaluating, and Communicating Information</b></p> <ul style="list-style-type: none"> <li>Communicate scientific information (e.g., about phenomena and/or the process of development)</li> </ul>	<p><b>LS4.A: Evidence of Common Ancestry and Diversity</b></p> <ul style="list-style-type: none"> <li>Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing</li> </ul>	<p><b>Patterns</b></p> <ul style="list-style-type: none"> <li>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of</li> </ul>

<p>and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-LS4-1)</p> <p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS4-2)</li> </ul>	<p>branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)</p> <p><b>LS4.B: Natural Selection</b></p> <ul style="list-style-type: none"> <li>Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2)</li> </ul> <p><b>LS4.C: Adaptation</b></p> <ul style="list-style-type: none"> <li>Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)</li> </ul>	<p>phenomena. (HS-LS4-1)</p> <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2)</li> </ul>
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**The following standards are threaded throughout all units of the NJSLS-Science:**

**21st Century Life and Career Standards: Career Awareness, ELD Standards, and Technology Standards.**

**WIDA ELD Standards: Teaching with Standards | WIDA**

WIDA has established language development standards for English and Spanish. These standards represent the language students need to be successful in early childhood programs and Grades K-12.

The first standard, **Social and Instructional Language**, reflects the ways in which students interact socially to build community and establish working relationships with peers and teachers in ways that support learning.

The remaining four standards present ways multilingual learners can communicate information, ideas and concepts necessary for academic success in **Language Arts, Math, Science and Social Studies**.

**Specifically in Science Standard 4- Language of Science- English Language learners communicate information, ideas and concepts necessary for academic success in the content area of science.**

**New Jersey Student Learning Standards**

**Standard 9**

**21st Century Life and Careers**

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world. To address these demands, Standard 9, 21st Century Life and Careers, which includes the 12 Career Ready Practices, establishes clear guidelines for what students need to know and be able to do in order to be successful in their future careers and to achieve financial independence.

**Mission:** *21st century life and career skills enable students to make informed decisions that prepare them to engage as active citizens in a dynamic global society and to successfully meet the challenges and opportunities of the 21st century global workplace.*

**Vision:** To integrate 21st Century life and career skills across the K-12 curriculum and to foster a population that:

- Continually self-reflects and seeks to improve the essential life and career practices that lead to success.

- Uses effective communication and collaboration skills and resources to interact with a global society.
- Is financially literate and financially responsible at home and in the broader community.
- Is knowledgeable about careers and can plan, execute, and alter career goals in response to changing societal and economic conditions.
- Seeks to attain skill and content mastery to achieve success in a chosen career path.

### **Career Ready Practices**

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

#### **CRP1. Act as a responsible and contributing citizen and employee.**

Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

#### **CRP2. Apply appropriate academic and technical skills.**

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.

#### **CRP3. Attend to personal health and financial well-being.**

Career-ready individuals understand the relationship between personal health, workplace performance and personal well-being; they act on that understanding to regularly practice healthy diet, exercise and mental health activities. Career-ready individuals also take regular action to contribute to their personal financial wellbeing, understanding that personal financial security provides the peace of mind required to contribute more fully to their own career success.

#### **CRP4. Communicate clearly and effectively and with reason.**

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

**CRP5. Consider the environmental, social and economic impacts of decisions.**

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

**CRP6. Demonstrate creativity and innovation.**

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

**CRP7. Employ valid and reliable research strategies.**

Career-ready individuals are discerning in accepting and using new information to make decisions, changes. They use reliable research process to search for new information. They evaluate the validity of sources when considering the use and adoption of external information or practices in their workplace situation.

**CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.**

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

**CRP9. Model integrity, ethical leadership and effective management.**

Career-ready individuals consistently act in ways that align personal and community-held ideals and principles while employing strategies to positively influence others in the workplace. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the directions and actions of a team or organization, and they apply insights into human behavior to change others' action, attitudes and/or beliefs. They recognize the near-term and long-term effects that management's actions and attitudes can have on productivity, morals and organizational culture.



**CRP10. Plan education and career paths aligned to personal goals.**

Career-ready individuals take personal ownership of their own education and career goals, and they regularly act on a plan to attain these goals. They understand their own career interests, preferences, goals, and requirements. They have perspective regarding the pathways available to them and the time, effort, experience and other requirements to pursue each, including a path of entrepreneurship. They recognize the value of each step in the education and experiential process, and they recognize that nearly all career paths require ongoing education and experience. They seek counselors, mentors, and other experts to assist in the planning and execution of career and personal goals.

**CRP11. Use technology to enhance productivity.**

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

**CRP12. Work productively in teams while using cultural global competence.**

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

**2014 New Jersey Core Curriculum Content Standards - Technology**

<b>Content Area</b>		<b>Technology</b>	
<b>Standard</b>		<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>	
<b>Strand</b>		<b>A. Technology Operations and Concepts: <i>Students demonstrate a sound understanding of technology concepts, systems and operations.</i></b>	
<b>Grade Level bands</b>	<b>Content Statement Students will:</b>	<b>Indicator</b>	<b>Indicator</b>
<b>P</b>	Understand and use technology systems.	8.1.P.A.1	Use an input device to select an item and navigate the screen
		8.1.P.A.2	Navigate the basic functions of a browser.
	Select and use applications effectively and productively.	8.1.P.A.3	Use digital devices to create stories with pictures, numbers, letters and words.
		8.1.P.A.4	Use basic technology terms in the proper context in conversation with peers and teachers (e.g., camera, tablet, Internet, mouse, keyboard, and printer).
		8.1.P.A.5	Demonstrate the ability to access and use resources on a computing device.

<b>K-2</b>	Understand and use technology systems.	8.1.2.A.1	Identify the basic features of a digital device and explain its purpose.
	Select and use applications effectively and productively.	8.1.2.A.2	Create a document using a word processing application.
		8.1.2.A.3	Compare the common uses of at least two different digital applications and identify the advantages and disadvantages of using each.
		8.1.2.A.4	Demonstrate developmentally appropriate navigation skills in virtual environments (i.e. games, museums).
		8.1.2.A.5	Enter information into a spreadsheet and sort the information.
		8.1.2.A.6	Identify the structure and components of a database.
		8.1.2.A.7	Enter information into a database or spreadsheet and filter the information.
<b>3-5</b>	Understand and use technology systems.	8.1.5.A.1	Select and use the appropriate digital tools and resources to accomplish a variety of tasks including solving problems.
	Select and use applications effectively and productively.	8.1.5.A.2	Format a document using a word processing application to enhance text and include graphics, symbols and/ or pictures.
		8.1.5.A.3	Use a graphic organizer to organize information about problem or issue.
		8.1.5.A.4	Graph data using a spreadsheet, analyze and produce a report that explains the analysis of the data.
		8.1.5.A.5	Create and use a database to answer basic questions.
		8.1.5.A.6	Export data from a database into a spreadsheet; analyze and produce a report that explains the analysis of the data.
<b>6-8</b>	Understand and use technology systems.	8.1.8.A.1	Demonstrate knowledge of a real world problem using digital tools.
	Select and use applications effectively and productively.	8.1.8.A.2	Create a document (e.g. newsletter, reports, personalized learning plan, business letters or flyers) using one or more digital applications to be critiqued by professionals for usability.
		8.1.8.A.3	Use and/or develop a simulation that provides an environment to solve a real world problem or theory.
		8.1.8.A.4	Graph and calculate data within a spreadsheet and present a summary of the results
		8.1.8.A.5	Create a database query, sort and create a report and describe the process, and explain the report results.
<b>9-12</b>	Understand and use technology systems.	8.1.12.A.1	Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.
	Select and use applications effectively and productively.	8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
		8.1.12.A.3	Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.
		8.1.12.A.4	Construct a spreadsheet workbook with multiple worksheets, rename tabs

			to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
		8.1.12.A.5	Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.
<b>Content Area</b>	<b>Technology</b>		
<b>Standard</b>	<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>		
<b>Strand</b>	<b>B. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.</b>		
<b>Grade Level bands</b>	<b>Content Statement</b> Students will:	<b>Indicator</b>	<b>Indicator</b>
P	Apply existing knowledge to generate new ideas, products, or processes.	8.1.P.B.1	Create a story about a picture taken by the student on a digital camera or mobile device.
K-2	Create original works as a means of personal or group expression.	8.1.2.B.1	Illustrate and communicate original ideas and stories using multiple digital tools and <a href="#">resources</a> .
3-5		8.1.5.B.1	Collaborative to produce a digital story about a significant local event or issue based on first-person interviews.
6-8		8.1.8.B.1	Synthesize and publish information about a local or global issue or event (ex. telecollaborative project, blog, school web).
9-12		8.1.12.B.2	Apply previous content knowledge by creating and piloting a digital learning game or tutorial.
<b>Content Area</b>	<b>Technology</b>		
<b>Standard</b>	<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>		
<b>Strand</b>	<b>C. Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.</b>		
<b>Grade Level bands</b>	<b>Content Statement</b>	<b>Indicator</b>	<b>Indicator</b>
<b>P</b>	Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media.	8.1.P.C.1	Collaborate with peers by participating in interactive digital games or activities.
<b>K-2</b>	Communicate information and ideas to multiple audiences using a variety of media and formats.  Develop cultural understanding and	8.1.2.C.1	Engage in a variety of developmentally appropriate learning activities with students in other classes, schools, or countries using various media formats such as online collaborative tools, and social media.
<b>3-5</b>		8.1.5.C.1	Engage in online discussions with learners of other cultures to investigate a worldwide issue from multiple perspectives and sources, evaluate findings and present possible solutions, using digital tools and online resources for all steps.

	global awareness by engaging with learners of other cultures.		
<b>6-8</b>		8.1.8.C.1	Collaborate to develop and publish work that provides perspectives on a global problem for discussions with learners from other countries.
<b>9-12</b>	Contribute to project teams to produce original works or solve problems.	8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
<b>Content Area</b>		<b>Technology</b>	
<b>Standard</b>		<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>	
<b>Strand</b>		<b>D. Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.</b>	
<b>Grade Level bands</b>	<b>Content Statement</b>	<b>Indicator</b>	<b>Indicator</b>
<b>K-2</b>	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.2.D.1	Develop an understanding of ownership of print and nonprint information.
<b>3-5</b>	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.5.D.1	Understand the need for and use of copyrights.
		8.1.5.D.2	Analyze the resource citations in online materials for proper use.
	Demonstrate personal responsibility for lifelong learning.	8.1.5.D.3	Demonstrate an understanding of the need to practice cyber safety, cyber security, and cyber ethics when using technologies and social media.
	Exhibit leadership for digital citizenship.	8.1.5.D.4	Understand digital citizenship and demonstrate an understanding of the personal consequences of inappropriate use of technology and social media.
<b>6-8</b>	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.8.D.1	Understand and model appropriate online behaviors related to cyber safety, cyber bullying, cyber security, and cyber ethics including appropriate use of social media.
	Demonstrate personal responsibility for lifelong learning.	8.1.8.D.2	Demonstrate the application of appropriate citations to digital content.
		8.1.8.D.3	Demonstrate an understanding of fair use and Creative Commons to intellectual property.
	Exhibit leadership for digital citizenship.	8.1.8.D.4	Assess the credibility and accuracy of digital content.
8.1.8.D.5		Understand appropriate uses for social media and the negative consequences of misuse.	
<b>9-12</b>	Advocate and practice safe, legal, and	8.1.12.D.1	Demonstrate appropriate application of copyright, fair use and/or Creative

	responsible use of information and technology.		Commons to an original work.
	Demonstrate personal responsibility for lifelong learning.	8.1.12.D.2	Evaluate consequences of unauthorized electronic access (e.g., hacking) and disclosure, and on dissemination of personal information.
		8.1.12.D.3	Compare and contrast policies on filtering and censorship both locally and globally.
	Exhibit leadership for digital citizenship.	8.1.12.D.4	Research and understand the positive and negative impact of one's digital footprint.
		8.1.12.D.5	Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs.
<b>Content Area</b>		<b>Technology</b>	
<b>Standard</b>		<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>	
<b>Strand</b>		<b>E: Research and Information Fluency: <i>Students apply digital tools to gather, evaluate, and use information.</i></b>	
<b>Grade Level bands</b>	<b>Content Statement</b> <b>Students will:</b>	<b>Indicator</b>	<b>Indicator</b>
<b>P</b>	Plan strategies to guide inquiry.	8.1.P.E.1	Use the Internet to explore and investigate questions with a teacher's support.
<b>K-2</b>	Plan strategies to guide inquiry  Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.  Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.	8.1.2.E.1	Use digital tools and online resources to explore a problem or issue.
<b>3-5</b>	Plan strategies to guide inquiry.  Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.  Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.	8.1.5.E.1	Use digital tools to research and evaluate the accuracy of, relevance to, and appropriateness of using print and non-print electronic information sources to complete a variety of tasks.

<b>6-8</b>	<p>Plan strategies to guide inquiry.</p> <p>Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.</p> <p>Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.</p> <p>Process data and report results.</p>	8.1.8.E.1	Effectively use a variety of search tools and filters in professional public databases to find information to solve a real world problem.
<b>9-12</b>	<p>Plan strategies to guide inquiry.</p> <p>Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.</p> <p>Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.</p> <p>Process data and report results.</p>	8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
		8.1.12.E.2	Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.
<b>Content Area</b>	<b>Technology</b>		
<b>Standard</b>	<b>8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.</b>		
<b>Strand</b>	<b>F: Critical thinking, problem solving, and decision making:</b> <i>Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.</i>		
<b>Grade Level bands</b>	<b>Content Statement</b> <b>Students will:</b>	<b>Indicator</b>	<b>Indicator</b>
<b>K-2</b>	<p>Identify and define authentic problems and significant questions for investigation.</p> <p>Plan and manage activities to develop a solution or complete a project.</p> <p>Collect and analyze data to identify</p>	8.1.2.F.1	Use geographic mapping tools to plan and solve problems.

	<p>solutions and/or make informed decisions.</p> <p>Use multiple processes and diverse perspectives to explore alternative solutions.</p>		
<b>3-5</b>	<p>Identify and define authentic problems and significant questions for investigation.</p> <p>Plan and manage activities to develop a solution or complete a project.</p> <p>Collect and analyze data to identify solutions and/or make informed decisions.</p> <p>Use multiple processes and diverse perspectives to explore alternative solutions</p>	8.1.5.F.1	Apply digital tools to collect, organize, and analyze data that support a scientific finding.
<b>6-8</b>	<p>Identify and define authentic problems and significant questions for investigation.</p> <p>Plan and manage activities to develop a solution or complete a project.</p> <p>Collect and analyze data to identify solutions and/or make informed decisions.</p> <p>Use multiple processes and diverse perspectives to explore alternative solutions.</p>	8.1.8.F.1	Explore a local issue, by using digital tools to collect and analyze data to identify a solution and make an informed decision.
<b>9-12</b>	<p>Identify and define authentic problems and significant questions for investigation.</p> <p>Plan and manage activities to develop a solution or complete a project.</p> <p>Collect and analyze data to identify solutions and/or make informed decisions.</p>	8.1.12.F.1	Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

	Use multiple processes and diverse perspectives to explore alternative solutions.		
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