Unit Summary
What do fossils tell us about the organisms and the environments in which they lived?
In this unit of study, students develop an understanding of the types of organisms that lived long ago and also about the nature of their environments. Students develop an understanding of the idea that when the environment changes, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. The crosscutting concepts of *systems and system models*; *scale, proportion, and quantity*; and *the influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *asking questions and defining problems*, *analyzing and interpreting data*, and *engaging in argument from evidence*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 3-LS4-1, 3-LS4-4, and 3-5-ETS1-1.
Student Learning Objectives
Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. *[Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.]* [Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.*]* **(3-LS4-1)**
Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* *[Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.]* [Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]* **(3-LS4-4)**
Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Quick Links		

Unit Sequence	
Part A: *What do fossils tell us about the organisms and the environments in which they lived?*	
Concepts	**Formative Assessment**
• Observable phenomena exist from very short to very long periods of time. • Science assumes consistent patterns in natural systems. • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. • Fossils provide evidence about the types of organisms that lived long ago, and also about the nature of their environments.	*Students who understand the concepts are able to:* • Observe that phenomena exist from very short to very long periods of time. • Analyze and interpret data to make sense of phenomena using logical reasoning. • Analyze and interpret data from fossils (e.g., type, size, distributions of fossil organisms) to provide evidence of the organisms and the environments in which they lived long ago. *(Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.)* Examples of fossils and environments could include: ✓ Marine fossils found on dry land; ✓ Tropical plant fossils found in Arctic areas; or ✓ Fossils of extinct organisms.

Unit Sequence	
Part B: *What happens to the plants and animals when the environment changes?*	
Concepts	**Formative Assessment**
• A system can be described in terms of its components and their interactions. • People's needs and wants change over time, as do their demands for new and improved technologies. • Populations live in a variety of habitats, and change in those habitats affects the organisms living there. • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, others move into the transformed environment, and some die.	*Students who understand the concepts are able to:* • Describe a system in terms of its components and interactions. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of a problem. • Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (Assessment is limited to a single environmental change and does not include the greenhouse effect or climate change.) Examples of environmental changes could include changes in

• Possible solutions to a problem are limited by available materials and resources (constraints). • The success of a designed solution is determined by considering the desired features of a solution (criteria). • Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each	✓ Land characteristics, ✓ Water distribution, ✓ Temperature, ✓ Food, or ✓ Other organisms. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and that includes several criteria for success and constraints on materials, time, or cost. • Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.

What It Looks Like in the Classroom

In this unit, students will study fossils or organisms that lived long ago. Students will use that understanding to make a claim about the merit of a solution to problem created by some environmental change. (Assessment is limited to one change.) Additionally, they will learn that solutions are limited by available resources (constraints), and that the success of a solution is determined by considering the desired features of a solution (criteria). This process is outlined in greater detail in the previous section.

Students gather evidence from fossils to learn about the types of organisms that lived long ago and the nature of their environments. As they learn about organisms from long ago, they come to understand that when the environment changes, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.

To begin the progression of learning in this unit, students need multiple opportunities to study fossils. If actual fossils are not available, pictures and diagrams found in books and other media sources can be used. Students should observe fossils of a variety of organisms, both plant and animal, and they should observe diagrams of fossils within layers of rock. As students examine each fossil, they should be asked to identify whether the organism lived on land or in water and to give evidence to support their thinking. As students examine diagrams of fossils in layers of rock, they should be asked to identify the type of environment that existed when the layers of rock were formed. Students should consider the types of organisms that are fossilized in the rock layers in order to provide evidence to support their thinking.

If the type of environment in which the fossil was found is different from the type of environment that might have existed when the organism lived (e.g., marine fossils found on dry land, or tropical plant fossils found in Arctic areas), this would provide the opportunity to ask students to think about the types of changes that might have occurred in the environment and what effects these changes might have had on the organisms that lived in the environment as it changed over time. As students observe and analyze fossils, they learn that fossils provide evidence about the types of organisms that lived long ago and the nature of their environments. They also learn that some kinds of plants and animals that once lived on Earth are no longer found anywhere, and that this could be a result of changes that occurred in the environment.

During this unit, students also learn that populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms will survive and reproduce,

some will move to new locations, others will move into the transformed environment, and others will die.

Students will need the opportunity to engage in a portion of the engineering design process in order to investigate the merit of solutions to problems caused when the environment changes. This process should include the following steps:

- ✓ Students brainstorm a list of environmental changes that might affect the organisms that live in the environment. This could include changes in
  - o Land characteristics,
  - o Water distribution,
  - o Temperature,
  - o Food,
  - o Other organisms.
- ✓ As a class or in small groups, students define a problem that occurs when the environment changes. For example, if the distribution of water changes, the available water may no longer support the types of organisms that are found in the environment.
- ✓ As a class, determine criteria that can be used to weigh a possible solution's viability. For example, the response (solution) to the problem should not result in the extinction of a species.
- ✓ Small groups conduct research, using books and other reliable media sources, to determine possible solutions/ways in which organisms can solve the problem. For example, if the available water supply is no longer adequate for the organisms in the environment, there are a number of ways in which organisms respond (i.e., solve the problem); these include:
  - o Plants do not grow as large as before (shorter plant, smaller or fewer leaves);
  - o Fewer seeds germinate, thereby resulting in a smaller population;
  - o Herd animals may move to another environment where the water supply is adequate;
  - o Populations of some species may decrease, either through lower rate of reproduction or death;
  - o Some populations completely die out; or
  - o Other organisms (plants and animals) that require less water to survive may move into the environment.
- ✓ Students make claims about the merit of each of the various responses (solutions) by organisms based on how well the responses meet criteria; students use research data as evidence to support their thinking.
- ✓ At every stage, communicating with peers is an important part of the design process. Students should identify cause-and-effect relationships throughout the process and use these relationships to explain the changes that might occur in the environment and in the populations of organisms that live there.

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts Students use content-specific print and digital sources such as books, articles, and other reliable media to observe and analyze fossils, and they use their observations to describe the types of organisms that lived in the past and characteristics of the environments in which they lived. When using these types of resources, students should determine the main idea and key details and use this information as evidence to support their thinking. They should take notes as they read and observe and use their notes as they write opinion and/or informational/explanatory pieces that convey information and ideas about organisms, both past and present, and their environments. As students discuss and write about the effects of a changing environment on organisms, they should ask and answer questions to demonstrate understanding and should cite evidence from their observations or from texts to support their thinking. Third graders should also have the opportunity to use their work to report on their findings about the effects of a changing environment on organisms living today, as well as those that lived in the past. Students should use appropriate facts and relevant descriptive details as they report out, speaking clearly at an understandable pace. *Mathematics* In order to connect the CCSS for mathematics, students generate measurement data using appropriate tools, such as rulers marked with halves and fourths of an inch, and show the data by making a line plot where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. For example, students could make a line plot to show the length of a variety of fossils, then use that data, as well as other observational data, to make comparisons to modern-day organisms and to support their thinking. Questions such as the ones below might be used to guide students' analysis of data. ✓ Do any of the fossilized organisms resemble organisms that we see today? In what ways? ✓ Can you make any inferences about a fossilized organism's way of life based on size, body style, external features, or other similarities to modern-day organisms? (Where might it have lived? What might it have eaten? How might it have moved? Could it have been part of a group?)

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena.

- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning

Some research suggests that students' understanding of evolution is related to their understanding of the nature of science and their general reasoning abilities. Findings indicate that poor reasoners tend to retain nonscientific beliefs such as "evolutionary change occurs as a result of need" because they fail to examine alternative hypotheses and their predicted consequences, and they fail to comprehend conflicting evidence. Thus, they are left with no alternative but to believe their initial intuitions or the misstatements they hear. Lower elementary-school students can understand simple food links involving two organisms. Yet they often think of organisms as independent of each other but dependent on people to supply them with food and shelter. Upper elementary-school students may not believe food is a scarce resource in ecosystems, thinking that organisms can change their food at will according to the availability of particular sources. Students of all ages think that some populations of organisms are numerous in order to fulfill a demand for food by another population (NSDL, 2015).

Prior Learning

Kindergarten Unit 4: Basic Needs of Living Things

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.
- Asking questions, making observations, and gathering information are helpful in thinking about problems. *(secondary)*

Grade 2 Unit 1: Relationships in Habitats

- Plants depend on water and light to grow.
- Plants depend on animals for pollination or to move their seeds around.

Future Learning

Grade 4 Unit 2: Earth Processes

- A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Grade 4 Unit 7: Using Engineering Design with Force and Motion Systems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for

success or how well each takes the constraints into account. *(secondary)*

Grade 6 Unit 2: Matter and Energy in Organisms and Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Grade 6 Unit 3: Interdependent Relationships in Ecosystems

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Grade 7 Unit 8: Earth Systems

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

Grade 8 Unit 1: Evidence of Common Ancestry and Diversity

- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
- Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

Grade 8 Unit 2: Selection and Adaptation

- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Grade 8 Unit 4: Human Impacts

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Connections to Other Units

Grade 3 Unit 1: Weather and Climate

- A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

Sample of Open Education Resources

Mass Environmental Change: In this lesson, students explore what happens to organisms when they cannot meet their needs due to changes in the environment. They categorize scenario cards representing different changes to an environment, then discuss in a whole group. Using what they have learned, they write about how changes to the environment can affect organisms. The resource link takes you to a full unit titled Effects of Changes in an Environment on the Survival of Organisms, of which Mass Environmental Change is a lesson.

Teacher Professional Learning Resources

***NGSS* Crosscutting Concepts: Energy and Matter—Flows, Cycles, and Conservation**

The presenters were Charles W. (Andy) Anderson and Joyce Parker from Michigan State University. Dr. Anderson and Dr. Parker began the web seminar by discussing the role of energy and matter as a crosscutting concept. They talked about energy and matter at different scales, from the atomic to the macroscopic. The presenters shared information about how students learn about this crosscutting concept and how to address preconceptions. They then described instructional strategies such as modeling that can help students better understand the flow of energy and matter.

***NGSS* Crosscutting Concepts: Scale, Proportion, and Quantity**

The presenters were Amy Taylor and Kelly Riedinger from the University of North Carolina Wilmington. Dr. Taylor began the presentation by discussing the definition of scale. Next, Dr. Riedinger talked about the role of scale, proportion, and quantity in NGSS. Participants shared their own experiences teaching about scale in the classroom before the presenters described additional instructional strategies that can provide students with a real-world understanding of this crosscutting concept. Dr. Taylor and Dr. Riedinger showed examples of activities from elementary, middle, and high school. They shared video clips and other resources that can help educators build their capacity for teaching about scale.

***NGSS* Core Ideas: Ecosystems: Interactions, Energy, and Dynamics**

The presenters were Andy Anderson and Jennifer Doherty of Michigan State University. This was the ninth web seminar in a series focused on the disciplinary core ideas that are part of the Next Generation Science Standards (NGSS). The program featured strategies for teaching about life science concepts that answer questions such as "How do organisms interact with the living and nonliving environments to obtain matter and energy?" and "How do matter and energy move through an ecosystem?"

Dr. Anderson and Dr. Doherty began the presentation by discussing the two main strands of the ecosystems disciplinary core idea: community ecology and ecosystem science. They talked about common student preconceptions and strategies for addressing them. Next, Dr. Anderson and Dr. Doherty shared learning progressions for this core idea, showing how student understanding builds from elementary through high school. Last, the presenters described approaches for teaching about ecosystems and shared resources to use with students.

Visit the resource collection.

Continue discussing this topic in the community forums.

***NGSS* Core Ideas: Biological Evolution: Unity and Diversity**

The presenter was Cindy Passmore. The program featured strategies for teaching about life science concepts that answer questions such as "How are the characteristics of one generation related to the previous generation?" and "Why do individuals of the same species vary in how they look, function, and behave?"

Following an overview of the web seminar's main topics to be covered, Cindy Passmore discussed what makes LS4 a "core" idea and how its subsections A, B, C and D should be approached as being related to one another, rather than sequenced elements to be taught one after the other. Cindy then spoke about the concept of using models to explain and make sense of the natural world through two detailed examples about the Peppered moth and the Galapagos finches. View the resource collection.

Continue discussing this topic in the community forums.

Appendix A: NGSS and Foundations for the Unit
Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. *[Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.]* [Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.*]* **(3-LS4-1)**
Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* *[Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.]* [Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]* **(3-LS4-4)**
Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)
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
Analyzing and Interpreting Data • Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS4-1) **Engaging in Argument from Evidence** • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-LS4-4) **Asking Questions and Defining Problems** • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)	**LS4.A: Evidence of Common Ancestry and Diversity** • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (3-LS4-1) • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (3-LS4-1) **LS4.D: Biodiversity and Humans** • Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some	**Scale, Proportion, and Quantity** • Observable phenomena exist from very short to very long time periods. (3-LS4-1) **Systems and System Models** • A system can be described in terms of its components and their interactions. (3-LS4-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Engineering, Technology, and Science on Society and the Natural World** • Knowledge of relevant scientific concepts and research findings is important in engineering. (3-LS4-4)

	die.*(secondary to 3-LS4-4)* **ETS1.A: Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	**Influence of Science, Engineering, and Technology on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems. (3-LS4-1)

English Language Arts	Mathematics
Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS4-4) **RI.3.1** Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-1),(3-LS4-4) **RI.3.2** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS4-1),(3-LS4-4) **RI.3.3** Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS4-1),(3-LS4-4) **W.3.1** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-LS4-1),(3-LS4-4) **W.3.2** Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-LS4-1) **W.3.8** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1) **W.5.7** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-1) **W.5.8** Draw evidence from literary or informational texts to support analysis, reflection, and research.	Reason abstractly and quantitatively. (3-LS4-1),(3-LS4-4), (3-5-ETS1-1) **MP.2** Model with mathematics. (3-LS4-1),(3-LS4-4), (3-5-ETS1-1) **MP.4** Use appropriate tools strategically. (3-LS4-1), (3-5-ETS1-1) **MP.5** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. (3-LS4-2),(3-LS4-3) **3.MD.B.3** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. (3-LS4-1) **3.MD.B.4** Operations and Algebraic Thinking (3-ETS1-1) **3-5.OA**

(3-5-ETS1-1) **W.5.9** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-4) **SL.3.4**	