INTRODUCTION TO PERFORMANCE EXPECTATIONS

"The NGSS are standards or goals, that reflect what a student should know and be able to do; they do not dictate the manner or methods by which the standards are taught. . . . Curriculum and assessment must be developed in a way that builds students' knowledge and ability toward the PEs [performance expectations]" (*Next Generation Science Standards*, 2013, page xiv).

This chapter shows how the NGSS Performance Expectations were bundled in the **Earth History Course** to provide a coherent set of instructional materials for teaching and learning.

This chapter also provides details about how this FOSS course fits into the matrix of the FOSS Program (page 51). Each FOSS module K–5 and middle school course 6–8 has a functional role in the FOSS conceptual frameworks that were developed based on a decade of research on science education and the influence of *A Framework for K–12 Science Education* (2012) and *Next Generation Science Standards* (NGSS, 2013).

The FOSS curriculum provides a coherent vision of science teaching and learning in the three ways described by the NRC *Framework*. First, FOSS is designed around learning as a developmental progression, providing experiences that allow students to continually build on their initial notions and develop more complex science and engineering knowledge. Students develop functional understanding over time by building on foundational elements (intermediate knowledge). That progression is detailed in the conceptual frameworks.

Second, FOSS limits the number of core ideas, choosing depth of knowledge over broad shallow coverage. Those core ideas are addressed at multiple grade levels in ever greater complexity. FOSS investigations at each grade level focus on elements of core ideas that are teachable and learnable at that grade level.

Third, FOSS investigations integrate engagement with scientific ideas (content) and the practices of science and engineering by providing firsthand experiences.

Teach the course with the confidence that the developers have carefully considered the latest research and have integrated into each investigation the three dimensions of the NRC *Framework* and NGSS, and have designed powerful connections to the Common Core State Standards for English Language Arts.

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DISCIPLINARY CORE IDEAS

A Framework for K–12 Science Education has three core ideas in earth and space sciences.

ESS1: Earth's place in the universe

ESS2: Earth's systems

ESS3: Earth and human activity

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC *Framework* for grades 6–8 to keep the core ideas in a rich and useful context.

The performance expectations related to each core idea are taken from the NGSS for middle school.

Disciplinary Core Ideas Addressed

The **Earth History Course** connects with the NRC *Framework* 6–8 grade band and the NGSS performance expectations for the middle school grades. The course focuses on core ideas for Earth sciences primarily and life sciences secondarily.

Earth and Space Sciences

Framework core idea ESS1: Earth's place in the universe—What is the universe, and what is Earth's place in it?

- **ESS1.C: The history of planet Earth**
  How do people reconstruct and date events in Earth's planetary history? [The geological time scale interpreted from rock strata provides a way to organize Earth's history. Major historical events include the formation of mountain chains and ocean basins, the evolution and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and development of watersheds and rivers through glaciation and water erosion. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.]

The following NGSS grades 6–8 performance expectation for ESS1 is derived from the Framework disciplinary core idea above.

- **MS-ESS1-4.** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]

Framework core idea ESS2: Earth's systems—How and why is Earth constantly changing?

- **ESS2.A: Earth materials and systems**
  How do the major Earth systems interact? [All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce

chemical and physical changes in Earth's materials and living organisms. The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.]

- **ESS2.B: Plate tectonics and large-scale system interactions**
  Why do the continents move, and what causes earthquakes and volcanoes? [Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geological history. Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust. 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.]
- **ESS2.C: The roles of water in Earth's surface processes**
  How do the properties and movements of water shape Earth's surface and affect its systems? [Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.]

The following NGSS grades 6–8 performance expectations for ESS2 are derived from the Framework disciplinary core ideas above.

- **MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.]
- **MS-ESS2-2.** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]

REFERENCES

National Research Council. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: National Academies Press, 2012.

NGSS Lead States. *Next Generation Science Standards: For States, by States.* Washington, DC: National Academies Press, 2013.

National Governors Association Center for Best Practices and Council of Chief State School Officers. *Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects, Washington, DC:* 2010.

- **MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. [Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.]

Framework core idea ESS3: Earth and human activity—How do Earth's surface processes and human activities affect each other?

- **ESS3.A: Natural resources**
  How do humans depend on Earth's resources? [Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes. Renewable energy resources, and the technologies to exploit them, are being rapidly developed.]

- **ESS3.B: Natural hazards**
  How do natural hazards affect individuals and societies? [Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.]

- **ESS3.C: Human impacts on Earth systems**
  How do humans change the planet? [Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many 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.]

- **ESS3.D: Global climate change**
  How do people model and predict the effect of human activities on Earth's climate? [Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing human vulnerability to whatever climate changes do occur depends on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, and on applying that knowledge wisely in decisions and activities.]

The following NGSS grades 6–8 performance expectations for ESS3 are derived from the Framework disciplinary core ideas above.

- **MS-ESS3-1.** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]
- **MS-ESS3-2.** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

- **MS-ESS3-3**. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]
- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]
- **MS-ESS3-5**. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

Life Sciences

Framework core idea LS4: Biological evolution: Unity and diversity—How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms? How does biodiversity affect humans?

- **LS4.A: Evidence of common ancestry and diversity** *What evidence shows that different species are related?* [Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers. 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. Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved. 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.]

The following NGSS grades 6–8 performance expectation for LS4 is derived from the Framework disciplinary core idea above.

- **MS-LS4-1.** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life-forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]

  NOTE: This standard is also a main focus of the **FOSS Heredity and Adaptation Course**.

DISCIPLINARY CORE IDEAS

A Framework for K–12 Science Education has four core ideas in life sciences.

LS1: From molecules to organisms: Structures and processes

LS2: Ecosystems: Interactions, energy, and dynamics

LS3: Heredity: Inheritance and variation of traits

LS4: Biological evolution: Unity and diversity

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC *Framework* for grades 6–8 to keep the core ideas in a rich and useful context.

The performance expectations related to each core idea are taken from the NGSS for middle school.

SCIENCE AND ENGINEERING PRACTICES

A Framework for K–12 Science Education (National Research Council, 2012) describes eight science and engineering practices as essential elements of a K–12 science and engineering curriculum.

The learning progression for this dimension of the framework is addressed in *Next Generation Science Standards* (National Academies Press, 2013), volume 2, appendix F. Elements of the learning progression for practices recommended for grades 6–8 as described in the performance expectations appear in bullets below each practice.

Science and Engineering Practices Addressed

1. *Asking questions*

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.
- Ask questions that require sufficient and appropriate empirical evidence to answer.
- Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.

2. *Developing and using models*

- Evaluate limitations of a model for a proposed object or tool.
- Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.
- Use and/or develop a model of simple systems with uncertain and less predictable factors.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

3. *Planning and carrying out investigations*

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meets the goals of the investigation.
- Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

4. *Analyzing and interpreting data*

- Use graphical displays of large data sets to identify temporal and spatial relationships.
- Distinguish between causal and correlational relationships in data.
- Analyze and interpret data to provide evidence for phenomena.
- Analyze and interpret data to determine similarities and differences in findings.

5. *Using mathematics and computational thinking*

- Use digital tools to analyze very large data sets for patterns and trends.
- Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

6. *Constructing explanations*

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict and/or describe phenomena.
- Construct an explanation using models or representations.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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.
- Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.

7. *Engaging in argument from evidence*

- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present 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.

8. *Obtaining, evaluating, and communicating information*

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
- Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.

Crosscutting Concepts Addressed

Patterns: *Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.*

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.
- Patterns can be used to identify cause-and-effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

Cause and effect: *Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.*

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

CROSSCUTTING CONCEPTS

A Framework for K–12 Science Education describes seven crosscutting concepts as essential elements of a K–12 science and engineering curriculum. The learning progression for this dimension of the framework is addressed in volume 2, appendix G, of the NGSS. Elements of the learning progression for crosscutting concepts recommended for grades 6–8, as described in the performance expectations, appear after bullets below each concept.

Scale, proportion, and quantity: *In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.*

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Phenomena that can be observed at one scale may not be observable at another scale.

Systems and system models: *A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.*

- Systems may interact with other systems; they may have subsystems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

Energy and matter: *Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.*

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

Structure and function: *The way an object is shaped or structured determines many of its properties and functions.*

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Stability and change: *For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.*

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Connections to the Nature of Science

- **Scientific investigations use a variety of methods.** Scientific investigations are guided by a set of values to ensure accuracy of measurements, observations, and objectivity of findings. Science depends on evaluating proposed explanations. Scientific values function as criteria in distinguishing between science and nonscience.
- **Scientific knowledge is based on empirical evidence.** Scientific knowledge is based upon logical and conceptual connections between evidence and explanations. Science disciplines share common rules of obtaining and evaluating empirical evidence.
- **Scientific knowledge is open to revision in light of new evidence.** The certainty and durability of scientific findings vary. Scientific findings are frequently revised and/or reinterpreted based on new evidence.
- **Science models, laws, mechanisms, and theories explain natural phenomena.** Theories are explanations for observable phenomena. Scientific theories are based on a body of evidence developed over time. Laws are regularities or mathematical descriptions of natural phenomena. A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory. The term "theory" as used in science is very different from the common use outside of science.
- **Science is a way of knowing.** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Scientific knowledge is cumulative, and many people from many generations and nations have contributed to scientific knowledge. Science is a way of knowing used by many people, not just scientists.

CONNECTIONS

See volume 2, appendix H and appendix J, in the NGSS for more on these connections.

- **Scientific knowledge assumes an order and consistency in natural systems.** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Science carefully considers and evaluates anomalies in data and evidence.
- **Science is a human endeavor.** Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers. Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination, and creativity. They are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. Advances in technology influence the progress of science, and science has influenced advances in technology.
- **Science addresses questions about the natural and material world.** Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence. Scientific knowledge can describe consequences of actions but is not responsible for society's decisions.

Connections to Engineering, Technology, and Applications of Science

- **Influence of engineering, technology, and science on society and the natural world.** All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Technology use varies over time and from region to region.

FOSS CONCEPTUAL FRAMEWORK

FOSS has conceptual structure at the course level. The concepts are carefully selected and organized in a sequence that makes sense to students when presented as intended. In the last half decade, research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching—ideas such as the structure of matter or the relationship between the distribution and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things we can and should understand about them in our primary school years, and progressively more complex and sophisticated things we should know about them as we gain experience and develop our cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing the learning progressions involves identifying successively more sophisticated ways of thinking about core ideas over multiple years. "If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination" (National Research Council, *A Framework for K–12 Science Education*, 2012, page 26).

The FOSS modules (grades K–5) and courses (grades 6–8) are organized into three domains: physical science, earth science, and life science. Each domain is subdivided into two strands, each representing a core scientific idea, as shown in the columns in the table: matter/energy and change, atmosphere and Earth/rocks and landforms, structure and function/complex systems. The sequence of modules and courses in each strand relates to the core ideas described in the national framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as they proceed up the columns.

In addition to the science content framework, every course provides opportunities for students to engage in and understand science practices, and many courses explore issues related to engineering practices and the use of natural resources.

The science content used to develop the FOSS courses describes what we want students to learn; the science and engineering practices describe how we want students to learn; and crosscutting concepts stitch the whole effort into a coherent fabric describing the whole natural world. Practices involve a number of habits of mind and philosophical orientations, and these, too, will develop in richness and complexity as students advance through their science studies. Science and engineering practices involve behaviors, so they can be best assessed while in progress. Thus, assessment of practices is based on teacher observation. The indicators of progress include students involved in the many aspects of active thinking, students motivated to learn, and students taking responsibility for their own learning.

FOSS Next Generation—K–8 Sequence

	PHYSICAL SCIENCE		EARTH SCIENCE		LIFE SCIENCE	
	MATTER	ENERGY AND CHANGE	ATMOSPHERE AND EARTH	ROCKS AND LANDFORMS	STRUCTURE/ FUNCTION	COMPLEX SYSTEMS
6–8	Waves; Gravity and Kinetic Energy Chemical Interactions Electromagnetic Force		Planetary Science Earth History Weather and Water		Heredity and Adaptation Populations and Ecosystems Diversity of Life; Human Systems Interactions	
5	Mixtures and Solutions		Earth and Sun		Living Systems	
4		Energy		Soils, Rocks, and Landforms	Environments	
3	Motion and Matter		Water and Climate		Structures of Life	
2	Solids and Liquids			Pebbles, Sand, and Silt	Insects and Plants	
1		Sound and Light	Air and Weather		Plants and Animals	
K	Materials and Motion		Trees and Weather		Animals Two by Two	

BACKGROUND FOR THE CONCEPTUAL FRAMEWORK *in Earth History*

History of Earth

Historical geologists, the "genealogists" of Earth, are interested in both the mundane and the catastrophic as they search for evidence to help them unravel Earth's history over the past 4.6 billion years. When they observe a stream, they don't see just water: they see the phenomena of ripple marks, meanders, erosion, and deposition that are evidence of the interaction of flowing water and rock. When they monitor volcanoes, like those in Hawaii, they see that lava soon cools to form basalt and other extrusive igneous rocks.

The evidence of these constancies and catastrophes provides geologists great insights into Earth's past. The processes of erosion, deposition, folding, and faulting that happen today have probably happened in much the same way throughout Earth's history, at least since the surface solidified and water filled the ocean basins. How do geologists know this? The evidence is in the rocks that cover much of Earth's surface.

Rocks have preserved much of the story of Earth's history. The challenge is learning to read the evidence. One of the easier places to begin learning to read rocks is the Colorado Plateau. And the Colorado River has exposed an almost continuous history spanning 1.7 billion years in the Grand Canyon.

The basic geology of the Grand Canyon is relatively easy to interpret and can be used to teach many important geological concepts and processes that are applicable to other regions as well. Through observations of rocks, erosion and deposition in a stream table, making models of sedimentary basins, and observing crystals grow, students develop a mental picture of these processes in action. They can begin to make the necessary inferences from evidence observed in rocks and landforms to reconstruct Earth history as it happened on the Colorado Plateau and in their neighborhood.

The study of Earth history is a good opportunity to challenge students to exercise their inferential thinking. Early adolescents are often fairly confident about what they do know. Confusion usually sets in when they are asked the question "How do you know it?" Knowing something involves two parts—being able to state what you know and being able to defend your knowledge with evidence.

By understanding the process of knowing, students can begin to view the investigations and activities in the **Earth History Course** in a new way. They shake granite pieces around in a jar not just to have fun and make a lot of noise, but to help answer the question, "Which came first—the sand or the sandstone?" and then use the answer to begin thinking about the evidence they observe in the rocks of the Grand Canyon. They blow carbon dioxide into limewater and observe the precipitate to build an understanding of the process of limestone formation.

Explaining how you know something is a lot harder than just knowing it. This metacognitive process—thinking about your thinking—is difficult. Students will stumble and resist in the beginning. But by the end of the course, students should be more confident in their ability to find and observe evidence and to use the evidence to come up with inferences. And if they stop to think about it, they will be impressed by how their thinking has changed. They will no longer look at a rock or a pile of sand in the same way.

CONCEPTUAL FRAMEWORK
Earth Science, Rocks and Landforms:
Earth History

Structure of Earth

Concept A The geosphere (lithosphere) has properties that can be observed and quantified.

- The geological time scale, interpreted from rock strata and fossils, provides a way to organize Earth's history. Lower layers are older than higher layers—superposition.
- Earth's crust is fractured into plates that move over, under, and past one another. Volcanoes and earthquakes occur along plate boundaries.
- The rock cycle is a way to describe the process by which new rock is created.

Concept B The hydrosphere has properties that can be observed and quantified.

Concept C Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources.

- Minerals, fresh water, and other natural resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- As human populations and use of resources increase, so do the negative impacts on Earth. The burning of fossil fuels are major factors causing global warming. Humans can use scientific knowledge and engineering design to reduce the impact of Earth's natural hazards.

Earth Interactions

Concept A All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems.

- Weathered rock materials can be reshaped into new landforms by the slow processes of erosion and deposition. Water plays a large role in these processes.
- Landforms are shaped by slow, persistent processes driven by weathering, erosion, deposition, and plate tectonics. Some catastrophic Earth events happen very quickly. Energy from the Sun and Earth's hot interior drives these processes.

Concept B Understanding how landforms develop, weather, and erode can help us infer Earth's history.

- Sediments deposited by water usually form flat, horizontal layers and turn into rock over time. The presence and location of certain fossil types indicate the order in which rock layers were formed.
- Evolution is shaped by geologic conditions. The fossil record provides evidence of ancient organisms and the nature of past environments.

Earth Science Content Sequence

This table shows the four FOSS modules and courses that address the content sequence "Earth's place in the universe" for grades K–8. Running through the sequence are the two main content progressions—structure and Earth interactions. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the **Earth History Course** are expanded to show how they fit into the sequence.

	ROCKS AND LANDFORMS	
Module or course	**Structure of Earth**	**Earth interactions**
Earth History (middle school)		
Earth and Sun (grade 5)	• Most of Earth's air resides in the troposphere, where weather happens. • Most of Earth's water is in the ocean; most of Earth's fresh water is in glaciers and underground. • Weather is described in terms of variables including temperature, humidity, precipitation, wind, and air pressure. • Scientists observe, measure, and record patterns of weather to make predictions. • The Sun is the major source of energy that heats Earth.	• The different energy-transferring properties of earth materials lead to uneven heating of Earth's surface and convection currents. • The water cycle is driven by the Sun and involves evaporation and condensation. • Energy transfers to Earth materials by radiation, conduction, and convection. • Climate—the range of an area's typical weather conditions—is changing globally; this change will affect all life.
Soils, Rocks, and Landforms (grade 4)	• Soils are composed of different kinds and amounts of earth materials and humus; they can be described by their properties. • Water exists in three states. • Earth materials are natural resources. Some resources are renewable, others are not. • Humans can use scientific knowledge and engineering design to reduce the impact of Earth's hazards. • Landforms and bodies of water can be represented in models and maps.	• Physical and chemical weathering breaks rock into smaller pieces (sediments). • Downhill movement of water as it flows to the ocean shapes land. • Erosion is the movement of sediments; deposition is the process by which sediments come to rest in another place. • Sediments usually form flat, horizontal layers. Sediments turn into solid rock over time. The presence and location of certain fossil types indicate the order in which rock layers were formed. • Some changes to Earth's surface happen quickly (landslides, earthquakes, and volcanoes); others more slowly.
Pebbles, Sand, and Silt (grade 2)	• Rocks are earth materials composed of minerals; rocks have properties. • Rock sizes include clay, silt, sand, gravel, pebbles, cobbles, and boulders. • The properties of different earth materials make them suitable for specific uses. • Water can be a solid, liquid, or gas. • Natural sources of water include streams, rivers, ponds, lakes, marshes, and the ocean. • Landforms and bodies of water can be represented in models and maps.	• Smaller rocks result from weathering. • Water carries soils and rocks from one place to another. • Soil is made partly from weathered rock and partly from organic material. • Soils vary from place to place. Soils differ in their ability to support plants.

Earth History

Structure of Earth	Earth interactions
• The geological time scale, interpreted from rock strata and fossils, provides a way to organize Earth's history. Lower layers are older than higher layers—superposition. • Earth's crust is fractured into plates that move over, under, and past one another. • Volcanoes and earthquakes occur along plate boundaries. • The rock cycle is a way to describe the process by which new rock is created. • Minerals, fresh water, and other natural resources are limited, and are distributed unevenly around the planet as a result of past geologic processes. • As human populations and use of resources increase, so do the negative impacts on Earth. Humans can use scientific knowledge and engineering design to reduce the impact of Earth's natural hazards.	• Landforms are shaped by slow, persistent processes driven by weathering, erosion, deposition, and plate tectonics. Some catastrophic Earth events happen very quickly. Energy from the Sun and Earth's hot interior drives these processes. • Water's movement changes Earth's surface. • Energy is derived from the Sun and Earth's hot interior. • All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. • Evolution is shaped by geological conditions.

NOTE

See the Assessment chapter in this *Investigations Guide* for more details on how the FOSS embedded and benchmark assessment opportunities align to the conceptual frameworks and the learning progressions. In addition, the Assessment chapter describes specific connections between the FOSS assessments and the NGSS performance expectations.

The NGSS Performance Expectations addressed in this course include

Earth and Space Sciences

MS–ESS1-4
MS–ESS2-1
MS–ESS2-2
MS–ESS2-3
MS–ESS3-1
MS–ESS3-2
MS–ESS3-3
MS–ESS3-4
MS–ESS3-5

Life Sciences

MS–LS4-1

See pages 38–43 in this chapter for more details on the Grades 6–8 NGSS Performance Expectations.

CONNECTIONS TO NGSS BY INVESTIGATION

	Science and Engineering Practices	Connections to Common Core State Standards—ELA
Inv. 1: Earth Is Rock	Asking questions Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 1. Cite specific textual evidence to support analysis of text. 2. Determine the central ideas or conclusions of a text; provide an accurate summary. 5. Analyze the structure an author uses to organize a text. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text on the same topic. 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 2. Write informative/explanatory texts. 4. Produce clear and coherent writing. 7. Conduct short research projects to answer a question. 8. Gather relevant information from multiple print and digital sources. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 6. Adapt speech to a variety of contexts and tasks. **Language** 4. Determine or clarify meaning of unknown words and phrases. 6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas		Crosscutting Concepts
ESS1.C: The history of planet Earth • 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. **(MS-ESS1-4; MS-ESS2-2)**	**ESS2.A: Earth materials and systems** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)** **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. **(MS-ESS2-2)**	Patterns Cause and effect Scale, proportion, and quantity

Science and Engineering Practices	Connections to Common Core State Standards—ELA
Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 1. Cite specific textual evidence to support analysis of text. 2. Determine the central ideas or conclusions of a text; provide an accurate summary. 5. Analyze the structure an author uses to organize a text. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text on the same topic. 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 4. Produce clear and coherent writing. 8. Gather relevant information from multiple print and digital sources. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 1. Engage effectively in a range of collaborative discussions building on others' ideas and expressing their own clearly 5. Include multimedia components and visual displays in presentations. 6. Adapt speech to a variety of contexts and tasks. **Language** 5. Demonstrate understanding of word relationships and nuances in word meanings. 6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas		Crosscutting Concepts
ESS2.A: Earth materials and systems • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)**	**ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. **(MS-ESS2-1; MS-ESS2-2)**	Patterns Cause and effect Scale, proportion, and quantity Systems and system models

Inv. 3: Deposition

Science and Engineering Practices	Connections to Common Core State Standards—ELA
Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 2. Determine the central ideas or conclusions of a text; provide an accurate summary. 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text on the same topic. 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 4. Produce clear and coherent writing. 5. Develop and strengthen writing as needed. 8. Gather relevant information from multiple print and digital sources. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 1. Engage effectively in a range of collaborative discussions building on others' ideas and expressing their own clearly. 4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence. 5. Include multimedia components and visual displays in presentations. 6. Adapt speech to a variety of contexts and tasks. **Language** 4. Determine or clarify the meaning of unknown words and phrases. 5. Demonstrate understanding of word relationships and nuances in word meanings. 6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas		Crosscutting Concepts
ESS1.C: The history of planet Earth • 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. **(MS-ESS1-4)** **ESS2.A: Earth materials and systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)** **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. **(MS-ESS2-2)**		Patterns Cause and effect Scale, proportion, and quantity Systems and system models Energy and matter

Inv. 4: Fossils and Past Environments

Science and Engineering Practices	Connections to Common Core State Standards—ELA
Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 1. Cite specific textual evidence to support analysis of text. 2. Determine the central ideas or conclusions of a text; provide an accurate summary. 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text on the same topic. 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 4. Produce clear and coherent writing. 5. Develop and strengthen writing as needed. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 1. Engage effectively in a range of collaborative discussions building on others' ideas and expressing their own clearly. 2. Interpret and analyze information presented in diverse media. 4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence. 5. Include multimedia components and visual displays in presentations. **Language** 5. Demonstrate understanding of word relationships and nuances in word meanings. 6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas		Crosscutting Concepts
ESS1.C: The history of planet Earth • 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. **(MS-ESS1-4)** **LS4.A: 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. **(MS-LS4-1)**		Patterns Cause and effect Scale, proportion, and quantity Structure and function Stability and change

	Science and Engineering Practices	Connections to Common Core State Standards—ELA
Inv. 5: Igneous Rocks	Asking questions Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 2. Determine the central ideas or conclusions of a text. 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, or multimedia sources with that from reading a text on the same topic. 10. Read science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 5. Develop and strengthen writing as needed. 8. Gather relevant information from multiple print and digital sources. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 3. Delineate and evaluate a speaker's argument. 5. Include visual displays in presentations. **Language** 5. Demonstrate understanding of word relationships and nuances in word meanings. 6. Acquire and use academic and domain-specific words and phrases.
Inv. 6: Volcanoes and Earthquakes	Asking questions Developing and using models Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 1. Cite specific textual evidence to support analysis. 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases. 6. Analyze the author's purpose in providing an explanation or discussing an experiment in a text. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. 10. Read and comprehend science texts independently. **Writing—Literacy in Science and Technical Subjects** 8. Gather relevant information from multiple print and digital sources, using search terms effectively. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Language** 5. Demonstrate understanding of word relationships and nuances in word meanings.

Disciplinary Core Ideas		Crosscutting Concepts
ESS2.A: Earth materials and systems • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)**		Patterns Cause and effect Scale, proportion, and quantity Energy and matter
ESS1.C: The history of planet Earth • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. **(MS-ESS2-3)** **ESS2.A: Earth materials and systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** **ESS2.B: Plate tectonics and large-scale system interactions** • 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. **(MS-ESS2-3)**	**ESS3.A: Natural resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. **(MS-ESS3-1)** **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. **(MS-ESS3-2)**	Patterns Cause and effect Scale, proportion, and quantity Systems and system models Energy and matter Stability and change

Science and Engineering Practices	Connections to Common Core State Standards—ELA
Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 1. Cite specific textual evidence to support analysis of text. 2. Determine the central ideas or conclusions of a text; provide an accurate summary. 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually. 9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text on the same topic. 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 2. Write informative/explanatory texts. 5. Develop and strengthen writing as needed. 7. Conduct short research projects to answer a question. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Speaking and Listening** 1. Engage effectively in a range of collaborative discussions building on others' ideas and expressing their own clearly. 6. Adapt speech to a variety of contexts and tasks. **Language** 6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas		Crosscutting Concepts
ESS1.C: The history of planet Earth • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. **(MS-ESS2-3)**	**ESS2.A: Earth materials and systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)** **ESS2.B: Plate tectonics and large-scale system interactions** • 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. **(MS-ESS2-3)**	Patterns Cause and effect Systems and system models Energy and matter Stability and change

	Science and Engineering Practices	Connections to Common Core State Standards—ELA
Inv. 8: Geoscenarios	Asking questions and defining problems Using mathematics and computational thinking Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 2. Write informative/explanatory texts. 7. Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. 8. Gather relevant information from multiple print and digital sources. **Speaking and Listening** 4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence. 6. Adapt speech to a variety of contexts and tasks.
Inv. 9: What Is Earth's Story?	Developing and using models Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information	**Reading—Literacy in Science and Technical Subjects** 10. Read and comprehend science texts independently and proficiently. **Writing—Literacy in Science and Technical Subjects** 5. Develop and strengthen writing as needed. 8. Gather relevant information from multiple print and digital sources.

Disciplinary Core Ideas		Crosscutting Concepts
ESS3.A: Natural resources • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. **(MS-ESS3-1)** **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. **(MS-ESS3-2)** **ESS3.C: Human impacts on earth systems** • 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. **(MS-ESS3-3; MS-ESS3-4)**	**ESS3.D: Global climate change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. **(MS-ESS3-5)**	Cause and effect Stability and change
ESS1.C: The history of planet Earth • 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. **(MS-ESS1-4)** **ESS2.A: Earth materials and systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **(MS-ESS2-1)** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **(MS-ESS2-2)**	**ESS2.B: Plate tectonics and large-scale system interactions** • 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. **(MS-ESS2-3)** **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. **(MS-ESS2-2)**	Patterns Cause and effect Scale, proportion, and quantity Systems and system models

RECOMMENDED FOSS NEXT GENERATION K–8 SCOPE AND SEQUENCE

Grade	Integrated Middle Grades				
6–8	Heredity and Adaptation*	Electromagnetic Force*	Gravity and Kinetic Energy*	Waves*	Planetary Science
	Chemical Interactions		Earth History		Populations and Ecosystems
	Weather and Water		Diversity of Life		Human Systems Interactions*

*Half-length courses | Physical Science content | Earth Science content | Life Science content | Engineering content

Grade	Physical Science	Earth Science	Life Science
5	Mixtures and Solutions	Earth and Sun	Living Systems
4	Energy	Soils, Rocks, and Landforms	Environments
3	Motion and Matter	Water and Climate	Structures of Life
2	Solids and Liquids	Pebbles, Sand, and Silt	Insects and Plants
1	Sound and Light	Air and Weather	Plants and Animals
K	Materials and Motion	Trees and Weather	Animals Two by Two