Contents

INTRODUCTION

Human beings have used Earth's resources since prehistoric times. We made tools from stones. We mined raw materials to refine and manufacture into tools, utensils, shelters, ovens, and other useful items. We figured out how to extract precious metals from ores. We captured the energy of flowing streams behind dams and found numerous ways to put this power to use. We diverted water into channels for irrigation. And because it is human nature to try to explain everyday phenomena, we made up stories to explain how Earth was created.

Middle school students are ready to exercise their inferential thinking, and the study of earth history is made to order for this effort. They can begin to grapple with Earth's processes and systems that have operated over geologic time. Students should make observations and do investigations that involve constructing and using conceptual models. They should generate questions for investigation, which may lead to new questions. Through their study of earth history, students should become more confident in their ability to ask good questions and to recognize and use evidence from the rocks to come up with explanations of past environments. This course uses the anchor phenomenon of the Grand Canyon to engage students with history of Earth and introduce them to the geologic history of a place. The driving question for the course is what do we need to know to tell the geologic story of a place?

The NGSS Performance Expectations bundled 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

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	Investigation Summary	Time	Guiding and Focus Questions for Phenomena
Inv. 1	**Earth Is Rock** *Earth Is Rock* uses the anchor phenomenon of the Grand Canyon to introduce students to the study of the landforms and rocks that make up Earth's crust. Through observations of aerial images of Earth's surface, sedimentary rock samples, and images from the Grand Canyon, students begin developing awareness about the complexity of Earth's crust and how geologists study it by trying to answer the question "What is the story of this place?"	**Activities 7 sessions *** **Assessment 1 session**	***What information can we learn by studying the rocks in the Grand Canyon?*** **Part 1** **What's the Story of This Place?**, 2 sessions **Which landforms occur at different locations on Earth?** **Part 2** **Grand Canyon Rocks**, 3 sessions **Why do there appear to be stripes on the walls of the Grand Canyon?** **Part 3** **Correlating Grand Canyon Rocks**, 2 sessions **Why do there appear to be stripes on the walls of the Grand Canyon?**
Inv. 2	**Weathering and Erosion** In *Weathering and Erosion* students explore the phenomena of earth material movement over the surface of Earth. Students observe a stream table to discover how water can erode sediments from one location and deposit the sorted sediments in a basin downstream. They model how rocks weather and what happens to sediments. Students also consider how soil forms.	**Activities 7 sessions** **Assessment 1–2 sessions**	***How are sediments formed, moved, and deposited?*** **Part 1** **Stream Table,** 2 sessions **What happens to earth materials when water flows over landforms?** **Part 2** **Weathering**, 3 sessions **How did weathering and erosion contribute to the formation of the Grand Canyon?** **Part 3** **Soils**, 2 sessions **How is soil related to rocks?**
Inv. 3	**Deposition** In *Deposition*, students investigate the phenomenon of the variety of sedimentary rocks on Earth. They look closely at the processes by which bedrock that is weathered and eroded ends up deposited in basins. There, favorable conditions can turn the sediments into sedimentary rock. Students consider how evidence in sedimentary rocks can lead to inferences about the ancient environments in which they formed.	**Activities 6 sessions**	***How do sedimentary rocks form?*** **Part 1** **Sandstone and Shale**, 2 sessions **What happens to sediments that get deposited in basins?** **Part 2** **Limestone**, 2 sessions **How does limestone form?** **Part 3** **Interpreting Sedimentary Layers**, 2 sessions **What do sedimentary rock layers reveal about ancient environments?**

* A class session is 45–50 minutes.

Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
• Earth's surface has a variety of different landforms and water features. • Every place on Earth's surface has a unique geologic story. • Rocks hold the clues to the story of a place. • Limestone, sandstone, and shale are rocks found in the Grand Canyon that can be identified by their characteristics.	**Science Resources Book** "Seeing Earth" "Powell's Grand Canyon Expedition, 1869" (optional) **Online Activities** "Landforms Tour" "Scale Model" "Grand Canyon Correlation " **Video and Slide Show** *Grand Canyon Flyover* *Powell's River Trip* slide show (optional)	**Benchmark Assessment** *Entry-Level Survey* **NGSS Performance Expectations** MS-ESS1-4 MS-ESS2-1 MS-ESS2-2
• Most landforms are shaped by slow, persistent processes that proceed over the course of millions of years: weathering, erosion, and deposition. • Rock can be weathered into sediments by a number of processes, including frost wedging, abrasion, chemical dissolution, and root wedging. • Particles of earth material can be categorized and sorted by size. • Most sediments move downhill until they are deposited in a basin. Sediments that do not form rock can become widely distributed over Earth's surface as soil. • Most sediments move downhill until they are deposited in a basin. Sediments that do not form rock can become widely distributed over Earth's surface as soil.	**Science Resources Book** "Grand Canyon Flood!" "Weathering and Erosion" "Soil Stories" (optional) **Videos** *Stream Table: High Flow vs. Low Flow* *Stream Table: High Slope vs. Low Slope* (optional) *Stream Table: Heterogeneous vs. Homogeneous Material* *Glen Canyon Dam High Flow Experiment, USGS* *Debris Flow* *Frost Wedging* *Rock Fall* *Freezing Glass Bottle* (optional)	**Benchmark Assessment** *Investigations 1–2 I-Check* **NGSS Performance Expectations** MS-ESS2-1 MS-ESS2-2
• Sediments deposited by water usually form flat, horizontal layers. • Sediments turn into solid rock through the process of lithification, which involves compaction, cementation, and dissolution. • The relative ages of sedimentary rock can be determined by the sequence of layers. Lower layers are older than higher layers. • The processes we observe today probably acted in the same way millions of years ago, producing sedimentary rocks.	**Science Resources Book** "Where in the World Is Calcium Carbonate?" "Water on Mars?" **Online Activities** "Sandstone Formation" "Shale Formation" "Zion National Park Expedition" (optional) "Limestone Formation" "Rock Column Movie Maker" "Rock Database" (optional) "Sedimentary Rocks Tour" (optional)	**NGSS Performance Expectations** MS-ESS1-4 MS-ESS2-1 MS-ESS2-2

	Investigation Summary	Time	Guiding and Focus Questions for Phenomena
Inv. 4	**Fossils and Past Environments** In *Fossils and Past Environments*, students experience the phenomenon of fossils. Students become familiar with the geologic time scale to understand how old fossils are and begin to comprehend the enormous spans of time that are described by geologic time. They use fossils to put the history of the Grand Canyon into the geologic time scale.	**Activities 8 sessions *** **Assessment 1–2 sessions**	***What can fossils tell us about Earth's past?*** **Part 1** **Fossils**, 3 sessions **How do fossils get in rocks?** **Part 2** **A Long Time Ago**, 2 sessions **How old are fossils?** **Part 3** **Index Fossils**, 3 sessions **When did the Grand Canyon rocks form?**
Inv. 5	**Igneous Rocks** *Igneous Rocks* presents students with new rock samples from a new location. It leads to an investigation of the relationship between crystal size and the formation of igneous rocks. The formation of igneous rocks is the phenomenon investigated by students.	**Activities 6 sessions**	***How do igneous rocks help us understand Earth's interior?*** **Part 1** **Earth's Layers**, 1 session **How do igneous rocks form?** **Part 2** **Salol Crystals**, 3 sessions **Student-generated question, e.g., What affects crystal formation in igneous rocks?** **Part 3** **Types of Igneous Rocks**, 2 sessions **What can crystal size tell us about where an igneous rock formed?**

* A class session is 45–50 minutes.

Course Matrix

Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
• A fossil is any remains, trace, or imprint of a plant or animal that was preserved in Earth's crust during ancient times. • The fossil record represents what we know about ancient life and is constantly refined as new fossil evidence is discovered. • Geologic time extends from Earth's origin to the present. • Earth's history is measured in millions and billions of years. • Index fossils allow rock layers to be correlated by age over vast distances.	**Science Resources Book** "A Fossil Primer" "Rocks, Fossils, and Time" "Floating on a Prehistoric Sea" (optional) **Online Activities** "Rock Column Movie Maker" "Sandstone Formation" "Shale Formation" "Limestone Formation" "Timeliner" "Index-Fossil Correlation" "Dating Rock Layers"	**Benchmark Assessment** *Investigations 3–4 I-Check* **NGSS Performance Expectations** MS-ESS1-4 MS-LS4-1
• Earth is composed of layers of earth materials, from its hard crust of rock all the way down to its hot core. • Heat inside Earth melts rocks; melted rock can cool and form igneous rocks. • Molten rock cools quickly on the surface of Earth and can be identified by small mineral crystals. Molten rock that cools more slowly inside Earth forms larger mineral crystals.	**Science Resources Book** "Minerals, Crystals, and Rocks" **Online Activities** "Pacific Northwest Tour" "Extrusive Rock Formation" "Intrusive Rock Formation" "Yosemite National Park Tour" (optional) "Hawaii Tour" (optional) "Rock Database" (optional) **Video** *Salol Crystal Formation* **Slide Show** *Earth's Interior*	**NGSS Performance Expectations** MS-ESS2-1 MS-ESS2-2

	Investigation Summary	Time	Guiding and Focus Questions for Phenomena
Inv. 6	**Volcanoes and Earthquakes** *Volcanoes and Earthquakes* provides engaging phenomena to investigate and gives students the opportunity to discover a pattern of geologic activity. Subduction, convection, and the theory of crustal plate tectonics are introduced to explain continental drift, plate-boundary interactions, and the patterns of volcanoes and earthquakes.	**Activities 5 sessions *** **Assessment 1–2 sessions**	***How and why are Earth's continents constantly changing?*** **Part 1** **Mapping Volcanoes and Earthquakes**, 2 sessions **Where do volcanoes occur on Earth?** **Where do earthquakes occur on Earth?** **Part 2** **Moving Continents**, 1 session **Why do volcanoes and earthquakes occur where they do?** **Part 3** **Plate Tectonics**, 2 sessions **What causes plates to move?**
Inv. 7	**Mountains and Metamorphic Rocks** *Mountains and Metamorphic Rocks* builds on the phenomena of earthquakes and volcanoes by focusing on new landforms—mountains. Students investigate the interactions at plate boundaries that form mountains and metamorphic rocks, leading students to consider the rock cycle.	**Activities 7 sessions** **Assessment 1–2 sessions**	***How do the interactions between tectonic plates result in different landforms and rocks?*** **Part 1** **Plate Models**, 3 sessions **What happens to Earth's crust during plate interactions?** **Part 2** **Metamorphic Rocks**, 4 sessions **How do metamorphic rocks form?**

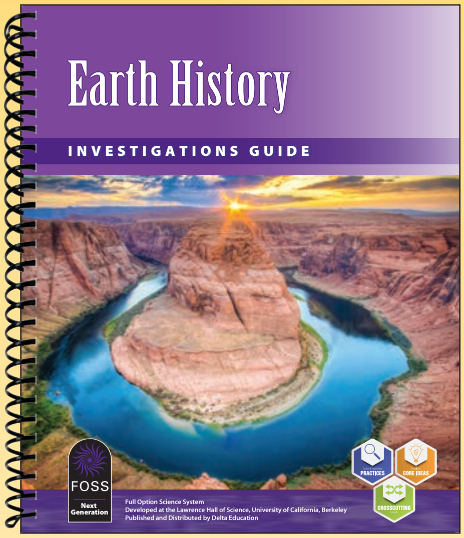
* A class session is 45–50 minutes.

Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
• Volcanoes and earthquakes occur along plate boundaries. • Earth's crust and solid upper mantle make up Earth's plates. Plates can be the size of continents or larger or smaller. • Earth's plates "float" on top of the layer of viscous, semisolid earth material below the asthenosphere. • The asthenosphere is a heated, semisolid, semifluid material that flows due to convection currents. • Plate movements result in plate-boundary interactions that produce volcanoes, earthquakes, and continental drift.	**Science Resources Book** "The History of the Theory of Plate Tectonics" "Historical Debates about a Dynamic Earth" (optional) **Online Activities** "Latitude and Longitude" "Volcano-Plotting Activity" "Volcanoes around the World" "Volcanoes" "Earthquake-Plotting Activity" (optional) "Earthquakes around the World" "Plate-Boundaries Map" (optional) **Videos** *Mount St. Helens: The Eruption Impact* *ShakeAlert* *Wegener* *Convection* *Plate Tectonics*	**Benchmark Assessment** *Investigations 5–6 I-Check* **NGSS Performance Expectations** MS-ESS2-2 MS-ESS2-3 MS-ESS3-1 MS-ESS3-2
• Interactions between tectonic plates at their boundaries deform the plates, producing landforms on Earth's surface. • Mountains form as a result of plate interactions. • When plates interact, high heat and immense pressure can change rock into new forms of rock (metamorphic rock). • The rock cycle describes how rock is constantly being recycled and how each type of rock can be transformed into other rock types.	**Science Resources Book** "Earth's Dynamic Systems" "Rock Transformations" "How One Rock Becomes Another Rock" (optional) **Online Activities** "Convergent Boundary" "Divergent Boundary" "Transform Boundary" "Folding" "Volcanoes around the World" "Appalachian Mountain Tour" "Rock Database" "How Metamorphic Rocks Form" "Slate" **Slide Show** *Mountain Types*	**Benchmark Assessment** *Investigation 7 I-Check* **NGSS Performance Expectations** MS-ESS2-1 MS-ESS2-2 MS-ESS2-3

	Investigation Summary	Time	Guiding and Focus Questions for Phenomena
Inv. 8	**Geoscenarios** In *Geoscenarios*, students apply prior knowledge from the Earth History Course and new, site-specific information to develop a geologic story of a place or process. Students are introduced to four sites across the United States—four phenomena. Each team of students researches the story of one of those places, the processes that shaped it, and the implications of the story for human society.	**Activities** **5 sessions** *	***How do Earth's surface processes and human activities affect each other?*** **Part 1** **Introduction to the Project**, 1 session **What do we need to know to tell the geologic story of a place?** **Part 2** **Research and Writing**, 2 sessions **What do we need to know to tell the geologic story of a place?** **Part 3** **Presentations**, 2 sessions **What do we need to know to tell the geologic story of a place?**
Inv. 9	**What Is Earth's Story?** *What Is Earth's Story?* challenges students to put together what they have learned about Earth's geologic history and to use their knowledge to finish telling the story of the phenomenal Grand Canyon.	**Activities** **3 sessions** **Assessment** **1-2 sessions**	***How does evidence found in rock reveal the geologic story of a place?*** **Part 1** **Revisit the Grand Canyon**, 2 sessions **What is the geologic story of the Grand Canyon?** **Part 2** **Review the Evidence**, 1 session **How do earth materials recycle through constructive and destructive processes?**

* A class session is 45–50 minutes.

Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
• Geologic processes help tell the story of a physical place. • Evidence and observations of a site's geology provide clues to tell the geologic story. • Knowledge of uplift, plate tectonics, volcanism, weathering, erosion, and fossil evidence plus the principles of uniformitarianism, superposition, and original horizontality can help tell the story of a place.	**Science Resources Book** "Geoscenario Introduction: Glaciers" "Geoscenario Introduction: Coal" "Geoscenario Introduction: Yellowstone Hotspot" "Geoscenario Introduction: Oil" **Online Activities** "Geoscenarios" "Timeliner" "Rock Column Movie Maker" (optional)	**NGSS Performance Expectations** MS-ESS3-1 MS-ESS3-2 MS-ESS3-3 MS-ESS3-4 MS-ESS3-5
• Evidence that provides clues about Earth's geologic history comes from observing rocks, landforms, and other earth materials. • Scientists specialize in many different disciplines to collect and analyze evidence to help put together Earth's geologic history. • Scientists use a number of different tools and techniques to analyze and synthesize evidence obtained from Earth to tell its story.	**Science Resources Book** "Research Careers in the Lab and Field" **Online Activities** "Grand Canyon Revisited" "Rock Column Movie Maker" (optional) "Timeliner" (optional) **Video** *Colorado Plateau over Time*	**Benchmark Assessment** *Posttest* **NGSS Performance Expectation** MS-ESS1-4 MS-ESS2-1 MS-ESS2-2 MS-ESS2-3



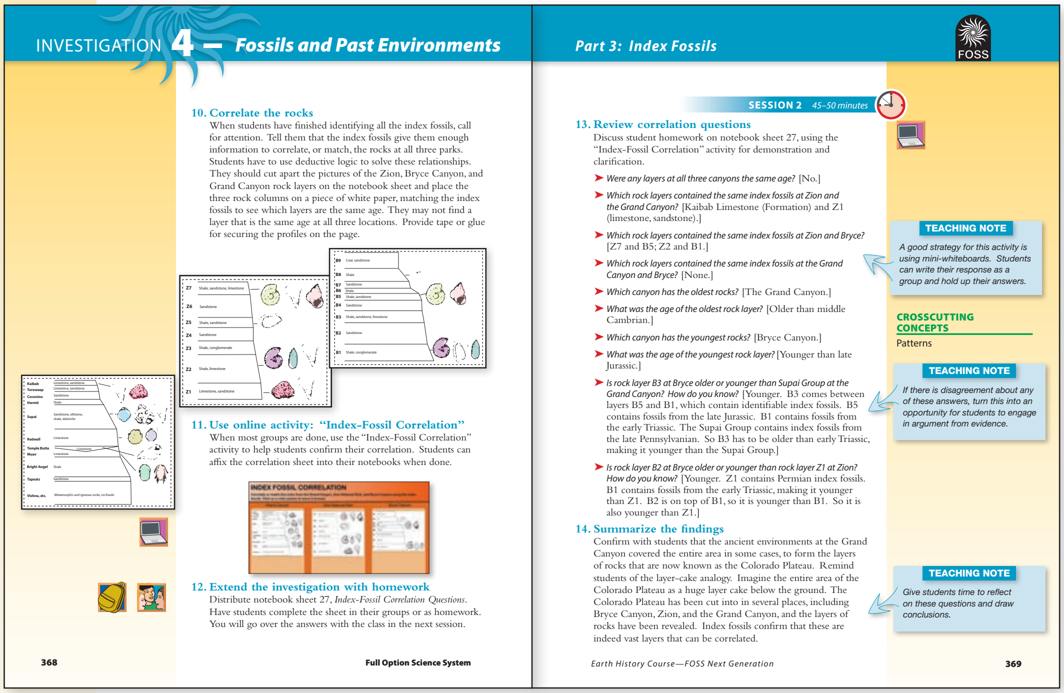
FOSS MIDDLE SCHOOL COMPONENTS

Teacher Toolkit

Each course comes with a *Teacher Toolkit*. The *Teacher Toolkit* is the most important part of the FOSS Program. It is here that all the wisdom and experience contributed by hundreds of educators has been assembled. Everything we know about the content of the course, how to teach the subject, and the resources that will assist the effort are presented here. Each middle school toolkit has three parts.

Investigations Guide. This spiral-bound document contains these chapters.

- Overview
- Framework and NGSS
- Materials
- Technology
- Investigations (nine in this course)
- Assessment


INVESTIGATION 4 — Fossils and Past Environments

10. Correlate the rocks
When students have finished identifying all the index fossils, call for attention. Tell them that the index fossils give them enough information to correlate, or match, the rocks at all three parks. Students have to use deductive logic to solve these relationships. They should cut apart the pictures of the Zion, Bryce Canyon, and Grand Canyon rock layers on the notebook sheet and place the three rock columns on a piece of white paper, matching the index fossils to see which layers are the same age. They may not find a layer that is the same age at all three locations. Provide tape or glue for securing the profiles on the page.

11. Use online activity: "Index-Fossil Correlation"
When most groups are done, use the "Index-Fossil Correlation" activity to help students confirm their correlation. Students can affix the correlation sheet into their notebooks when done.

12. Extend the investigation with homework
Distribute notebook sheet 27, *Index-Fossil Correlation Questions*. Have students complete the sheet in their groups or as homework. You will go over the answers with the class in the next session.

368 Full Option Science System

Part 3: Index Fossils

SESSION 2 45–50 minutes

13. Review correlation questions
Discuss student homework on notebook sheet 27, using the "Index-Fossil Correlation" activity for demonstration and clarification.

- *Were any layers at all three canyons the same age?* [No.]
- *Which rock layers contained the same index fossils at Zion and the Grand Canyon?* [Kaibab Limestone (Formation) and Z1 (limestone, sandstone).]
- *Which rock layers contained the same index fossils at Zion and Bryce?* [Z7 and B5; Z2 and B1.]
- *Which rock layers contained the same index fossils at the Grand Canyon and Bryce?* [None.]
- *Which canyon has the oldest rocks?* [The Grand Canyon.]
- *What was the age of the oldest rock layer?* [Older than middle Cambrian.]
- *Which canyon has the youngest rocks?* [Bryce Canyon.]
- *What was the age of the youngest rock layer?* [Younger than late Jurassic.]
- *Is rock layer B3 at Bryce older or younger than Supai Group at the Grand Canyon? How do you know?* [Younger. B3 comes between layers B5 and B1, which contain identifiable index fossils. B5 contains fossils from the late Jurassic. B1 contains fossils from the early Triassic. The Supai Group contains index fossils from the late Pennsylvanian. So B3 has to be older than early Triassic, making it younger than the Supai Group.]
- *Is rock layer B2 at Bryce older or younger than rock layer Z1 at Zion? How do you know?* [Younger. Z1 contains Permian index fossils. B1 contains fossils from the early Triassic, making it younger than Z1. B2 is on top of B1, so it is younger than B1. So it is also younger than Z1.]

14. Summarize the findings
Confirm with students that the ancient environments at the Grand Canyon covered the entire area in some cases, to form the layers of rocks that are now known as the Colorado Plateau. Remind students of the layer-cake analogy. Imagine the entire area of the Colorado Plateau as a huge layer cake below the ground. The Colorado Plateau has been cut into in several places, including Bryce Canyon, Zion, and the Grand Canyon, and the layers of rocks have been revealed. Index fossils confirm that these are indeed vast layers that can be correlated.

TEACHING NOTE
A good strategy for this activity is using mini-whiteboards. Students can write their response as a group and hold up their answers.

CROSSCUTTING CONCEPTS
Patterns

TEACHING NOTE
If there is disagreement about any of these answers, turn this into an opportunity for students to engage in argument from evidence.

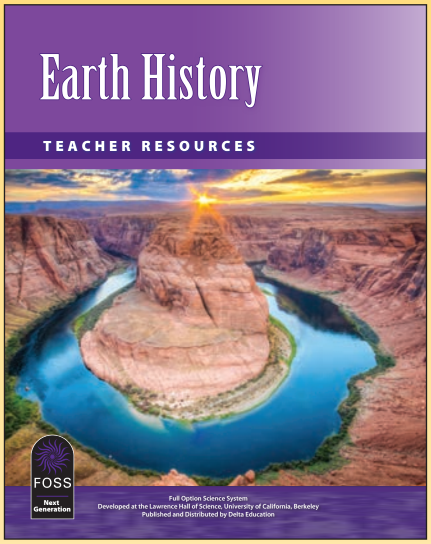
TEACHING NOTE
Give students time to reflect on these questions and draw conclusions.

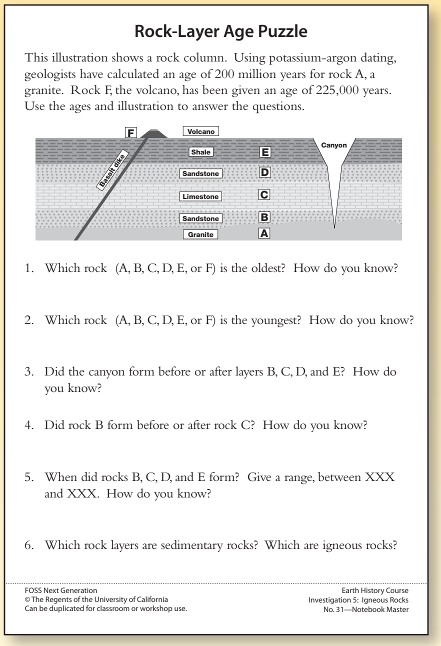
Earth History Course—FOSS Next Generation 369

***FOSS Science Resources* book.** One copy of the student book of readings is included in the *Teacher Toolkit*.

Teacher Resources. These chapters can be downloaded from FOSSweb and most are also in the bound *Teacher Resources* book.

- FOSS Program Goals
- Grade-Level Planning Guide
- Science and Engineering Practices
- Crosscutting Concepts and Integration
- Sense-Making Discussions for Three-Dimensional Learning
- Access and Equity
- Science Notebooks in Middle School
- Science-Centered Language Development in Middle School
- FOSS and Common Core ELA
- FOSS and Common Core Math
- Taking FOSS Outdoors
- Science Notebook Masters
- Teacher Masters
- Assessment Masters
- Notebook Answers





Rock-Layer Age Puzzle

This illustration shows a rock column. Using potassium-argon dating, geologists have calculated an age of 200 million years for rock A, a granite. Rock F, the volcano, has been given an age of 225,000 years. Use the ages and illustration to answer the questions.

1. Which rock (A, B, C, D, E, or F) is the oldest? How do you know?
2. Which rock (A, B, C, D, E, or F) is the youngest? How do you know?
3. Did the canyon form before or after layers B, C, D, and E? How do you know?
4. Did rock B form before or after rock C? How do you know?
5. When did rocks B, C, D, and E form? Give a range, between XXX and XXX. How do you know?
6. Which rock layers are sedimentary rocks? Which are igneous rocks?

FOSS Next Generation
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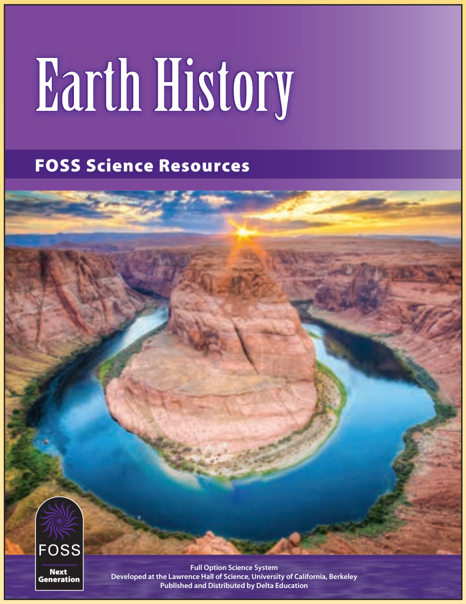
Can be duplicated for classroom or workshop use.

Earth History Course
Investigation 5: Igneous Rocks
No. 31—Notebook Master

Equipment for Each Course

The FOSS Program provides the materials needed for the investigations in sturdy, front-opening drawer-and-sleeve cabinets. Inside, you will find high-quality materials packaged for a class of 32 students. Consumable materials are supplied for five sequential uses (five periods in one day) before you need to restock. You will need to supply some items usually available in middle school science classrooms, and they are listed separately in the materials lists.

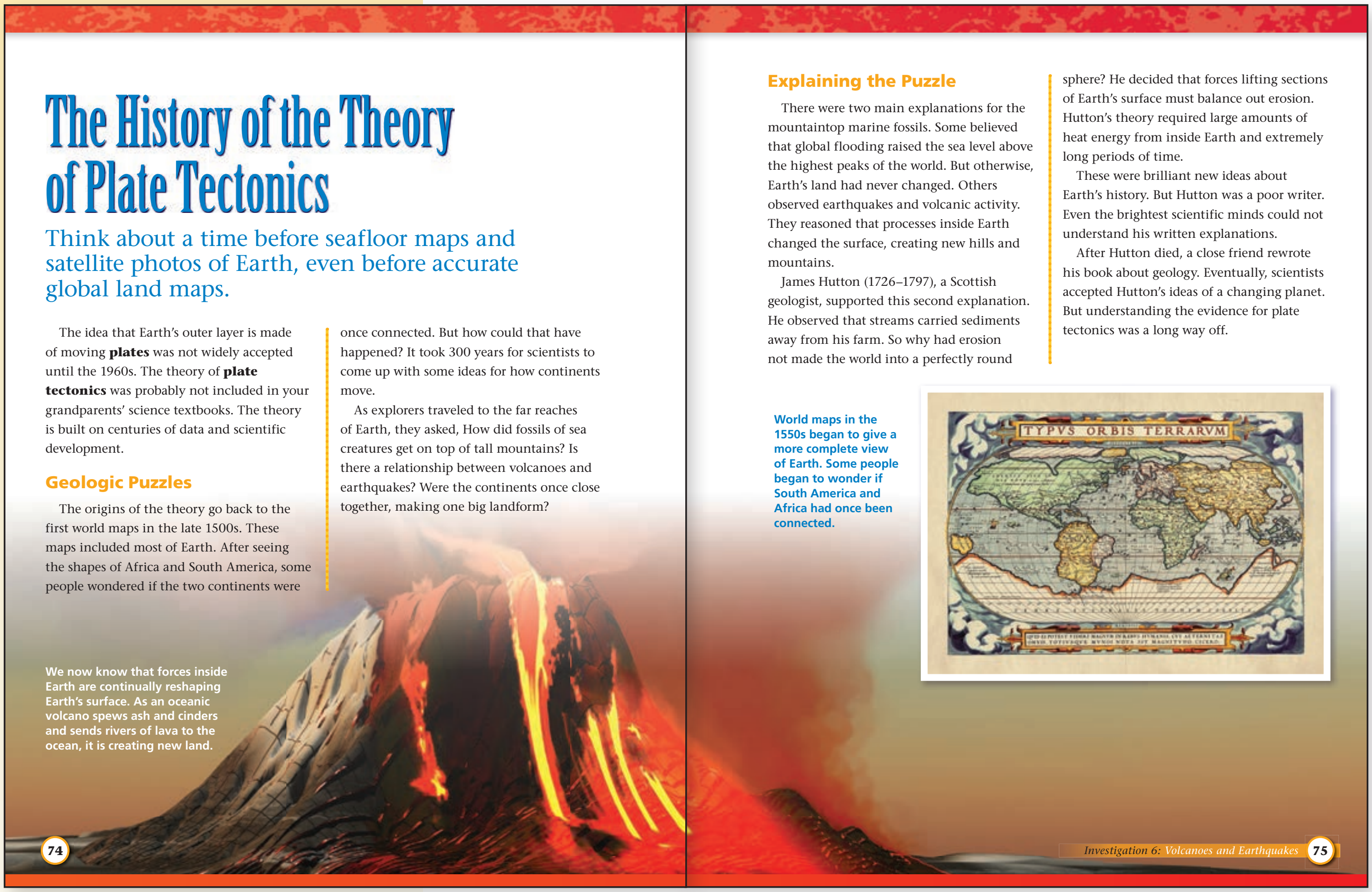
The middle school equipment kits are divided into unique permanent items, common permanent items, and consumable items. Speak to your FOSS sales representative about custom configuration to best address your classroom needs.



FOSS Science Resources Books

FOSS Science Resources: Earth History is a book of original readings developed to accompany this course. The readings, available in hard copy and digital formats, are referred to as articles in *Investigations Guide*. Students read the articles in the book as they progress through the course. Some readings are done in class; others are used as homework or for research projects. The articles cover specific concepts, usually after the concepts have been introduced in the active investigation.

The articles in *FOSS Science Resources* and the discussion questions provided in *Investigations Guide* help students make connections to the science concepts introduced and explored during the active investigations. Concept development is most effective when students are allowed to experience organisms, objects, and phenomena firsthand before engaging the concepts in text. The text and illustrations help make connections between what students experience concretely and the ideas that explain their observations.



The History of the Theory of Plate Tectonics

Think about a time before seafloor maps and satellite photos of Earth, even before accurate global land maps.

The idea that Earth's outer layer is made of moving **plates** was not widely accepted until the 1960s. The theory of **plate tectonics** was probably not included in your grandparents' science textbooks. The theory is built on centuries of data and scientific development.

Geologic Puzzles

The origins of the theory go back to the first world maps in the late 1500s. These maps included most of Earth. After seeing the shapes of Africa and South America, some people wondered if the two continents were once connected. But how could that have happened? It took 300 years for scientists to come up with some ideas for how continents move.

As explorers traveled to the far reaches of Earth, they asked, How did fossils of sea creatures get on top of tall mountains? Is there a relationship between volcanoes and earthquakes? Were the continents once close together, making one big landform?

We now know that forces inside Earth are continually reshaping Earth's surface. As an oceanic volcano spews ash and cinders and sends rivers of lava to the ocean, it is creating new land.

74

Explaining the Puzzle

There were two main explanations for the mountaintop marine fossils. Some believed that global flooding raised the sea level above the highest peaks of the world. But otherwise, Earth's land had never changed. Others observed earthquakes and volcanic activity. They reasoned that processes inside Earth changed the surface, creating new hills and mountains.

James Hutton (1726–1797), a Scottish geologist, supported this second explanation. He observed that streams carried sediments away from his farm. So why had erosion not made the world into a perfectly round sphere? He decided that forces lifting sections of Earth's surface must balance out erosion. Hutton's theory required large amounts of heat energy from inside Earth and extremely long periods of time.

These were brilliant new ideas about Earth's history. But Hutton was a poor writer. Even the brightest scientific minds could not understand his written explanations.

After Hutton died, a close friend rewrote his book about geology. Eventually, scientists accepted Hutton's ideas of a changing planet. But understanding the evidence for plate tectonics was a long way off.

TYPVS ORBIS TERRARVM

World maps in the 1550s began to give a more complete view of Earth. Some people began to wonder if South America and Africa had once been connected.

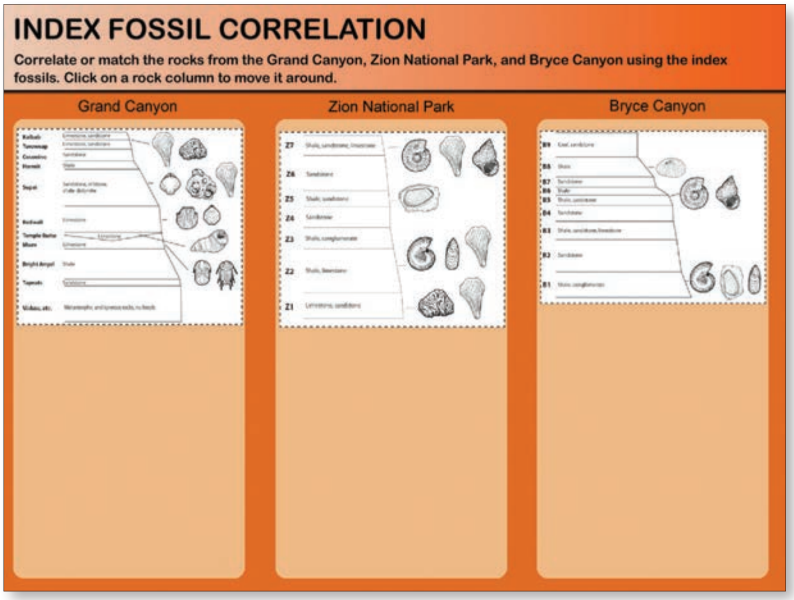
Investigation 6: Volcanoes and Earthquakes 75

Technology

The FOSS website opens new horizons for educators and students in the classroom or at home. Each course has digital resources for students—interactive simulations, resources for research, and online activities. For teachers, FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Program, and technical support.

For each course, registered FOSSweb users can view teacher preparation videos, download editable teacher slides for classroom instruction, print or display digital duplication masters in English or Spanish, and get reports from the online assessment system, FOSSmap.

As a registered FOSSweb educator, you can customize your homepage, set up easy access to the digital components of the courses you teach, and create class pages for your students with access to activities and online assessments.



NOTE
To access all the teacher resources and to set up customized pages for using FOSS, log in to FOSSweb through an educator account. See the Technology chapter for more specifics.

Ongoing Professional Learning

The Lawrence Hall of Science and Delta Education strive to develop long-term partnerships with districts and teachers through thoughtful planning, effective implementation, and ongoing teacher support. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS.

NOTE
Look for professional-development opportunities and online teaching resources on www.FOSSweb.com.

FOSS INSTRUCTIONAL DESIGN

FOSS is designed around active investigation that provides engagement with science concepts and science and engineering practices. Surrounding and supporting those firsthand investigations are a wide range of experiences that help build student understanding of core science concepts and deepen scientific habits of mind.

The Elements of the FOSS Instructional Design

Each FOSS investigation follows a similar design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation in collaborative groups: firsthand experiences with phenomena in the natural and designed worlds
- Recording in science notebooks to answer a focus question dealing with the scientific phenomenon under investigation
- Informational reading in *FOSS Science Resources* books
- Online activities to acquire data or information or to elaborate and extend the investigation
- Opportunities to apply knowledge to solve problems through the engineering design process or to address regional ecological issues
- Assessment to monitor progress and motivate student learning

In practice, these components are seamlessly integrated into a curriculum designed to maximize every student's opportunity to learn.

A **learning cycle** employs an instructional model based on a constructivist perspective that calls on students to be actively involved in their own learning. The model systematically describes both teacher and learner behaviors in a systematic approach to science instruction.

The most recent model employs a series of five phases of intellectual involvement known as the 5Es: engage, explore, explain, elaborate, and evaluate. The body of foundational knowledge that informs contemporary learning-cycle thinking has been incorporated seamlessly and invisibly into the FOSS curriculum design.

Engagement with real-world **phenomena** is at the heart of FOSS. In every part of every investigation, the central phenomenon is referenced implicitly in the focus question that guides instruction and frames the intellectual work. The focus question is a prominent part of each lesson and is called out for the teacher and student. The investigation Scientific and Historical Background section is organized by focus question—the teacher has the opportunity to read and reflect on the phenomenon in each part before preparing for the lesson. Students record the focus question in their science notebooks, and after exploring the phenomenon thoroughly, explain their thinking in words and drawings.

In science a phenomenon is a natural occurrence, circumstance, or structure that is perceptible by the senses—an observable reality. Scientific phenomena are not necessarily phenomenal (although they may be)—most of the time they are pretty mundane and well within the everyday experience. What FOSS does to enact an effective engagement with the NGSS is thoughtful selection of scientific phenomena for students to investigate.

NOTE

The anchor phenomena establish the storyline for the course. The investigative phenomena guide each investigation part. Related examples of everyday phenomena are incorporated into the readings, videos, discussions, formative assessments, outdoor experiences, and extensions.

Active Investigation

Active investigation is a master pedagogy. Embedded within active learning are a number of pedagogical elements and practices that keep active investigation vigorous and productive. The enterprise of active investigation includes

- context: questioning and planning;
- activity: doing and observing;
- data management: recording, organizing, and processing;
- analysis: discussing and writing explanations.

Context: questioning and planning. Active investigation requires focus. The context of an inquiry can be established with a focus question about a phenomenon or challenge from you, or in some cases, from students—Why do volcanoes and earthquakes occur where they do? At other times, students are asked to plan a method for investigation. This might include determining the important data to gather and the necessary tools. In either case, the field available for thought and interaction is limited. This clarification of context and purpose results in a more productive investigation.

Activity: doing and observing. In the practice of science, scientists put things together and take things apart, they observe systems and interactions, and they conduct experiments. This is the core of science—active, firsthand experience with objects, organisms, materials, and systems in the natural world. In FOSS, students engage in the same processes. Students often conduct investigations in collaborative groups of four, with each student taking a role to contribute to the effort.

The active investigations in FOSS are cohesive, and build on each other and the readings to lead students to a comprehensive understanding of concepts. Through the investigations, students gather meaningful data.

Online activities throughout the course provide students with opportunities to collect data, manipulate variables, and explore models and simulations beyond what can be done in the classroom. Seamless integration of the online activities forms an integral part of students' active investigations in FOSS.

Data management: recording, organizing, and processing. Data accrue from observation, both direct (through the senses) and indirect (mediated by instrumentation). Data are the raw material from which scientific knowledge and meaning are synthesized. During and after work with materials, students record data in their notebooks. Data recording is the first of several kinds of student writing.

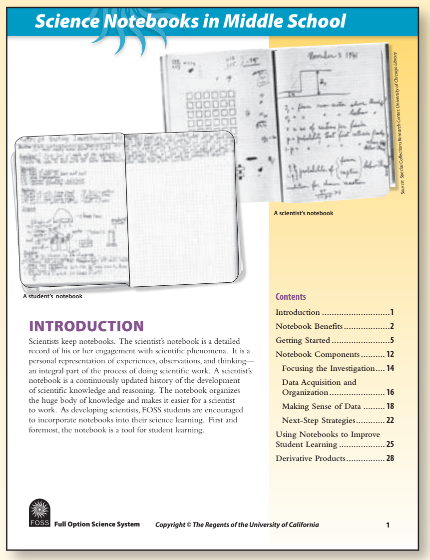
Students then organize data so that they will be easier to think about. Tables allow efficient comparison. Organizing data in a sequence (time) or series (size) can reveal patterns. Students process some data into graphs, providing visual display of numerical data. They also organize data and process them in the science notebook.

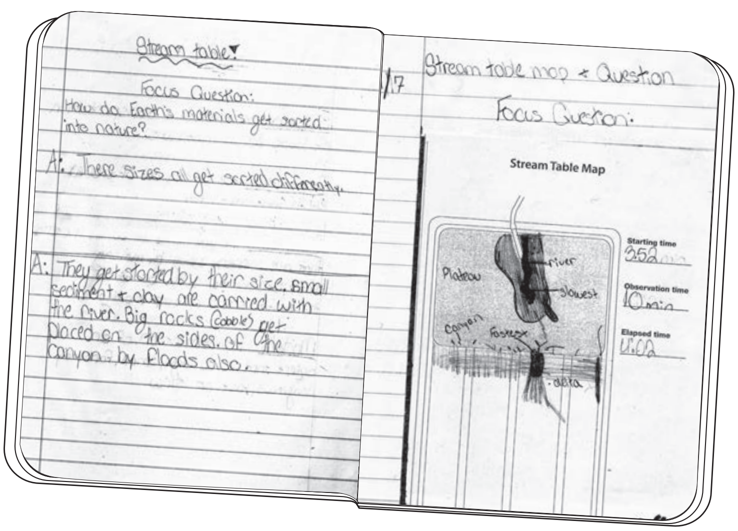
Analysis: discussing and writing explanations. The most important part of an active investigation is extracting its meaning. This constructive process involves logic, discourse, and existing knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing in their notebooks a summary of their learning as well as questions raised during the activity.

Science Notebooks

Research and best practice have led us to place more emphasis on the student science notebook. Keeping a notebook helps students organize their observations and data, process their data, and maintain a record of their learning for future reference. The process of writing about their science experiences and communicating their thinking is a powerful learning device for students. And the student notebook entries stand as a credible and useful expression of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for middle school presented in a notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) in a bound composition book. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets. Full-sized masters that can be filled in electronically and are suitable for projection are available on FOSSweb. Look to the chapter in *Teacher Resources* called Science Notebooks in Middle School for more details on how to use notebooks with FOSS.





Reading in *FOSS Science Resources*

Reading is a vital component of the FOSS Program. Reading enhances and extends information and concepts acquired through direct experience.

Readings are included in the ***FOSS Science Resources: Earth History*** book. Students read articles as well as access data and information for use in investigations.

Some readings can be assigned as homework or extension activities, whereas other readings have been deemed important for all students to complete with a teacher's support in class.

Each in-class reading has a reading guide embedded in Guiding the Investigation. The reading guide suggests breakpoints with questions to help students connect the reading to their experiences from class, and recommends notebook entries. Each of these readings also includes one or more prompts that ask students to make additional notebook entries. These prompts should help students who missed the in-class reading to process the article in a more meaningful way. Some of the most essential articles are provided as notebook masters. Students can highlight the article as they read, add notes or questions, and add the article to their science notebooks.

The FOSS and Common Core ELA chapter in *Teacher Resources* shows how FOSS provides opportunities to develop and exercise the Common Core ELA practices through science. A detailed table identifies these opportunities in the FOSS courses for middle school.

Integrating Technology through FOSSweb

The simulations and online activities on FOSSweb are designed to support students' learning at specific times during instruction. Digital resources include streaming videos that can be viewed by the class or small groups.

The Technology chapter provides details about the online activities for students and the tools and resources for teachers to support and enrich instruction. There are many ways for students to engage with the digital resources—in class as individuals, in small groups, or as a whole class, and at home with family and friends.

Assessing Progress

The FOSS assessment system includes both formative and summative assessments. Formative assessment monitors learning during the process of instruction. It measures progress, provides information about learning, and is predominantly diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called **embedded assessment**, is an integral part of instruction, and occurs on a daily basis. You observe action during class in a performance assessment or review notebooks after class. Performance assessments look at students' engagement in science and engineering practices or their recognition of crosscutting concepts. Embedded assessment provides continuous monitoring of students' learning and helps you make decisions about whether to review, extend, or move on to the next idea to be covered.

The embedded assessments are based on authentic work produced by students during the course of participating in the FOSS activities. Students do their science, and you look at their notebook entries. Bullet points in Guiding the Investigation tell you specifically what students should know and be able to communicate.

Benchmark assessments are short summative assessments given after each investigation. These **I-Checks** are actually hybrid tools: they provide summative information about students' achievement, and because they occur soon after teaching each investigation, they can be used diagnostically as well. Reviewing specific items on an I-Check with the class provides additional opportunities for students to clarify their thinking.

If student work is incorrect or incomplete, you know that there has been a breakdown in learning or communications. The assessment system provides a menu of next-step strategies to resolve the situation. Embedded assessment is assessment *for* learning, not assessment *of* learning.

Assessment *of* learning is the domain of the benchmark assessments. Benchmark assessments are delivered at the beginning of the course (*Entry-Level Survey*) and at the end of the course (*Posttest*), and after each investigation (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments composed of valid and reliable items. The assessment items do not simply identify whether a student knows a piece of science content. They also identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding.

TECHNOLOGY COMPONENTS OF THE FOSS ASSESSMENT SYSTEM

FOSSmap for teachers and online assessment for students are the technology components of the FOSS assessment system. Students can take assessments online. FOSSmap provides the tools for you to review those assessments online so you can determine next steps for the class or differentiated instruction for individual students based on assessment performance. For updated information on FOSSmap, download the latest Assessment chapter and coding guides on FOSSweb.

Solving Real-World Problems

FOSS investigations introduce science content in the context of real-world applications, so that students develop an understanding of how scientific principles explain natural phenomena. By middle school, students can begin to apply this understanding of science to develop solutions to real-world problems. We ask students to consider problem-solving and engineering challenges that are precise in scope, giving students a thorough understanding of the problem and potential solutions. Students have clear criteria and constraints (in the case of engineering design challenges) and focused topics of research (in the case of research projects).

In life science, students explore local environments, issues of biodiversity, medical technology applications, and human impact upon ecosystems. In earth science, students consider natural resource supplies and demands, technological advances in space exploration, and human effects on Earth's ocean and atmosphere. In physical science, students apply concepts of motion, kinetic energy, heat, and energy transfer in a series of engineering challenges where students develop and refine designs to solve an engineering problem.

Throughout all content areas, students have opportunities to collaborate and develop or select solutions to real-world issues. As described in the NRC *Framework* (2012, page 12), "engineering and technology provide a context in which students can test their own developing scientific knowledge and apply it to practical problems; doing so enhances their understanding of science—and, for many, their interest in science—as they recognize the interplay among science, engineering, and technology." By providing students with ongoing opportunities to understand and engage with the application of science, we help students develop an appreciation of and enthusiasm for science.

Taking FOSS Outdoors

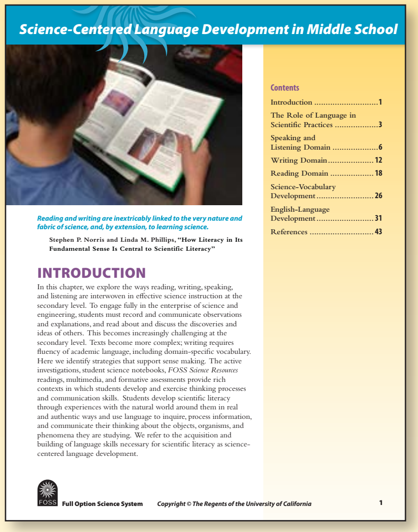
The true value of science knowledge is its usefulness in the real world and not just in the classroom. When students are able to transfer knowledge of scientific principles to natural systems, they experience a sense of accomplishment.

FOSS middle school courses provide outdoor activities and extensions. Teaching outdoors is the same as teaching indoors—except for the space. Because of the different space, new management procedures are required. Students can get farther away. Materials have to be transported. The space has to be defined and honored. Time has to be budgeted for getting to, moving around in, and returning from the outdoor study site. All these and more issues and solutions are discussed in the Taking FOSS Outdoors chapter in *Teacher Resources* on FOSSweb.

Science-Centered Language Development and Standards for Literacy in Science

The FOSS active investigations, science notebooks, *FOSS Science Resources* articles, and formative assessments provide rich contexts in which students develop and exercise thinking and communication. These elements are essential for effective instruction in both science and language arts—students experience the natural world in real and authentic ways and use language to inquire, process information, and communicate their thinking about scientific phenomena. FOSS refers to this development of language process and skills within the context of science as science-centered language development.

In the Science-Centered Language Development in Middle School chapter in *Teacher Resources*, we explore the intersection of science and language and the implications for effective science teaching and language development. Language plays two crucial roles in science learning: (1) it facilitates the communication of conceptual and procedural knowledge, questions, and propositions, and (2) it mediates thinking—a process necessary for understanding. Science provides a real and engaging context for developing literacy, and language-arts skills and strategies to support conceptual development and scientific practices. The skills and strategies used for enhancing reading comprehension, writing expository text, and exercising oral discourse are applied when students are recording their observations, making sense of science content, and communicating their ideas.



Science-Centered Language Development in Middle School

Reading and writing are inextricably linked to the very nature and fabric of science, and, by extension, to learning science.

Stephen P. Norris and Linda M. Phillips, "How Literacy in Its Fundamental Sense Is Central to Scientific Literacy"

INTRODUCTION

In this chapter, we explore the ways reading, writing, speaking, and listening are interwoven in effective science instruction at the secondary level. To engage fully in the enterprise of science and engineering, students must record and communicate observations and explanations, and read about and discuss the discoveries and ideas of others. This becomes increasingly challenging at the secondary level. Texts become more complex; writing requires fluency of academic language, including domain-specific vocabulary. Here we identify strategies that support sense making. The active investigations, student science notebooks, *FOSS Science Resources* readings, multimedia, and formative assessments provide rich contexts in which students develop and exercise thinking processes and communication skills. Students develop scientific literacy through experiences with the natural world around them in real and authentic ways and use language to inquire, process information, and communicate their thinking about the objects, organisms, and phenomena they are studying. We refer to the acquisition and building of language skills necessary for scientific literacy as science-centered language development.

Contents

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The most effective integration depends on the type of investigation, the experience of students, the language skills and needs of students, and the language objectives that you deem important at the time. The Science-Centered Language Development chapter is a library of resources and strategies for you to use. The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, gives suggestions for additional literacy strategies that both enhance students' learning in science and develop or exercise English-language literacy skills, and develops science vocabulary with scaffolding strategies for supporting all learners. We identify effective practices in language-arts instruction that support science learning and examine how learning science content and engaging in science and engineering practices support language development.

Specific methods to make connections to the Common Core State Standards for Literacy in Science are included in the flow of Guiding the Investigation. These recommended methods are linked through ELA Connection notes. In addition, the FOSS and the Common Core ELA chapter in *Teacher Resources* summarizes all of the connections to each standard at the given grade level.

DIFFERENTIATED INSTRUCTION FOR ACCESS AND EQUITY

"Active science by itself provides part of the solution to full inclusion and provides many opportunities at the same time for differentiated instruction."

Learning from Experience

The roots of FOSS extend back to the mid-1970s and the Science Activities for the Visually Impaired and Science Enrichment for Learners with Physical Handicaps projects (SAVI/SELPH). As those special-education science programs expanded into fully integrated settings in the 1980s, hands-on science proved to be a powerful medium for bringing all students together. The subject matter is universally interesting, and the joy and satisfaction of discovery are shared by everyone. Active science by itself provides part of the solution to full inclusion and provides many opportunities at one time for differentiated instruction.

Many years later, FOSS began a collaboration with educators and researchers at the Center for Applied Special Technology (CAST), where principles of Universal Design for Learning (UDL) had been developed and applied. FOSS continues to learn from our colleagues about ways to use new media and technologies to improve instruction. Here are the UDL principles.

Principle 1. Provide multiple means of representation. Give learners various ways to acquire information and demonstrate knowledge.

Principle 2. Provide multiple means of action and expression. Offer students alternatives for communicating what they know.

Principle 3. Provide multiple means of engagement. Help learners get interested, be challenged, and stay motivated.

FOSS for All Students

The FOSS Program has been designed to maximize the science learning opportunities for students with special needs and students from culturally and linguistically diverse origins. FOSS is rooted in a 35-year tradition of multisensory science education and informed by recent research on UDL. Procedures found effective with students with special needs and students who are learning English are incorporated into the materials and strategies used with all students. In addition, the **Access and Equity** chapter in *Teacher Resources* (or go to FOSSweb to download this chapter) provides strategies and suggestions for enhancing the science and engineering experiences for each of the specific groups noted above.

FOSS instruction allows students to express their understanding through a variety of modalities. Each student has multiple opportunities to demonstrate his or her strengths and needs. The challenge is then to provide appropriate follow-up experiences for each student. For some students, appropriate experience might mean more time with the active investigations or online activities. For other students, it might mean more experience building explanations of the science concepts orally or in writing or drawing. For some students, it might mean making vocabulary more explicit through new concrete experiences or through reading to students. For some students, it may be scaffolding their thinking through graphic organizers. For other students, it might be designing individual projects or small-group investigations. For some students, it might be more opportunities for experiencing science outside the classroom in more natural, outdoor environments.

Assessment and Extensions

The next-step strategies used during the self-assessment sessions after I-Checks provide many opportunities for differentiated instruction. For more on next-step strategies, see the Assessment chapter.

There are additional strategies for providing differentiated instruction. The FOSS Program provides formative assessment tools and strategies so that you know what students are thinking throughout the course. The Assessment chapter provides recommendations for how to engage students who are having difficulty with specific concepts. Online activities are effective tools to provide differentiated instruction. The extension activities are appropriate for students who need additional practice with the basic concepts as well as those ready for more advanced projects. Interdisciplinary extensions are listed at the end of each investigation. Use these ideas to meet the individual needs and interests of your students.

English Learners

The FOSS multisensory program provides a rich laboratory for language development for English learners. The program uses a variety of techniques to make science concepts clear and concrete, including modeling, visuals, and active investigations in small groups at centers. Key vocabulary is usually developed within an activity context with frequent opportunities for interaction and discussion between teacher and student and among students. This provides practice and application of the new vocabulary. Instruction is guided and scaffolded through carefully designed lesson plans, and students are supported throughout. The learning is active and engaging for all students, including English learners.

Science vocabulary is introduced in authentic contexts while students engage in active learning. Strategies for helping all students read, write, speak, and listen are described in the Science-Centered Language Development chapter. There is a section on science-vocabulary development with scaffolding strategies for supporting English learners. These strategies are essential for English learners, and they are good teaching strategies for all learners.

FOSS INVESTIGATION ORGANIZATION

Courses are subdivided into **investigations** (nine in this course). Investigations are further subdivided into two to four **parts**. Each investigation has a general guiding question for the phenomenon students investigate and each part of each investigation is driven by a **focus question**. The focus question, usually presented as the part begins, signals the challenge to be met, mystery to be solved, or principle to be uncovered. The focus question guides students' actions and thinking and makes the learning goal of each part explicit for teachers over several class sessions. Each part concludes with students recording an answer to the focus question in their notebooks.

The investigation is summarized for the teacher in the At a Glance chart at the beginning of each investigation.

Investigation-specific **scientific background** information for the teacher is presented in each investigation chapter organized by the focus questions.

The **Teaching and Learning about** section makes direct connections to the NGSS foundation boxes for the grade level—Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts. This information is later presented in color-coded sidebar notes to identify specific places in the flow of the investigation where connections to the three dimensions of science learning appear. The section ends with a conceptual-flow graphic of the content.

The **Materials** and **Getting Ready** sections provide scheduling information and detail exactly how to prepare the materials and resources for conducting the investigation. The **Quick Start** table lists planning and preparation steps.

Teaching Notes and **ELA Connections** appear in blue boxes in the sidebars. These notes compose a second voice in the curriculum—an educative element. The first (traditional) voice is the message you deliver to students. The second educative voice, shared as a teaching note, is designed to help you understand the science content and pedagogical rationale at work behind the instructional scene. ELA Connection boxes show the relevant Common Core State Standards for English Language Arts.

The **Getting Ready** and **Guiding the Investigation** sections have several features that are flagged in the sidebars. These include icons to remind you when a particular pedagogical method is suggested, as well as concise bits of information in several categories.

FOCUS QUESTION

How do fossils get in rocks?

SCIENCE AND ENGINEERING PRACTICES

Constructing explanations

DISCIPLINARY CORE IDEAS

ESS1.C: The history of planet Earth

CROSSCUTTING CONCEPTS

Stability and change

TEACHING NOTE

This focus question can be answered with a simple yes or no, but the question has power when students support their answers with evidence. Their answers should take the form "Yes, because ____ ."

The **safety** icon alerts you to potential safety issues related to chemicals, allergic reactions, and the use of safety goggles.

The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups.

The **vocabulary** icon indicates where students should review recently introduced vocabulary.

The **recording** icon points out where students should make a science-notebook entry.

The **reading** icon signals when the class should read a specific article in the *FOSS Science Resources* book.

The **technology** icon signals when the class should use a digital resource on FOSSweb.

The **assessment** icons appear when there is an opportunity to assess student progress using embedded or benchmark assessments. Some are performance assessments, indicated by an icon with a beaker and ruler.

The **outdoor** icon signals when to move the science learning experience into the schoolyard.

The **engineering** icon indicates opportunities for an experience incorporating engineering practices.

The **math** icon indicates an opportunity to engage in numerical data analysis and mathematics practice.

The **crosscutting concepts** icon indicates a key opportunity to integrate content between courses by using supports from the Crosscutting Concepts and Integration chapter in *Teacher Resources*.

The **homework** icon indicates science learning experiences that extend beyond the classroom.

EL NOTE

The **EL note** provides a specific strategy to assist English learners in developing science concepts.

Look for the start of a new **session** within an investigation part.

SESSION 2 *45–50 minutes*

CLASSROOM ORGANIZATION

FOSS has tried to anticipate the most likely learning environments in which science will be taught and designed the curriculum to be effective in those settings. The most common setting is the 1-hour period (45–55 minutes) every day, one teacher, in the science room. Students come in wave after wave, and they all learn the same thing. Some teachers may have two preps because they teach seventh-grade and eighth-grade classes. The **Earth History Course** was designed to work effectively in this traditional hour-a-day format.

The 1-hour subdivisions of the course adapt nicely to the block-scheduling model. It is usually possible to conduct two of the 1-hour sessions in a 90-minute block because of the uninterrupted instructional period. A block allows students to set up an experiment and collect, organize, and process the data all in one sequence. Block scheduling is great for FOSS; students learn more, and teachers are responsible for fewer preps.

Interdisciplinary teams of teachers provide even more learning opportunities. Students will be using mathematics frequently and in complex ways to extract meaning from their inquiries. It has been our experience, however, that middle school students are not skilled at applying mathematics in science because they have had few opportunities to use these skills in context. In an interdisciplinary team, the math teacher can use student-generated data to teach and enhance math skills and application.

The integration of other subject areas, such as language arts, into the science curriculum is also enhanced when interdisciplinary teams are used.

Managing Time

Time is a precious commodity. It must be managed wisely in order to realize the full potential of your FOSS curriculum. The right amount of time should be allocated for preparation, instruction, discussion, assessment, research, and current events. Start from the premise that there will not be enough time to do everything, so you will have to budget selectively. Don't scrimp on the prep time, particularly the first time you use the curriculum. Spend enough time with *Investigations Guide* to become completely familiar with the lesson plans. Take extra time at the start of the course to set up your space efficiently; you will be repaid many times over later. As you become more familiar with the FOSS Program and the handling of the materials, the proportion of time devoted to each aspect of the program may shift, so that you are spending more and more time on instruction and enrichment activities.

Effective use of time during the instructional period is one of the keys to a great experience with this course. *Investigations Guide* offers suggestions for keeping the activities moving along at a good pace, but our proposed timing will rarely exactly match yours. The best way we know for getting in stride with the curriculum is to start teaching it. Soon you will be able to judge where to break an activity or push in a little enrichment to fill your instructional period.

Managing Space

The **Earth History Course** will work in the ideal setting: flat-topped tables where students work with materials in groups of four; theater seating for viewing online activities (darkened); technology available for accessing the Internet and online activities, and other reference materials available. But we don't expect many teachers to have the privilege of working in such a space. So we designed FOSS courses to work effectively in a number of typical settings, including the science lab and regular classroom. We have described, however, the minimum space and resources needed to use FOSS. Here's the list, in order of importance.

- A computer with Internet access, and a large-screen display monitor or projector
- Tables or desks for students to work in groups of four
- A whiteboard, blackboard, or chart paper and marking pens
- A surface for materials distribution
- A place to clean and organize equipment
- A convenient place to store the kit
- A computer lab or multiple digital devices

Once the minimum resources are at hand, take a little time to set up your science area. This investment will pay handsome dividends later since everyone will be familiar with the learning setup.

- Organize your computer and projection system and be sure the Internet connection is working smoothly.
- Think about the best organization of furniture. This may change from investigation to investigation.
- Plan where to set up your materials stations.
- Know how students will keep notes and record data, and plan where students will keep their notebooks.

Managing Students

A typical class of middle school students is a wonderfully complex collection of personalities, including the clown, the athlete, the fashion statement, the worrier, the achiever, the pencil sharpener, the show-off, the reader, and the question-answerer. Notice there is no mention of the astrophysicist, but she could be in there, too. Management requires delicate coordination and flexibility—some days students take their places in an orderly fashion and sit up straight in their chairs, fully prepared to learn. Later in the week, they are just as likely to have the appearance of migrating waterfowl, unable to find their place, talkative, and constantly moving.

FOSS employs a number of strategies for managing students. Often a warm-up activity is a suitable transition from lunch or the excitement of changing rooms to the focused intellectual activities of the **Earth History Course**. Warm-ups tend to be individual exercises that review what transpired yesterday with a segue to the next development in the curriculum. This gives students time to get out their notebooks, grind points on their pencils, settle into their space, and focus.

Students most often work in groups in this course. Groups of four are generally used, but at other times, students work in pairs.

Suggestions for guiding students' work in collaborative groups are described later in this chapter.

When Students Are Absent

When a student is absent for a session, another student can act as a peer tutor and share the science notebook entries made for that day. The science notebooks should be a valuable tool for students to share in order to catch up on missed classes. Also consider giving him or her a chance to spend some time with the materials.

Students can use the resources on FOSSweb at school or at home for the missed class. And finally, allow the student to bring home *FOSS Science Resources* to read any relevant articles. Each article has a few review items that the student can respond to verbally or in writing.

Managing Technology

The **Earth History Course** includes an online component. The online activities and materials are not optional. For this reason, it is essential that you have in your classroom at minimum one computer, a large-screen display monitor or projection system, and a connection to the Internet. Sometimes you will use multimedia to make presentations to the entire class. Sometimes small groups or individuals will use the online program to work simulations and representations, and to gather information. Plan on the students having access to computers or tablets for work in groups for these sessions.

- Investigation 3, Part 3
- Investigation 4, Part 1
- Investigation 6, Part 1
- Investigation 8, Parts 1 and 2

Option 1: The computer lab. If you have access to a lab where all students can work simultaneously as individuals, pairs, or small groups, schedule time in the lab for your classes. If you have access to a cart with a class set of devices, schedule that for your classroom.

Option 2: Classroom computers or other digital devices. With multiple devices for groups in the science classroom, you can set up a multitasking environment with half the students working with Internet resources and half engaged in reading or small-group discussions. Then swap roles. If every student or pair has access to a device, you are all set.

Option 3: Home access. Students can access FOSSweb from home by visiting www.FOSSweb.com and accessing the class pages with the account information you provide for student use. You must set up a class page for students to have home access to the multimedia.

Managing Materials

The Materials section lists the items in the equipment kit and any teacher-supplied materials. It also describes things to do to prepare a new kit and how to check and prepare the kit for your classroom. Individual photos of each piece of FOSS equipment are available for printing from FOSSweb, and can help students and you identify each item.

The FOSS Program designers suggest using a central materials distribution system. You organize all the materials for an investigation at a single location called the materials station. As the investigation progresses, one member of each group gets materials as they are needed, and another returns the materials when the investigation is complete. You place the equipment and resources at the station, and students do the rest. Students can also be involved in cleaning and organizing the materials at the end of a session.

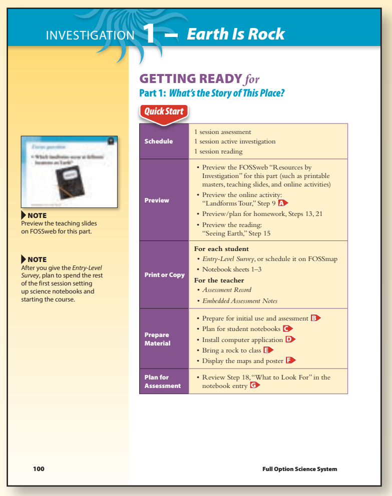
The Materials list for each investigation is divided into these categories.

- Equipment provided in the FOSS kit
- Teacher-supplied items
- FOSSweb resources to be downloaded or projected

Each category is further subdivided by need.

- For each student
- For each group
- For the class
- For the teacher

The Getting Ready section begins with the Quick Start table to help you immediately know the schedule; what to preview, print, or copy; what materials to prepare; and what to plan for assessment. Preparation details linked to the Quick Start provide specific information.



ESTABLISHING A CLASSROOM CULTURE

Working in Collaborative Groups

Collaboration is important in science. Scientists usually collaborate on research enterprises. Groups of researchers often contribute to the collection of data, the analysis of findings, and the preparation of the results for publication.

Collaboration is expected in the science classroom, too. Some tasks call for everyone to have the same experience, either taking turns or doing the same things simultaneously. At other times, group members may have different experiences that they later bring together.

Research has shown that students learn better and are more successful when they collaborate. Working together promotes student interest, participation, learning, and self-confidence. FOSS investigations use collaborative groups extensively.

No single model for collaborative learning is promoted by FOSS. We can suggest, however, a few general guidelines that have proven successful over the years.

For most activities in middle school, collaborative groups of four in which students take turns assuming specific responsibilities work best. Groups can be identified completely randomly (first four names drawn from a hat constitute group 1), or you can assemble groups to ensure diversity. Thoughtfully constituted groups tend to work better.

Groups can be maintained for extended periods of time, or they can be reconfigured more frequently. For a short course, you might keep students in the same groups for the entire course.

Functional roles within groups can be determined by the members themselves, or they can be assigned in one of several ways. Each member in a collaborative group can be assigned a number or a color. Then you need only announce which color or number will perform a certain task for the group at a certain time. Compass points can also be used: the person seated on the east side of the table will be the Reporter for this investigation.

The functional roles used in the investigations follow. If you already use other names for functional roles in your class, use those in place of these in the investigations.

Getters are responsible for materials. One person from each group gets equipment from the materials station, and another person later returns the equipment.

One person is the **Starter** for each task. This person makes sure that everyone gets a turn and that everyone has an opportunity to contribute ideas to the investigation.

The **Recorder** collects data as it happens and makes sure that everyone has recorded information on his or her science notebook sheets.

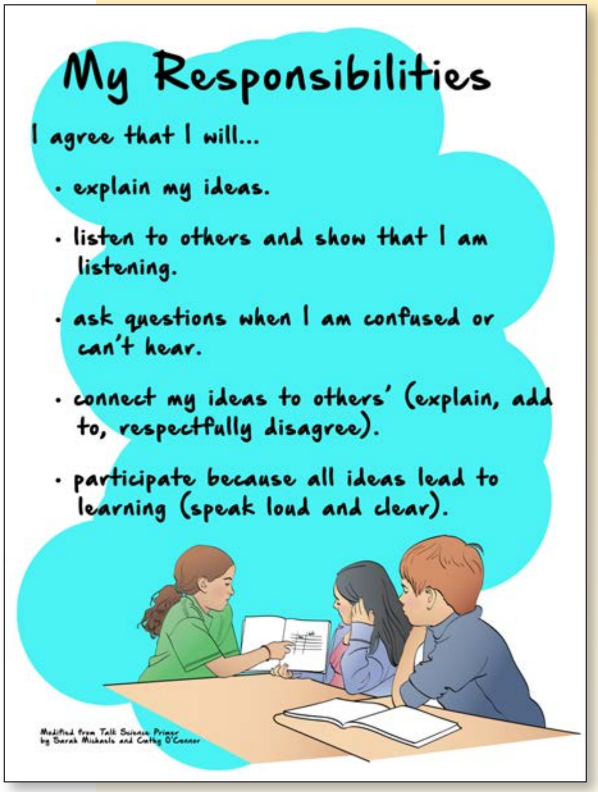
The **Reporter** shares group data with the class or transcribes it to the board or class chart.

Getting started with collaborative groups requires patience, but the rewards are great. Once collaborative groups are in place, you will be able to engage students more in meaningful conversations about science content. You are free to "cruise" the groups, to observe and listen to students as they work, and to interact with individuals and small groups as needed.

Norms for Sense-Making Discussions

Setting up norms for discussion and holding yourself and your students accountable is the first step toward creating a culture of productive talk in the classroom that supports engagement in the science and engineering practices. Students need to feel free to express their ideas, and to provide and receive criticism from others as they work toward understanding of the disciplinary core ideas of science and methods of engineering.

Establish norms at the beginning of the school year. It is recommended that this be done together as a class activity. However, presenting a poster of norms to students and asking them to discuss why each one is important can also be effective. Before each sense-making discussion, review the norms. Review what it will look like, sound like, and feel like when everyone is following the agreements. You might have students work on one or two at a time as they are developing their oral discourse skills. After discussion, save a few minutes for reflection on how well the group or the class adhered to the norms and what they can do better next time. More strategies for supporting academic discourse can be found in the Sense-Making Discussions for Three-Dimensional Learning and Science-Centered Language Development in Middle School chapters in *Teacher Resources* (also available as downloadable PDFs on FOSSweb).



This poster is an example of student responsibilities that the class discussed and adopted as their norms.

Collaborative Teaching and Learning

Collaborative learning requires a collective as well as individual growth mindset. A growth mindset is when people believe that their most basic abilities can be developed through dedication and hard work (see the research of Carol Dweck and her book *Mindset: The New Psychology of Success*). As students work together to make sense of phenomena and develop their inquiry and discourse skills, it's important to recognize and value their efforts to try new approaches and their willingness to make their thinking visible. Remind students that everyone in the classroom, including you the teacher, will be learning new ideas and ways to think about the world. Where there is productive struggle, there is learning. Here are a few ways to help students develop a growth mindset for science and engineering.

- **Praise effort, not right answers**. When students are successful at a task, provide positive feedback about their level of engagement and effort in the practices, e.g., the efforts they put into careful observations, how well they organized and interpreted their data, the relevancy of their questions, how well they connected or applied new concepts, and their use of precise vocabulary, etc. Also, try to provide feedback that encourages students to continue to improve their learning and exploring, e.g., is there another way to approach this question? Have you thought about _____? What evidence is there to support _____?
- **Foster and validate divergent thinking**. During sense-making discussions, continually emphasize how important it is to share emerging ideas and to be open to the ideas of others in order to build understanding. Model for students how you refine and revise your thinking based on new information. Make it clear to students that the point is not for them to show they have the right answer, but rather to help each other arrive at new understandings. Point out positive examples of students expressing and revising their ideas.

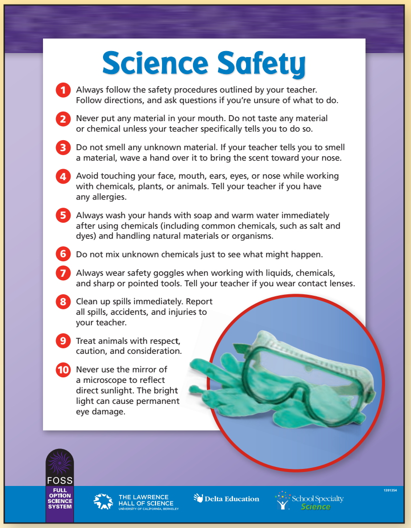
Establishing a classroom culture that supports three-dimensional teaching and learning centers on collaboration. Collaborative groupings, materials management, and norms are structures you can put into place to foster collaboration. These structures along with the expectations that students will be negotiating meaning together as a community of learners, creates a learning environment where students are compelled to work, think, and communicate like scientists and engineers to help one another learn.

SAFETY IN THE CLASSROOM AND OUTDOORS

Following the procedures described in each investigation will make for a very safe experience in the classroom. You should also review your district safety guidelines and make sure that everything that you do is consistent with those guidelines. Two posters are included in the kit, *FOSS Science Safety* and *FOSS Outdoor Safety*, for classroom use. The safety guidelines are also in *FOSS Science Resources* for student reference.

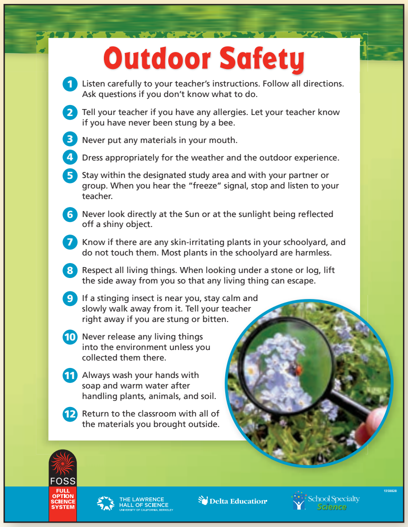
Look for the safety icon in the Getting Ready and Guiding the Investigation sections, which will alert you to safety considerations throughout the course.

Safety Data Sheets (SDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any SDS, call Delta Education at 1-800-258-1302 (Monday–Friday, 8 a.m. to 5 p.m. ET).



General classroom safety rules to share with students are listed here.

1. Always follow the safety procedures outlined by your teacher. Follow directions, and ask questions if you're unsure of what to do.
2. Never put any material in your mouth. Do not taste any material or chemical unless your teacher specifically tells you to do so.
3. Do not smell any unknown material. If your teacher tells you to smell a material, wave a hand over it to bring the scent toward your nose.
4. Avoid touching your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals. Tell your teacher if you have any allergies.
5. Always wash your hands with soap and warm water immediately after using chemicals (including common chemicals, such as salt and dyes) and handling natural materials or organisms.
6. Do not mix unknown chemicals just to see what might happen.
7. Always wear safety goggles when working with liquids, chemicals, and sharp or pointed tools. Tell your teacher if you wear contact lenses.
8. Clean up spills immediately. Report all spills, accidents, and injuries to your teacher.
9. Treat animals with respect, caution, and consideration.
10. Never use the mirror of a microscope to reflect direct sunlight. The bright light can cause permanent eye damage.



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Customer Service at Delta Education

www.DeltaEducation.com/contact.aspx

Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

FOSSmap (online component of FOSS assessment system)

http://FOSSmap.com/

FOSSweb account questions/access codes/help logging in

techsupport.science@schoolspecialty.com

Phone: 1-800-258-1302, 8:00 a.m. –5:00 p.m. ET

School Specialty online support

loginhelp@schoolspecialty.com

Phone: 1-800-513-2465, 8:30 a.m.–6:00 p.m. ET

FOSSweb tech support

support@FOSSweb.com

Professional development

www.FOSSweb.com/Professional-Development

Safety issues

www.DeltaEducation.com/SDS

Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

For chemical emergencies, contact Chemtrec 24 hours a day.

Phone: 1-800-424-9300

Sales and replacement parts

www.DeltaEducation.com/FOSS/buy

Phone: 1-800-338-5270, 8:00 a.m.–5:00 p.m. ET