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 geological 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.
## Investigation Summary

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Time</th>
<th>Parts</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earth Is Rock</strong></td>
<td>Assessment: 1 Session, Active Inv.: 6 Sessions, Reading: 1 Session</td>
<td>1. What’s the Story of This Place? 2. Grand Canyon Rocks 3. Correlating Grand Canyon Rocks</td>
<td>Which landforms occur at different locations on Earth? Why do there appear to be stripes on the walls of the Grand Canyon? How are the rocks from the two Grand Canyon sites related to each other?</td>
</tr>
<tr>
<td><strong>Weathering and Erosion</strong></td>
<td>Active Inv.: 7 Sessions, Reading: 1 Session, Assessment: 2 Sessions</td>
<td>1. Sorting Earth Materials 2. Stream Table 3. Weathering 4. Soils</td>
<td>How big are rocks? How do earth materials get sorted in nature? Which came first, the sand or the sandstone? How is soil related to rocks?</td>
</tr>
<tr>
<td><strong>Deposition</strong></td>
<td>Active Inv.: 4 Sessions, Assessment: 1 Session</td>
<td>1. Sandstone and Shale 2. Limestone 3. Interpreting Sedimentary Layers</td>
<td>What happens to sediments that get deposited in basins? How does limestone form? What do sedimentary rock layers reveal about ancient environments?</td>
</tr>
</tbody>
</table>
### Module Matrix

#### Content
- Earth’s surface has a variety of different landforms and water features.
- Every place on Earth’s surface has a unique geological 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.

- Particles of earth material can be categorized and sorted by size.
- Rock can be weathered into sediments by a number of processes.
- Most landforms are shaped by slow, persistent processes that proceed over the course of millions of years.
- 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.

- Sediments deposited by water usually form flat, horizontal layers.
- Sediments turn into solid rock through the process of lithification.
- 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.

#### Writing/Reading
- **Science Notebook Entry**
  - Landforms Tour
  - Anticipation Guide
  - Rock observations
  - Grand Canyon rocks lineup

- **Science Resources Book**
  - “Seeing Earth”
  - “Getting to Know the Grand Canyon”
  - “Powell’s Grand Canyon Expedition, 1869” (optional)

- **Science Notebook Entry**
  - Wentworth scale measurements
  - Stream-Table Map
  - Stream-Table Questions
  - Multimedia Stream Tables
  - Sand Comparison
  - Soil observations

- **Science Resources Book**
  - “Grand Canyon Flood!”
  - “Weathering and Erosion”
  - “Caverns” (optional)
  - “Soil Stories” (optional)

- **Science Notebook Entry**
  - Seawater Investigation
  - Basin Questions

- **Science Resources Book**
  - “Where in the World Is Calcium Carbonate?”
  - “Water on Mars?”

#### Assessment
- **Benchmark Assessment**
  - Survey (optional)

- **Embedded Assessment**
  - Science notebook entry
  - Quick write
  - Scientific practices

- **Embedded Assessment**
  - Scientific practices
  - Science notebook entry
  - Quick write
  - Response sheet

- **Benchmark Assessment**
  - Investigations 1–2 I-Check

- **Embedded Assessment**
  - Science notebook entry
  - Scientific practices
  - Quick write
  - Self-assessment

- **Benchmark Assessment**
  - Investigation 3 I-Check
## EARTH HISTORY — Overview

<table>
<thead>
<tr>
<th>Investigation Summary</th>
<th>Time</th>
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<tr>
<td><strong>Inv. 4</strong> Fossils and Past Environments Students consider the time scale in which rocks and fossils form. They create a scaled time line and identify the formation of Grand Canyon rocks on the time line after reviewing evidence from index fossils.</td>
<td><strong>Active Inv.</strong> 7–8 Sessions&lt;br&gt;&lt;br&gt;<strong>Assessment</strong> 2 Sessions</td>
<td>1. Fossils&lt;br&gt;2. A Long Time Ago&lt;br&gt;3. Student Time Lines&lt;br&gt;4. Index Fossils</td>
<td>How do fossils get in rocks?&lt;br&gt;How old are fossils?&lt;br&gt;How do we categorize extremely long periods of time?&lt;br&gt;When did the Grand Canyon rocks form?</td>
</tr>
<tr>
<td><strong>Inv. 5</strong> Igneous Rocks Students examine rock samples from a new location. They investigate the relationship between crystal size and the formation of igneous rocks.</td>
<td><strong>Active Inv.</strong> 4 Sessions&lt;br&gt;&lt;br&gt;<strong>Assessment</strong> 1 Session</td>
<td>1. Earth’s Layers&lt;br&gt;2. Salol Crystals&lt;br&gt;3. Types of Igneous Rocks</td>
<td>How do igneous rocks form?&lt;br&gt;What affects crystal formation in igneous rocks?&lt;br&gt;What can crystal size tell us about where an igneous rock formed?</td>
</tr>
<tr>
<td><strong>Inv. 6</strong> Volcanoes and Earthquakes Students plot data about geological events and identify patterns. Convection and the theory of plate tectonics are introduced to explain continental drift, plate boundary interactions, and the patterns of volcanoes and earthquakes.</td>
<td><strong>Active Inv.</strong> 4 Sessions&lt;br&gt;&lt;br&gt;<strong>Reading</strong> 1 Session&lt;br&gt;&lt;br&gt;<strong>Assessment</strong> 1 Session</td>
<td>1. Mapping Volcanoes and Earthquakes&lt;br&gt;2. Moving Continents&lt;br&gt;3. Plate Tectonics</td>
<td>Where do volcanoes occur on Earth?&lt;br&gt;Where do earthquakes occur on Earth?&lt;br&gt;Why do volcanoes and earthquakes occur where they do?&lt;br&gt;What causes plates to move?</td>
</tr>
<tr>
<td>Content</td>
<td>Writing/Reading</td>
<td>Assessment</td>
<td></td>
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</table>
| • 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.  
• Geological 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 Notebook Entry**  
Fossil observations  
Time Line  
*Time Line Calculations* (optional)  
Colorado Plateau correlation  
*Index-Fossil Correlation*  
*Index-Fossil Correlation Questions*  
Rocks over Time | **Embedded Assessment**  
Rock-Column Movie Maker  
Response sheet  
Scientific practices  
**Benchmark Assessment**  
Investigation 4 I-Check |
| **Science Resources Book**  
"A Fossil Primer" (optional)  
"Coconino Stories" (optional)  
"Rocks, Fossils, and Time" (optional)  
"Floating on a Prehistoric Sea" (optional) | | |
| | **Science Notebook Entry**  
Rock observations  
Cooling-Rate Investigation  
Rock-Layer Age Puzzle | | |
| | **Science Resources Book**  
"Minerals, Crystals, and Rocks" (optional) | | |
| **Embedded Assessment**  
Scientific practices  
Science notebook entry  
**Benchmark Assessment**  
Investigation 5 I-Check | | |
| **Science Notebook Entry**  
Wegener Video Questions  
*Plate Boundaries* (optional) | | |
| **Science Resources Book**  
"Volcanoes!" (optional)  
"The Human Story of the Theory of Plate Tectonics"  
"Historical Debates about a Dynamic Earth" (optional) | | |
| | **Embedded Assessment**  
Scientific practices  
Science notebook entry  
Quick write  
**Benchmark Assessment**  
Investigation 6 I-Check | | |
## Investigation Summary

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| Mountains and Metamorphic Rocks       | **Active Inv.** 5–7 Sessions | 1. Plate Models  
2. Mountains  
3. Metamorphic Rocks  
4. Shenandoah (optional) | What happens to Earth’s crust during plate interactions?  
What are some ways that mountains form?  
How do metamorphic rocks form?  
What is the geological history of Shenandoah National Park? |
|                                       | **Reading** 2 Sessions |                                                                      |                                                                                 |
|                                       | **Assessment** 1 Session |                                                                      |                                                                                 |
| Geoscenarios                          | **Active Inv.** 3 Sessions | 1. Introduction to the Project  
2. Research and Writing  
3. Presentations | What do we need to know to tell the geological story of a place? |
|                                       | **Assessment** 2 Sessions |                                                                      |                                                                                 |
| What Is Earth’s Story?                | **Active Inv.** 3 Sessions | 1. Revisit the Grand Canyon  
2. Review the Evidence | What is the geological story of the Grand Canyon?  
How do earth materials recycle through constructive and destructive processes? |
|                                       | **Assessment** 1 Session |                                                                      |                                                                                 |

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**Inv. 7**  
**Inv. 8**  
**Inv. 9**

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**Full Option Science System**
### At a Glance

**Concepts**
- 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.

**Reading/Writing**

**Science Notebook Entry**  
*Mountain Types*  
*Metamorphic rock*  
*Field Trip Notes (optional)*

**Science Resources Book**  
“Earth’s Dynamic Systems”  
“Rock Transformations”

**Assessment**

- Embedded Assessment: Scientific practices  
- Benchmark Assessment: Investigation 7 I-Check

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**Concepts**
- Geological processes help tell the story of a physical place.
- Evidence and observations of a site’s geology provide clues to tell the geological story.
- Knowledge of uplift, plate tectonics, volcanism, weathering, erosion, and fossil evidence plus the principles of uniformitarianism, superposition, and original horizontality can help the story of a place.

**Reading/Writing**

**Science Notebook Entry**  
*Geoscenario Team Questions*  
*Geoscenario Work Checklist*  
*Project research*  
*Geoscenario Presentation Notes*

**Science Resources Book**  
“Geoscenario Introduction—Glaciers”  
“Geoscenario Introduction—Coal”  
“Geoscenario Introduction—Yellowstone Hotspot”  
“Geoscenario Introduction—Oil”

**Assessment**

- Embedded Assessment: Scientific practices  
- Benchmark Assessment: Geoscenario presentation

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**Concepts**
- Evidence that provides clues about Earth’s geological 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 geological history.
- Scientists use a number of different tools and techniques to analyze and synthesize evidence from Earth to tell its story.

**Reading/Writing**

**Science Notebook Entry**  
*Grand Canyon Revisited*  
*Course review*

**Science Resources Book**  
“How One Rock Becomes Another Rock”  
“Careers in Geology”

**Assessment**

- Embedded Assessment: Science notebook entry  
- Benchmark Assessment: Posttest
A FRAMEWORK FOR K–12 SCIENCE EDUCATION

The Earth History Course for grades 6–8 emphasizes the use of knowledge and evidence to construct explanations for the landforms and earth materials found on Earth and the processes that created them. This course supports the following principles set forth in A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council, 2011).

Scientific and Engineering Practices
Develop students’ abilities to do and understand scientific practices.

- Asking questions (for science) and defining problems (for engineering).
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Developing and using models.
- Using mathematics, information and computer technology, and computational thinking.
- Constructing explanations (for science) and designing solutions (for engineering).
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

Crosscutting Concepts
Develop students’ understandings of concepts that bridge disciplinary core ideas and provide an organizational framework for connecting knowledge from different disciplines into a coherent and scientifically based view of the world.

- Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

- Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

- Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.
• **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

• **Energy and matter: Flows, cycles, and conservation.** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

• **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.

### Earth and Space Sciences

#### Core Idea ESS1: Earth’s Place in the Universe

- 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. (ESS1.C)

#### Core Idea ESS2: Earth’s 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.

  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.A)

- 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 the 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.B)
Core Idea ESS3: Earth and Human Activity

- 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.A)

Physical Sciences
Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted. Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (PS4.A)

Life Sciences
Core Idea LS4: Biological Evolution: Unity and Diversity

- 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. (LS4.A)
NEXT GENERATION SCIENCE STANDARDS

This course supports the following principles set forth in the *Next Generation Science Standards* (April 2013).

**Earth and Space Sciences**

- **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.
- **MS-ESS2-1.** Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.
- **MS-ESS2-2.** Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.
- **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.
- **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.
- **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.
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **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.
- **MS-ESS3-5.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

**Physical Sciences**

- **MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

**Life Sciences**

- **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.
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 been 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 structure 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 science is the ultimate educational destination, learning progressions are the routes that can be taken to reach that destination” (National Research Council, A Framework for K–12 Science Education, 2011).

The FOSS modules (grades K–6) and courses (grades 6–8) are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, which represent a core scientific idea, as shown in the columns in the table: matter/energy and change, dynamic atmosphere/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 you proceed up the columns.

In addition to the science content framework, every course provides opportunities for students to engage in and understand scientific 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. Scientific inquiry involves 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. Scientific inquiry is a behavior, so it can be assessed only while it is in progress. Thus, assessment of inquiry is based on teacher observation. The indicators of inquiry in progress include students involved in the many aspects of active thinking, students motivated to learn, and students taking responsibility for their own learning.
EARTH HISTORY IN MIDDLE SCHOOL

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 ripple marks, meanders, erosion, and deposition that are evidence of the interaction of flowing water and rock. When they monitor volcanoes, like those in Hawai‘i, they see 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.
Why Study the History of Earth?

The Student’s Case. It’s been heard so many times . . . the middle schooler’s mantra: “Why do I have to learn this? What does this have to do with my life?” They ask these questions, not to be argumentative, but because they are awakening to a larger world and feeling the first sting of realization that soon they will have to make their way in it. “I’ll need a job, and I’m not going to be a geologist. I really don’t want to do this.”

These questions betray the fact that middle schoolers have acquired a more complex worldview. They have progressed from a life guided by concrete experiences and events in the present to a more worldly view interwoven with powerful abstractions, extending from past to future. Now the curriculum can advance a level to take advantage of the new abilities of students. Students are ready to start grappling with some of the abstractions presented by the study of Earth history, geological time, and Earth processes.

As students travel through the adolescent years, they become more able to make inferences. Many probably still need concrete experiences, such as making sand and sandstone and watching salol crystals grow, to provide the basis for more complex, inferential thinking. Concrete experiences can certainly be extended further at this age than in earlier years. Students are more interested in thinking about the future and can begin to understand more about the past that they weren’t around to witness. They can begin to understand concepts that are not represented by objects and materials. The study of Earth history is a good opportunity to challenge their minds and 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.

The Teacher’s Case. Middle school teachers know that middle school students are in a universe of turmoil. Bodies, emotions, and social relationships are at odds. One day (or minute) they will be composed and ready to learn—actually quite mature—and the next they will be hopelessly distracted and sensitive. On the settled days, students will engage in analytical problem solving, grappling effectively with abstractions. But on the squirrely days, students will have better success with concrete experiences. Middle schoolers need both, and successful teachers know how to manage the balance of learning modalities to maximize student success.

The Earth History Course challenges students to consider the environment around them and to contemplate that all has not always been as we observe it today. To the perception of a middle school student (and many adults), the way the scenery looks today is the way it has always been.

The concept of a million and the mind-boggling extent of geological time is one that students begin to grapple with in this course. Most of us use the number 1 million quite casually in everyday conversation. (“What if I won the lottery and had a million dollars to spend?”) To visualize the number 4,600,000,000 is hard for most of us when we take the time to really think about it. To consider 4.6 billion years—that’s another whole dimension. This course exposes students to these large numbers in the context of Earth history to help them begin to put into perspective the changes that have happened over time and the human race’s place in them.
Can I Teach This? I’m Not a Geologist

FOSS assumes that teachers using this course possess no more than a minimal level of Earth science content knowledge and a functional vocabulary of basic geology. Additional knowledge is an asset but is not a prerequisite for teaching the course effectively. The specific content dealt with in each investigation is discussed in the Scientific and Historical Background section of each chapter. You may not have a thorough understanding of the material when students start the course, but you will have a pretty good understanding of the objects and principles at the end.

The Earth History Course focuses on the materials that make up Earth’s crust, the processes that create and change them, and how these processes acted in the past and are now preserved in rocks. As you help students explore the processes that form sedimentary rocks, you will see how the evidence in the rocks tells the story of past environments—where arid regions now exist, there was once a tropical climate, or where solid rock now exists was once a region of seething volcanic activity. As students observe and identify fossils, you can guide them to consider what clues the form and function of these prehistoric creatures contribute to the story of Earth. By studying prehistoric organisms and their relationship to each other over the course of time, students are introduced to the idea that organisms and populations of organisms have also changed over time, possibly in response to Earth’s changing environments. Eventually you will help students put together this information with findings about plate tectonics and metamorphism in rocks to be able to explain the rock cycle on Earth.

We have included reference materials in the kit that provide content updates for teachers as well as students. Some of these include

- Teacher reference set of rocks
- Weathering and Erosion (DVD)
- Fearless Planet (DVD)
- Geologic Cross Section of the Grand Canyon (poster)
- Grand Canyon, View from Rim (poster)
- This Dynamic Planet (map)

In addition to these resources, FOSSweb has extensive resources including animations, stream-table simulations, interactive simulations, video field trips, slide shows, and a database of rocks.
FOSS MIDDLE SCHOOL COMPONENTS

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 and how to teach the subject in a middle school classroom is presented here, along with the resources that will assist the effort. Each middle school *Teacher Toolkit* has three parts.

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

- Overview
- Materials
- Investigations (nine in this course)

*Teacher Resources.* This collection of resources contains these chapters.

- FOSS Middle School Introduction
- Assessment
- Science Notebooks in Middle School
- Science-Centered Language Development in Middle School
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters
- Notebook Answers

The chapters contained in *Teacher Resources* can also be found on FOSSweb as PDFs.

*FOSS Science Resources.* This is the student book of readings, images, and data that are integrated into the instruction.

Equipment Kit

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 be asked to supply small quantities of common classroom items.
**FOSS Science Resources Books**

*FOSS Science Resources: Earth History* is a book of original readings developed to accompany this course, along with images and data to analyze during investigations. The readings are referred to as articles in the *Investigations Guide*. Students read the articles in the book as they progress through the course, sometimes during class and sometimes as homework. The articles cover a specific concept, usually after that concept has been introduced in an active investigation.

The articles in *FOSS Science Resources* and the discussion questions in the *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.

**FOSSweb and Technology**

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each course has an interactive site where students can find instructional activities, interactive simulations, virtual investigations, and other resources. FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Program, and technical support. You do not need an account to view this general FOSS Program information. In addition to the general information, FOSSweb provides digital access to PDF versions of *Teacher Resources* and digital-only resources that supplement the print and kit materials.

Additional resources are available to support FOSS teachers. With an educator account, 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 tutorials and online assessments.

**Ongoing Professional Development**

The Lawrence Hall of Science and Delta Education are committed to supporting science educators with unrivaled teacher support, high-quality implementation, and continuous staff-development opportunities and resources. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS. Find out about professional-development opportunities on FOSSweb.
FOSS INSTRUCTIONAL DESIGN

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

- Active investigation, including multimedia and outdoor experiences
- Recording in science notebooks to answer the focus question
- Reading in FOSS Science Resources
- Assessment to monitor progress and motivate student reflection on learning

In practice, these components are seamlessly integrated into a continuum designed to maximize every student’s opportunity to learn. An instructional sequence may move from one pedagogy to another and back again to ensure adequate coverage of a concept.

FOSS Investigation Organization

Courses are subdivided into investigations (eight to ten). Investigations are further subdivided into two to four parts. Each part of each investigation is driven by a focus question. The focus question, 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’ inquiry and makes the goal of each part explicit for teachers. Each part concludes with students preparing a written answer to the focus question in their notebooks.

Investigation-specific scientific and historical background information for the teacher is presented in each investigation chapter. The content discussion is divided into sections, each of which relates directly to one of the focus questions. This facilitates finding the exact information you need for each part of the investigation.

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

Teaching notes appear in blue boxes in the sidebar. An arrow points to the place in the lesson where the note applies. These notes constitute a second voice in the curriculum—an educative element. The first (traditional) voice is the message you deliver to students. It supports your work teaching students at all levels, from management to inquiry. The second educative voice is designed to help you understand the science content and pedagogical reasoning at work behind the instructional scene.

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The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups. Often a Reporter shares the group’s conclusions with the class.

The **vocabulary** icon indicates where students should record vocabulary in their science notebooks, often just before preparing for a benchmark assessment.

The **recording** icon points out where students should make a science notebook entry. Students can record on prepared notebook sheets or on plain sheets in a bound notebook.

The **engineering** icon indicates opportunities for addressing engineering practices—applying and using scientific knowledge. These opportunities include developing a solution to a problem, constructing and evaluating models, and using systems thinking.

The **reading** icon signals when the class should read a specific article or refer to data in *FOSS Science Resources*. Some readings are critical to instruction and should take place in class. A reading guide is provided for each such reading.

The **safety** icon alerts you to a potential safety issue. It could relate to the use of a chemical substance, such as salt, requiring protective eyewear, or the possibility of an allergic reaction when students use latex or legumes.

The **assessment** icon appears when there is an opportunity to assess student progress or performance. The assessment methods are usually one of three kinds: observation of students engaged in science practices, review of a notebook entry, or review of students’ work on a prepared assessment tool.

The **technology** icon indicates when to have one or more computers available for accessing FOSSweb to use the multimedia resources. The multimedia is not optional.

The **homework** icon indicates science learning experiences that extend beyond the classroom. Some of the readings are suggested as homework. In that case, you will see two icons by that step.

The **outdoor** icon indicates science learning experiences that extend into the schoolyard.

To help with scheduling, you will see icons for **breakpoints**. Some breakpoints are essential, and others are optional.
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 or challenge from you, or in some cases, from students. How do fossils get in rock? At other times, students are asked to plan a method for investigation. This might start with a teacher demonstration or presentation. Then you challenge students to plan an investigation, such as to find out how cooling rate affects crystal formation. 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.

Multimedia 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 multimedia 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 a summary of their learning as well as questions raised during the activity in their notebooks.

**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-size masters that can be filled in electronically and are suitable for projection are available on FOSSweb.

*TEACHING NOTE*

The Science Notebooks in Middle School chapter includes guidance on how to structure a student-centered notebook in terms of organization, content, and classroom logistics. Reading this chapter will help you consider your instructional practices for notebooks and incorporate new techniques supported by research about student learning.
Reading in 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 on weathering, erosion, soil formation, landforms, plate tectonics, fossils, geological time, and the rock cycle, as well as historical and biographical material.

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.

Assessing Progress

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

Formative assessment in FOSS, called embedded assessment, occurs on a daily basis. You observe action during class or review notebooks after class. 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.

Benchmark assessments are short summative assessments given after one or two investigations. These I-Checks are actually hybrid tools: they provide summative information about students’ achievement, and because they occur soon after teaching an investigation, they can be used diagnostically as well. Reviewing a specific item on an I-Check with the class provides another opportunity for students to clarify their thinking.
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. Within the instructional sequence, you will see the heading **What to Look For** in red letters. Under that, you will see bullet points telling you specifically what students should know and be able to communicate.

If student work is incorrect or incomplete, you know that there has been a breakdown in the learning/communicating process. The assessment system then 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 (survey), at the end of the course (posttest), and after one or two investigations (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments.

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**FOSS Instructional Design**

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**13. Assess progress: notebook entry**

Have each student turn back to the focus question they wrote in Investigation 2, Part 3.

➤ *Which came first, the sand or the sandstone?*

Have them spend a few minutes adding additional information to their response. They can use a line of learning or a different-colored pen to show their change in thinking.

At the end of class, have students leave their notebooks open to this page. Collect a few notebooks from each class. Plan to spend 15 minutes reviewing the sample of responses, using *Embedded Assessment Notes* as a tool. Record any misconceptions that are evident from students’ responses, and keep these in mind as you teach the next part of this investigation.

**What to Look For**

- **Students understand that sand is just small rocks, formed by rocks breaking into pieces.**
- **Students explain that sand can flow into a basin and become sandstone by a process that involves compaction and introduction of a cement by groundwater.**
- **Students mention that sandstone can again be broken into bits of sand by weathering.**

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*Earth History Course, Second Edition*
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. Since the output from the benchmark assessments is descriptive and complex, it can be used for formative as well as summative assessment.

Completely incorporating the assessment system into your teaching practice involves realigning your perception of the interplay between good teaching and good learning, and usually leads to a considerably different social order in the classroom with redefined student-student and teacher-student relationships.

**Science-Centered Language Development**

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 chapter in *Teacher Resources*, we explore the intersection of science and language and the implications for effective science teaching and language development. We identify best practices in language-arts instruction that support science learning and examine how learning science content and engaging in scientific practices support 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.

The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, and gives suggestions for additional literacy strategies. The Science-Centered Language Development chapter is a library of resources and strategies for you to use.
Management Strategies

Management Strategies

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 the 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. The *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 multimedia (darkened); eight computers networked and linked to the Internet along the far wall; and a library at the back. 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.
- Flat tables or desks appropriate for students to work in groups of four.
- Standard metric measuring tools and classroom supplies, including an electronic balance.
- A whiteboard, blackboard, overhead, or chart paper and marking pens.
- A surface for materials distribution.
- A place to clean and organize equipment.
- A place to store safety goggles that students can get to easily.
- A convenient place to store the kit.
- A computer lab or multiple computers.

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 be sure the multimedia is running smoothly.
- Position your LCD and/or overhead projector(s) where everyone can see comfortably.
Management Strategies

- 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, give him or her a chance to spend some time with the materials at a center. Another student might 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.

Allow the student to bring home FOSS Science Resources to read with a family member. Each article has a few review items that the student can respond to verbally or in writing.

And finally, encourage the student to use the resources on FOSSweb at school or at home for the missed class.
Managing Technology

The Earth History Course includes a multimedia component. The multimedia is 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 multimedia program to work simulations and representations.

The important attribute of the multimedia component is that it is interactive. Students can manipulate variables to see what happens. They can ask the important question What would happen if . . . , and then find out, using the multimedia simulations.

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. Plan on sessions in the computer lab for Investigations 3, 4, 6, 7, and 8.

Option 2: classroom computers. With four to eight computers in the science classroom, you can set up a multitasking environment with half the students working on the multimedia and half engaged in reading or small-group discussions. Then swap roles. This could take one or two periods, depending on the activity.

Option 3: learning centers. If you have access to only one computer system, plan to use it with the whole class with a projection system for large-group viewing, followed by opportunities for small groups of students to explore the simulations. Try to organize your classroom for several activities, one of which will be a computer station.

Option 4: 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.
UNIVERSAL DESIGN FOR LEARNING

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.

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 knowledge.


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 30-year tradition of multisensory science education and informed by recent research on UDL. Procedures found effective with students with special needs and students learning English are incorporated into the materials and procedures used with all 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.

Differentiated Instruction
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. 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 the vocabulary more explicit through new concrete experiences or through reading to the students. For some students, it might be scaffolding their thinking through graphic organizers. For other students, it might be designing individual projects or small-group investigations. And for some students, it might be more opportunities for experiencing science outside of the classroom in more natural, outdoor environments.

There are several possible strategies for providing differentiated instruction. The FOSS Program provides tools and strategies so that you know what students are thinking throughout the course. Based on that knowledge, read through the extension activities for experiences that might be appropriate for students who need additional practice with the basic concepts as well as those ready for more advanced projects. Opportunities to extend the investigation are listed at the end of each investigation. Use these ideas to meet the individual needs and interests of your students.
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. Five to eight weeks seems about optimum, so students might work in two groups throughout an 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.
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 Safety and Outdoor Safety, for classroom use.

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

Materials Safety Data Sheets (MSDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any MSDS, call Delta Education at 800-258-1302 (Monday–Friday 8 a.m. to 6 p.m. EST).

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.
# FOSS K–8 SCOPE AND SEQUENCE

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