INTRODUCTION

Geology is the study of our planet’s earth materials and natural resources. Because they are so ubiquitous and abundant, they are often take for granted. The Soils, Rocks, and Landforms Module provides students with firsthand experiences with soils, rocks, and minerals, and modeling experiences to study changes to rocks and landforms at Earth’s surface. In this module, students will

- Investigate the processes of physical and chemical weathering of rocks and minerals.
- Investigate the composition of soils from four different locations; observe and compare local soils.
- Use stream tables to investigate how the slow processes of erosion and deposition alter landforms; predict the results of a student-designed stream–table investigation, and then compare actual results to predictions.
- Use physical tools and a table of diagnostic properties to make observations and identify minerals in common rocks.
- Make observations and interpret them to develop explanations in the way that scientists do.
- Observe how earth materials are used in the community around school, and consider the ways people impact natural resources.
SOILS, ROCKS, AND LANDFORMS — Overview

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<td><strong>Inv. 1: Soils and Weathering</strong></td>
<td>Students investigate properties of soil by comparing four different soils. They learn that soils are composed of essentially the same types of materials (inorganic earth materials and humus), but the amounts of the materials vary. They begin to explore how rocks break into smaller pieces through physical and chemical weathering. Students go outdoors to explore and compare properties of local soils.</td>
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<td><strong>Inv. 2: Landforms</strong></td>
<td>Students use stream-table models to observe that water moves earth materials from one location to another. They investigate the variables of slope and water quantity and plan and conduct their own stream-table investigations. Students look for evidence of erosion and deposition outdoors. Students are introduced to processes that cause rapid changes to Earth’s surface: landslides, earthquakes, floods, and volcanoes.</td>
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<td><strong>Inv. 3: Rocks and Minerals</strong></td>
<td>Students collect local rocks and describe their observable properties. Then they focus on minerals that make up rocks and test common minerals for properties of hardness, streak, luster, and magnetism. They observe 11 common rock-forming minerals and use a Mineral Properties Table and geologists’ tests to identify the minerals. They study the rock granite and determine what minerals make up this common igneous rock.</td>
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<td><strong>Inv. 4: Natural Resources</strong></td>
<td>Students review what they have learned in Investigations 1–3. Then they focus on earth materials as renewable and nonrenewable natural resources. They learn the importance of earth materials as resources. The class makes a stepping stone out of concrete and goes on a schoolyard walk to find objects and structures and consider what natural resources were used to construct them.</td>
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Full Option Science System
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<th>Content</th>
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<tr>
<td>• Soils are composed of different kinds and amounts of earth materials and humus.</td>
<td><strong>Science Resources Book</strong>  &quot;What Is Soil?&quot;  &quot;Weathering&quot;  <strong>Media</strong>  <em>Weathering and Erosion Soils</em></td>
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<td>• Weathering is the breakdown of rocks and minerals at or near Earth's surface.  • The physical-weathering processes of abrasion and freezing break rocks into smaller pieces.  • Chemical weathering occurs when exposure to water and air changes rocks and minerals into something new.</td>
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<td>• Weathered rock material can be reshaped into new landforms by the slow processes of erosion and deposition.  • Erosion is the transport of weathered rock material (sediments) by moving water or wind.  • Deposition is the settling of sediments when the speed of moving water or wind declines.  • The rate and volume of erosion relate directly to the amount of energy in moving water or wind.  • Catastrophic events have the potential to change Earth's surface quickly.</td>
<td><strong>Science Resources Book</strong>  &quot;Erosion and Deposition&quot;  &quot;Landforms Photo Album&quot;  &quot;It Happened So Fast!&quot;  <strong>Media</strong>  <em>Volcanoes</em></td>
<td><strong>Embedded Assessment</strong>  Science notebook entry  Scientific practices  Response sheet  <strong>Benchmark Assessment</strong>  Investigation 2 I-Check</td>
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<tr>
<td>• Rocks are made of ingredients called minerals; minerals are made of only one ingredient.  • Minerals can be identified and seriated by hardness.  • Rocks and minerals can be described by their properties (including hardness, streak, and luster).  • Granite is an igneous rock containing rock-forming minerals quartz, feldspar, mica, and hornblende.  • Igneous, sedimentary, and metamorphic rocks are formed by different processes.</td>
<td><strong>Science Resources Book</strong>  &quot;Where Do Rocks Come From?&quot;  &quot;Mohs' Scale and Birthstones&quot;  &quot;Identifying Minerals&quot;  &quot;Mining for Minerals&quot;</td>
<td><strong>Embedded Assessment</strong>  Scientific practices  Response sheet  Science notebook entry  <strong>Benchmark Assessment</strong>  Investigation 3 I-Check</td>
</tr>
<tr>
<td>• Rocks and minerals are natural resources important for shelter and transportation.  • Concrete is an important building material made from earth materials.  • Some natural resources are renewable (sunlight, air and wind, water, soil, plants, and animals) and some are nonrenewable (minerals and fossil fuels).</td>
<td><strong>Science Resources Book</strong>  &quot;Monumental Rocks&quot;  &quot;Geoscientists at Work&quot;  &quot;Making Concrete&quot;  &quot;Earth Materials in Art&quot;  <strong>Media</strong>  <em>Natural Resources</em></td>
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FOSS CONCEPTUAL FRAMEWORK

In the last half decade, teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—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 students can and should understand about these core ideas in primary school years, and progressively more complex and sophisticated things they should know as they gain experience and develop cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum for students.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing a learning progression involves identifying successively more sophisticated ways of thinking about a core idea over multiple years. “If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination” (National Research Council, *A Framework for K–12 Science Education*, 2011).

The FOSS modules are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, as shown in the table below for the FOSS Elementary Program. Each strand represents a core idea in science and has a conceptual framework.

- **Physical Science**: matter; energy and change
- **Earth and Space Science**: dynamic atmosphere; rocks and landforms
- **Life Science**: structure and function; complex systems

The sequence 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.

Information about the FOSS learning progression appears in the **conceptual framework** (page 7), which shows the structure of scientific knowledge taught and assessed in this module, and the **content sequence** (pages 14–15), a graphic and narrative description that puts this single module into a K–8 strand progression.

Full Option Science System
In addition to the science content development, every module provides opportunities for students to engage in and understand the importance of scientific practices, and many modules explore issues related to engineering practices and the use of natural resources.

**Asking questions and defining problems**
- Ask questions about objects, organisms, systems, and events in the natural and human-made world (science).
- Ask questions to define and clarify a problem, determine criteria for solutions, and identify constraints (engineering).

**Planning and carrying out investigations**
- Plan and conduct investigations in the laboratory and in the field to gather appropriate data (describe procedures, determine observations to record, decide which variables to control) or to gather data essential for specifying and testing engineering designs.

**Analyzing and interpreting data**
- Use a range of media (numbers, words, tables, graphs, images, diagrams, equations) to represent and organize observations (data) in order to identify significant features and patterns.

**Developing and using models**
- Use models to help develop explanations, make predictions, and analyze existing systems, and recognize strengths and limitations of proposed solutions to problems.

**Using mathematics and computational thinking**
- Use mathematics and computation to represent physical variables and their relationships and to draw conclusions.

**Constructing explanations and designing solutions**
- Construct logical explanations of phenomena, or propose solutions that incorporate current understanding or a model that represents it and is consistent with available evidence.

**Engaging in argumentation from evidence**
- Defend explanations, develop evidence based on data, examine one’s own understanding in light of the evidence offered by others, and challenge peers while searching for explanations.

**Obtaining, evaluating, and communicating information**
- Communicate ideas and the results of inquiry—orally and in writing—with tables, diagrams, graphs, and equations, in collaboration with peers.

*A Framework for K–12 Science Education* describes these eight scientific and engineering practices as essential elements of a K–12 science and engineering curriculum.
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK in Soils, Rocks, and Landforms

Origin of Earth

The rocks that form mountains; the water flowing in rivers, filling the ocean and forming clouds; the oxygen, carbon dioxide, and other gases that compose the atmosphere—these are all examples of what scientists call earth materials. All life on Earth depends on these materials, for they, with the addition of the Sun’s energy, provide the food, air, and water that every living plant and animal needs to survive.

The study of the atmosphere, Earth’s crust and interior, and its rivers and ocean is the task of the earth scientist. This module focuses on the properties of the solid materials that form Earth—the minerals, the rocks, and the landforms.

Geology is simply the study of Earth. Physical geology focuses on the materials that Earth is made of and the processes, such as erosion and mountain building, that occur at and below Earth’s surface. Historical geology focuses on understanding Earth’s origin, its physical development, and its future.

The latest theories suggest that Earth began as a protoplanet (a planet in the making), condensing out of the debris surrounding the protosun. Once formed, Earth fortuitously settled into orbit at a favorable distance from the thermonuclear reactions of the Sun, and had a gravitational field that allowed an atmosphere to form.

During the early history of Earth, the decay of radioactive elements and the heat released by colliding particles within Earth melted its interior. The heavier elements, mostly iron and nickel, sank to the center of Earth, while the lighter elements that compose most of Earth’s crust migrated upward. Layers of different materials formed inside Earth.

Today, geologists describe four basic layers of Earth’s interior: the inner core, a mostly solid iron-rich zone about 1216 km thick; the outer core, a molten metallic layer 2270 km thick; the mantle, a semi-solid, extremely viscous layer of molten-rock materials (minerals) of varying thickness up to 2885 km thick; and the crust, a thin outer skin of rock ranging from 5 to 40 km thick. It is with the crust that we are mostly concerned.
Soil
What is soil? To the farmer, soil is the layer of earth material in which plants anchor their roots and from which they get the nutrients and water they need to grow. To a geologist, soil is the layer of earth materials at Earth’s surface that has been produced by weathering of rocks and sediments and that hasn’t moved from its original location. To an engineer, soil is any ground that can be dug up by earth-moving equipment and requires no blasting. And to students, soil is dirt. In FOSS, soil is defined as a mixture of different-size earth materials, such as gravel, sand, and silt, and organic material called humus. Humus is the dark, musty-smelling stuff derived from the decayed and decomposed remains of plant and animal life. The proportions of these materials that make up soil differ from one location to another. All life depends on a dozen or so elements that must ultimately be derived from Earth’s crust. Soil has been called the bridge between earth material and life; only after minerals have been broken down and incorporated into the soil can plants process the nutrients and make them available to people and other animals.

Minerals and Rocks
According to one estimate, over 4000 different chemical compounds have been identified in Earth’s crust, and new ones are still being discovered. These chemical compounds are minerals. Minerals are the basic ingredients that make up the crust. Minerals occur naturally, and their composition is expressed by a chemical formula, such as NaCl, salt.

Minerals may occur as deposits of the pure materials, or they may be found in combination with other minerals, forming rocks. Each mineral in a rock has its own identifiable physical and chemical properties, which contribute to the properties of the rock.

Conceptual Framework

CONCEPTUAL FRAMEWORK
Earth Science, Rocks and Landforms: Soils, Rocks, and Landforms

Structure of Earth
Concept A  The geosphere (lithosphere) has properties that can be observed and quantified.
- Rocks are composed of minerals.
- There are three kinds of rock—igneous, sedimentary, and metamorphic.
- Soils vary from place to place and can be described by their properties.

Concept B  The hydrosphere has properties that can be observed and quantified.
- Water exists in three states on Earth: solid, liquid, and gas.

Concept C  Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources.
- Resources are distributed unevenly around the planet as a result of past geological processes; some resources are nonrenewable.
- People use earth materials to construct things. Properties of different earth materials make them suitable for specific uses.
- People can conserve resources.

Earth Interactions
Concept A  All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems.
- Earth changes over time. Understanding how landforms develop, are weathered and erode can help infer Earth’s history. Some events happen quickly; others take a long time; others happen in cycles.
Eight elements make up 98 percent of all the minerals in Earth’s crust: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium. These elements combine to form about 25 common minerals. The other 4000 or so minerals that have been identified are considered rare. More than 200 kinds of rocks are formed from these 25 minerals.

Silicon and oxygen, the two most abundant elements, combine to form the most common mineral group, the silicates. The silicate group includes minerals such as quartz, feldspar, mica, and hornblende.

The next most common mineral group is the carbonates. Carbonates contain carbon and oxygen. The mineral calcite is the most common member of the carbonate group.

**Rock Formation**

Where do rocks come from? How do they form? These innocent questions invite inquiry into one of the most challenging topics in geology. First of all, most of the material in Earth rocks has been here for 4.6 billion years or so. It all accreted from the batch of dust and water that happened to be in the vicinity when the solar system formed. We can imagine that, soon after Earth formed, the rocky material at the surface began to harden and the first rocks took shape. Because Earth is a dynamic place, those earliest rocks have all been recycled. We don’t know what the first rocks looked like, but we can be sure that they were igneous in origin.

Igneous rocks harden from molten material. You have probably seen images of red glowing lava pouring down the side of a volcano. That’s melted rock. When it cools, it is brand new rock, and because it originated as a liquid, it is igneous rock. Molten rock that comes to the surface and hardens in air or water is extrusive igneous rock. Molten rock that solidifies below the surface is intrusive igneous rock. Both qualify as igneous because they solidified from molten material.

Igneous rock is extremely varied. Featherweight pumice, shot into the air as frothy gobbets of molten material, solidifies almost immediately. Pumice floats in water. Scoria, also riddled with gas-bubble holes, and glassy obsidian are fast-cooling igneous rocks. At the other extreme are the dense granites and denser basalts. Most of Earth’s crust is made of these two kinds of rock—granite and basalt.

Igneous rocks eventually weather into bits and pieces. These are transported downhill until they accumulate in some kind of catchment, usually a water-filled basin like a lake or sea. Here the pieces of sand, silt, clay, and gravel, known as sediment, settle to the bottom of the
basin. The process is called deposition. Over time huge layers of sediments can deposit in a basin. The burden of later sediments and chemical processes can compact and cement the particles together. This is how sedimentary rocks form. Sedimentary rocks are accumulations of bits of older rocks and chemicals from the environment that are transformed into new rocks. Sedimentary rocks are often seen in cliffs and road cuts, still positioned in the layers that represent the original deposits from which they formed.

Dynamic processes can bury both igneous and sedimentary rocks. When overburden creates pressure and heat, changes can happen in the buried rocks. The chemicals might reformulate, and crystalline structures might change. After exposure to heat and pressure, new rocks form from the old ones. The new rocks are metamorphic rocks. The metamorphic process can be lengthy, as described above, but other metamorphic processes can proceed quite rapidly. On occasion a rising mass of magma (molten rock) might push through a section of crust. The rocks in the crust will be subjected to intense heat and pressure over a short time, producing metamorphic rocks in the immediate vicinity of the magma. Rock on an earthquake fault is subject to similar localized heat and pressure during an earthquake, and the infrequent occurrence of a meteor or comet impact can metamorphose rocks in an instant.

These complex ideas involve complex processes that require, in most cases, millions of years to complete. The products that emerge are often messy and difficult to analyze as to content and origin without high-powered laboratory equipment and processes. These concepts should be kept simple for students of this age: igneous rocks come from volcanoes; sedimentary rocks are little bits of rock that erode into basins and turn into rock; metamorphic rocks are old rocks that get changed into new rocks by heat and pressure.

**Earth Materials and Human Uses**

Humans from the earliest of times have used earth materials to fashion a wide variety of tools: mortars for grinding; axes, carving tools, digging sticks, hammers, and sickles for domestic and agricultural use; and daggers and arrowheads for weapons. Rocks and minerals have been used in many forms of art, from sculptures to decorative paints and jewelry. And ore minerals are the source of most useful metals. Copper was used to make beads and pins even before 5000 BCE.

Today earth materials continue to be a part of our lives at all levels. Children use the earth to make mud pies and sand castles. Adults put earth materials together to build roads, bridges, and buildings.
Erosion Shapes the Land

Anyone who has stood at the edge of Grand Canyon in Arizona has witnessed the results of awesome forces that interacted and changed the face of Earth. Few landforms on Earth’s surface rival Grand Canyon in size, beauty, and grandeur. Its dimensions—over 1.6 km deep in places, over 14 km wide, and almost 350 km long—are mind-boggling. At the bottom of the canyon is a café-au-lait ribbon of water that looks insignificant from the vantage point of the canyon rim. The ribbon is the Colorado River, and it can take most of the credit for creating this awe-inspiring landform. Grand Canyon can serve as our example to explore erosion.

This magnificent canyon began its life as a simple gully crossing a landform called the Colorado Plateau. Until maybe 7 million years ago the land was fairly flat, and water in the streams moved sluggishly. Then the Colorado Plateau was uplifted. As it rose, it tilted, increasing the slope of the land over which the ancient Colorado River flowed. This change in the slope multiplied the river’s ability to erode the rock and to carry sediments. Sediments are earth materials that have been eroded, transported, and eventually deposited. Just as a saw cuts through a piece of wood, the Colorado River cut through thousands of meters of rock, exposing what are today the walls of Grand Canyon.

Erosion takes several forms in Grand Canyon. Running water plays the most important role. The Colorado River carries a heavy load of earth materials. Some minerals, such as salts and carbonates, dissolve and travel in solution down the river. Tiny particles, such as silt, clay, and sand, travel in suspension, and heavier particles, such as gravel, cobbles, and boulders, roll and tumble down the riverbed. The materials carried by the river flow, slide, and roll along the sides and bottom of the stream channel, further eroding the riverbed as they pound, scrape, and scour, knocking off and carrying away additional rock particles.

Water can erode rock in another way. When water infiltrates cracks in rocks and the temperature falls below 0°C, the water freezes, expands, and breaks already weakened rock along the cracks. Huge blocks of rock can be wedged off the cliffs, accelerating the rate of erosion.

Gravity’s effect on large masses of rock also contributes to erosion. Gravity is the force behind rockfalls—large masses of broken rocks falling to the bottom of a cliff. This rock debris (talus) may continue to move imperceptibly downslope under the force of gravity.

Wind also erodes the canyon. Cliffs are literally sandblasted by strong winds carrying particles of sand. The particles wear away material that in turn is carried away by the wind.
The shape of Grand Canyon is also affected by differential erosion. Some rocks are more resistant to erosion than others. The results are often striking and may appear as caps of erosion-resistant rock perched on pinnacles of weaker rock, forming what people call hoodoos, goblins, and other names that pique the imagination. Western-movie buffs will recognize these landforms as traditional background scenery.

Although they haven’t played a part in shaping Grand Canyon, glaciers have produced dramatic changes to Earth’s surface in many areas. Huge continental glaciers gouged out the basins of the Great Lakes in the Midwest and the Finger Lakes in New York, and rounded the peaks and hills of most of the northern areas of the United States and Canada. Ancient valley glaciers carved Yosemite Valley in California, and valley glaciers are still at work in Alaska and on the slopes of mountains such as Mt. Rainier (Washington) and Mt. Shasta (California). Glaciers form from an accumulation of ice and snow that doesn’t melt from year to year. The weight of the ice eventually makes the glacier flow and push its way over the land. The cold and the weight of the ice freeze pieces of rock to the bottom surface of the glacier and tear them away from the bedrock. This turns the glacier into a gigantic sandpaper block, scraping and polishing the rock surfaces over which it moves.

**Deposition Creates Other Landforms**

The material eroded and transported by water, wind, and ice is the raw material of new landforms. When a stream slows down or dries up and can no longer carry its load, when the wind stops blowing, or when a glacier melts, the materials it carried are deposited.

Deposition is the process by which eroded earth materials settle out of the air, water, or ice. The amount of material carried by water depends primarily on the energy in the stream. Anything that increases the velocity of the water—an increase in slope or the amount of water, or a reduction in the friction of the water in contact with the riverbed due to a greater volume of water—increases the stream’s capacity for carrying a load. Anything that decreases the velocity or volume of water—a decrease in slope with no increase in water volume, an obstruction such as a dam, a stream joining a larger body of water—will cause a stream to drop its burden as sediments. The larger, heavier sediments such as boulders and gravel are deposited first, then the finer sand and silt. The salts and other minerals in solution are usually not deposited until the body of water in which they are dissolved evaporates.
The following list describes just a few of the great variety of landforms caused by erosion and deposition.

**Alluvial fan:** a fan-shaped deposit of earth materials formed where a stream flows from a steep slope onto flatter land.

**Canyon:** a V-shaped gorge with steep sides eroded by a stream.

**Delta:** a fan-shaped deposit of earth materials at the mouth of a stream.

**Dune:** a mound, ridge, or hill of wind-blown sand.

**Floodplain:** land that gets covered with water during a flood.

**Hill:** an isolated elevation in the land, usually no more than 30 m from base to peak.

**Levee:** an embankment along a stream that protects land from flooding. Levees can be natural or constructed.

**Meander:** a curve or loop in a river or a stream.

**Mesa:** an isolated, broad, flat-topped hill having at least one steep cliff.

**Mouth:** where a stream enters another body of water.

**Valley:** a low area between hills and mountains, where a stream often flows.

**Waterfall:** a steep to vertical descent of a stream channel.

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**Landforms**

Landforms can be very complex. Geographers, the scientists who study the features of Earth’s surface, describe and classify landforms in terms of several features and properties. These features include what landforms are made of, the process that formed them, and their relative age. One classification scheme describes three basic landform types. Mountains are the high, steeply sloped, uplifted areas of Earth’s surface. Some examples are the Rocky Mountains, the Andes, and the Himalayas. Plateaus are high, nearly level, uplifted areas composed of horizontal layers of rock. The Colorado Plateau through which the Colorado River flows and the Columbia Plateau in the northwest United States are examples of plateaus. Plains are low areas of Earth that either have been eroded nearly level or are formed of flat-lying sediments. The Great Plains in the midsection of the United States and the coastal plains along the continental boundaries are examples of this landform.

**Rapid Versus Slow Change**

Most processes that cause Earth’s surface to change happen at quite a bit less than a snail’s pace, with the effects accumulating over millions of years. Weathering, erosion, deposition, and movement of glaciers usually happen at such slow rates that only detailed records of observations of rocks, sediments, and landforms and good inferences provide support that change has occurred. But sometimes changes happen rapidly. Periodically intense rains result in massive flows of water, or floods. During floods, a stream’s speed increases dramatically. Giant boulders can roll down watercourses, and the force of the water undermines and carries away trees. Rivers can overflow their banks and change their course. Huge amounts of earth material can erode from one place and deposit in another during floods.

During these powerful natural events, human structures take a beating. Houses, washed from their foundations, end up in the rivers. Railroads and highways that follow a river’s floodplain wash away periodically. Reservoirs can become clogged with the sediments washed in by a river. Bridges, dams, and other structures fight against the natural processes that work to change the shape of the land.

Earthquakes, landslides, and volcanoes also produce relatively fast changes to the landscape. An understanding of the causes and effects of these various earth movements is important to anyone living in areas impacted by these processes. The effects are both beautiful landforms and scenery, and disasters to structures and lifestyle at the same time.
Where It Goes from Here

Throughout this module students learn the basic ideas that contribute to some of the big ideas and inferences geologists have conceived to explain the structure of Earth’s interior and crust and the internal and external processes that build and change them. The theory of plate tectonics has unified many observations and verified relationships geologists have made and discovered about Earth’s surface.

Geology and Elementary Students

The study of earth science offers a number of challenges. The planet Earth is an extremely large laboratory with many of its secrets not yet discovered or understood. Identifying all the variables that influence the creation of a rock or the eruption of a volcano is a formidable task. The processes that create earth materials take millions and millions of years, making them impossible to replicate in the laboratory or classroom. Yet students can undertake investigations in the classroom to prepare themselves to better understand the structure of their world.

In this module we emphasize several types of investigations. Students will have a variety of direct experiences with samples of earth materials, both rock and mineral. They will make detailed observations using meter tapes and hand lenses and will conduct a variety of simple physical tests that develop skills of rock and mineral identification.

Students also take materials apart and put materials together to gain an understanding of the complexity of earth materials. Although they cannot physically put rocks together, their experiences with the ingredients give them the basis for mentally putting a rock together. This is the same mental process a geologist must go through when examining fossils or rock materials and coming up with ideas about their origin and history.

Most Earth-shaping events happen on such a large scale and in such inaccessible places that it is impossible for students to experience them directly. So students also set up investigations to simulate processes of chemical and physical weathering. They view images and read about places where these processes occur in nature.

Models—small, simplified representations of the larger objects and events—are used by scientists to better comprehend the larger realities. Students set up stream tables to investigate some of the conditions that affect erosion and deposition in stream systems. From these experiences, it is expected that students will see relationships between their models and landforms in the world around them.
## Rocks and Landforms Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “rocks and landforms” for grades K–8. Running through the sequence are the two progressions—structure of Earth and Earth interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the **Soils, Rocks, and Landforms Module** are expanded to show how they fit into the sequence.

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<th>Module or course</th>
<th>Structure of Earth</th>
<th>Earth interactions</th>
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| Earth History                    | • The geological time scale, interpreted from rock strata and fossils, provides a way to organize Earth’s history. Lower layers are older than higher layers—superposition.  
  • Earth’s crust is fractured into plates that move over, under, and past one another.  
  • Volcanoes and earthquakes occur along plate boundaries.  
  • The rock cycle is a way to describe the process by which new rock is created. | • Landforms are shaped by slow, persistent processes driven by weathering, erosion, deposition, and plate tectonics.  
  • Water’s movement changes Earth’s surface.  
  • Energy is derived from the Sun and Earth’s hot interior.  
  • All Earth processes are the result of energy flowing and matter cycling within and among Earth’s systems.  
  • Evolution is shaped by geological conditions. |
| Soils, Rocks, and Landforms      |                                                                                     |                                                                                     |
| Water                            | • Water is found almost everywhere on Earth, e.g., vapor, clouds, rain, snow, ice.  
  • Water expands when heated, contracts when cooled, and expands when frozen.  
  • Cold water is more dense than warmer water; liquid water is more dense than ice.  
  • Soils retain more water than rock particles alone. | • Water moves downhill; the steeper the slope, the faster water moves. Flowing water can do work.  
  • Ice melts when heated; liquid water freezes when cooled. |
| Pebbles, Sand, and Silt          | • Rocks are earth materials composed of minerals; rocks have properties.  
  • Rock sizes include clay, silt, sand, gravel, pebbles, cobbles, and boulders.  
  • The properties of different earth materials make them suitable for specific uses.  
  • Water can be a solid, liquid, or gas. | • Smaller rocks result from weathering.  
  • Water carries soils and rocks from one place to another.  
  • Soil is made partly from weathered rock and partly from organic material.  
  • Soils vary from place to place. Soils differ in their ability to support plants. |
| Materials in Our World           | • Rocks, water, and soils are earth materials.  
  • Rocks and soils have observable properties with which they can be described and sorted.  
  • Land, air and water, and trees are natural resources. | • Water can change from solid to liquid when heated and from liquid to solid when cooled. |
### Structure of Earth

- Soils are composed of different kinds and amounts of earth materials and humus; they can be described by their properties.
- Rocks are made of minerals; rocks and minerals can be described and identified by their properties: hardness, streak, luster, and cleavage.
- There are three kinds of rocks: igneous, sedimentary, and metamorphic.
- Water exists in three states.
- Earth materials are natural resources. Some resources are renewable, others are not.

### Earth Interactions

- Physical and chemical weathering breaks rock into smaller pieces (sediments).
- Erosion is the movement of sediments; deposition is the process by which sediments come to rest in another place.
- Landslides, earthquakes, and volcanoes can produce significant changes in landforms in a short period of time.
- Some changes happen quickly, others more slowly.
- Some events happen in cycles; others have a beginning and an end.
- Downhill movement of water as it flows to the ocean shapes land.
SOILS, ROCKS, AND LANDFORMS — Overview

The Soils, Rocks, and Landforms Module aligns with the NRC Framework. The module addresses these 3–5 grade band endpoints described for core ideas from the national framework for Earth’s systems and Earth and human activity.

Earth and Space Sciences

Core idea ESS1: Earth’s place in the universe—What is the universe, and what is Earth’s place in it?

- ESS1.C: How do people reconstruct and date events in Earth’s planetary history? [Earth has changed over time. Understanding how landforms develop, are weathered and erode can help to infer the history of the current landscape.]

Core idea ESS2: Earth’s systems—How and why is Earth constantly changing?

- ESS2.A: How do the major Earth systems interact? [Rainfall, water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.]
- ESS2.B: Why do the continents move, and what causes earthquakes and volcanoes? [The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Earthquakes happen near or deep below Earth’s surface, volcanoes are found on the continents and ocean floor, major mountain chains form inside continents or near edges. Maps can help locate the different land and water features where people live and in other areas of Earth.]
- ESS2.C: How do the properties and movements of water shape Earth’s surface and affect its systems? [The downhill movement of water shapes the appearance of the land.]
- ESS2.E: How do living organisms alter Earth’s processes and structures? [Many types of rocks and minerals are formed from the remains of organisms or are altered by their activities.]
Core idea ESS3: Earth and human activity—How do Earth’s surface processes and human activities affect each other?

- ESS3.A: How do humans depend on Earth’s resources? [All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.]

- ESS3.B: How do natural hazards affect individuals and societies? [A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.]

- ESS3.C: How do humans change the planet? [Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments.]

Engineering, Technology, and Applications of Science Core idea ETS2: Links among engineering, technology, science, and society—How are engineering, technology, science, and society interconnected?

- ETS2.B: How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world? [Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world.]
SOILS, ROCKS, AND LANDFORMS — Overview

FOSS 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 module, how to teach the subject, and the resources that will assist the effort are presented here. Each toolkit has three parts.

Investigations Guide. This spiral-bound document contains these chapters.
- Overview
- Materials
- Investigations (four in this module)

Teacher Resources. This three-ring binder contains these chapters.
- FOSS Introduction
- Assessment
- Science Notebooks in Grades 3–6
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

The chapters contained in the Teacher Resources and the Spanish duplication masters can also be found on FOSSweb (www.FOSSweb.com) and on CDs included in the Teacher Toolkit.

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

Equipment Kit
The FOSS Program provides the materials needed for the investigations, including metric measuring tools, 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 two uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom items.
**FOSS Science Resources Books**

*FOSS Science Resources: Soils, Rocks, and Landforms* is a book of original readings developed to accompany this module. The readings are referred to as articles in the *Investigations Guide*. Students read the articles in the book as they progress through the module. The articles cover a specific concept, usually after that concept has been introduced in an active investigation.

The articles in *Science Resources* and the discussion questions provided 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 module has an interactive site where students and families can find instructional activities, interactive simulations and virtual investigations, and other resources. FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Project, 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 the *Teacher Resources* component of the *Teacher Toolkit* 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 modules 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 design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation, including 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

Modules are subdivided into investigations (four in this module). Investigations are further subdivided into three to five parts. 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. Each part concludes with students recording an answer to the focus question in their notebooks.

Investigation-specific scientific 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 section ends with information about teaching and learning and a conceptual-flow diagram for the content.

The Getting Ready and Guiding the Investigation sections have several features that are flagged or presented in the sidebars. 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 sidebars. These notes comprise 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, shared as a teaching note, is designed to help you understand the science content and pedagogical rationale at work behind the instructional scene.

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 a potential safety issue. It could relate to the use of a chemical substance, such as salt, requiring safety goggles, or the possibility of a student allergic reaction when students use latex, legumes, or wheat.

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 new-word icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully. The new vocabulary should also be entered onto the word wall (or pocket chart). A complete list of the scientific vocabulary used in each investigation appears in the sidebar on the last page of the Background for the Teacher section.

The vocabulary icon indicates where students should review recently introduced vocabulary, often just before they will be answering the focus question or preparing for benchmark assessment.

The recording icon points out where students should make a science-notebook entry. Students record on prepared notebook sheets or, increasingly, on pages in their science notebooks.

The reading icon signals when the class should read a specific article in the FOSS Science Resources book, preferably during a reading period.

The assessment icon appears when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some of the embedded-assessment methods for grades 3–6 include observation of students engaged in scientific practices, review of a notebook entry, and response sheets.

The outdoor icon signals when to move the science learning experience into the schoolyard. It also helps you plan for selecting and preparing an outdoor site for a student activity.

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 EL note in the sidebar provides a specific strategy to use to assist English learners in developing science concepts. A discussion of strategies is in the Science-Centered Language Development chapter.

To help with pacing, 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 weathered rock pieces move from one place to another?) 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 slope affects erosion and deposition. 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, observe systems and interactions, and 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.

**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 science notebooks. Data recording is the first of several kinds of student writing.

Students then organize data so 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 science notebooks a summary of their learning as well as questions raised during the activity.

Science Notebooks

Research and best practice have led FOSS 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. The science-notebook entries stand as credible and useful expressions of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for grades 1–6 presented in notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) into a bound composition book. Full-size duplication masters are also available on FOSSweb. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets.
Reading in FOSS Science Resources

The FOSS Science Resources books emphasize expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time. When language-arts skills and methods are embedded in content material that relates to the authentic experience students have had during the FOSS active learning sessions, students are interested, and they get more meaning from the text material.

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 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 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 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 module (Survey) and at the end of the module (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 or not a student knows a piece of science content. They 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.

15. Assess progress: notebook entry

Have students hand in their notebooks open to the page on which they answered the focus question. After class, review students’ entries to see if students clearly understand the difference between erosion and deposition.

**What to Look For**

- *Students describe erosion as part of the sediment-moving process:* earth materials are carried away by moving water in rivers, forming valleys.

- *Students describe deposition as part of the process:* the eroded earth materials eventually are deposited somewhere downstream, for example, in an alluvial fan or delta—smaller particles usually move farther than larger particles.
Taking FOSS Outdoors

FOSS throws open the classroom door and proclaims the entire school campus to be the science classroom. The true value of science knowledge is its usefulness in the real world and not just in the classroom. Taking regular excursions into the immediate outdoor environment has many benefits. First of all, it provides opportunities for students to apply things they learned in the classroom to novel situations. When students are able to transfer knowledge of scientific principles to natural systems, they experience a sense of accomplishment.

In addition to transfer and application, students can learn things outdoors that they are not able to learn indoors. The most important object of inquiry outdoors is the outdoors itself. To today’s youth, the outdoors is something to pass through as quickly as possible to get to the next human-managed place. For many, engagement with the outdoors and natural systems must be intentional, at least at first. With repeated visits to familiar outdoor learning environments, students may first develop comfort in the outdoors, and then a desire to embrace and understand natural systems.

The last part of most investigations is an outdoor experience. Venturing out will require courage the first time or two you mount an outdoor expedition. It will confuse students as they struggle to find the right behavior that is a compromise between classroom rigor and diligence and the freedom of recreation. With persistence, you will reap rewards. You will be pleased to see students’ comportment develop into proper field-study habits, and you may be amazed by the transformation of students with behavior issues in the classroom who become your insightful observers and leaders in the schoolyard environment.

Teaching outdoors is the same as teaching indoors—except for the space. You need to manage the same four core elements of teaching: time, space, materials, and students. 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 the Teacher Resources.

FOSS is very enthusiastic about this dimension of the program and looks forward to hearing about your experience using the schoolyard as a logical extension of your classroom.
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. For students, language development is intimately involved in their learning about the natural world. Science provides a real and engaging context for developing literacy, and language-arts skills and strategies support conceptual development and scientific practices. For example, 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. Students’ use of language improves when they discuss (speak and listen, as in the Wrap-Up/Warm-Up activities), write, and read about the concepts explored in each investigation.

There are many ways to integrate language into science investigations. 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. The last section covers language-development strategies that are specifically for English learners.
FOSSWEB AND TECHNOLOGY

FOSS is committed to providing a rich, accessible technology experience for all FOSS users. FOSSweb is the Internet access to FOSS digital resources. It provides enrichment for students and support for teachers, administrators, and families who are actively involved in implementing and enjoying FOSS materials. Here are brief descriptions of selected resources to help you get started with FOSS technology.

Technology to Engage Students at School and at Home

Multimedia activities. The multimedia simulations and activities were designed to support students’ learning. They include virtual investigations and student tutorials that you can use to support students who have difficulties with the materials or who have been absent.

FOSS Science Resources. The student reading book is available as an audio book on FOSSweb, accessible at school or at home. In addition, as premium content, FOSS Science Resources is available as an eBook. The eBook supports a range of font sizes and can be projected for guided reading with the whole class as needed.

Home/school connection. Each module includes a letter to families, providing an overview of the goals and objectives of the module. Most investigations have a home/school activity providing science experiences to connect the classroom experiences with students’ lives outside of school. These connections are available in print in the Teacher Resources binder and on FOSSweb.

Student media library. A variety of media enhances students’ learning. Formats include photos, videos, an audio version of each student book, and frequently asked science questions. These resources are also available to students when they log in with a student account.

Recommended books and websites. FOSS has reviewed print books and digital resources that are appropriate for students and prepared a list of these media resources.

Class pages. Teachers with a FOSSweb account can easily set up class pages with notes and assignments for each class. Students and families can then access this class information online.
Technology to Support Teachers

**Teacher-preparation video.** The video presents information to help you prepare for a module, including detailed investigation information, equipment setup and use, safety, and what students do and learn through each part of the investigation.

**Science-notebook masters and teacher masters.** All notebook masters and teacher masters used in the modules are available digitally on FOSSweb for downloading and for projection during class. These sheets are available in English and Spanish.

**Assessment masters.** The benchmark assessment masters for grades 1–6 (I-Checks) are available in English and Spanish.

**Focus questions.** The focus questions for each investigation are formatted for classroom projection and for printing onto labels that students can glue into their science notebooks.

**Equipment photo cards.** The cards provide labeled photos of equipment supplied in each FOSS kit.

**Materials Safety Data Sheets (MSDS).** These sheets have information from materials manufacturers on handling and disposal of materials.

**Teacher Resources chapters.** FOSSweb provides PDF files of all chapters from the Teacher Resources binder.

- Assessment
- Science Notebooks
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology

**Streaming video.** Some video clips are part of the instruction in the investigation, and others extend concepts presented in a module.

**Resources by investigation.** This digital listing provides online links to notebook sheets, assessment and teacher masters, and multimedia for each investigation of a module for projection in the classroom.

**Interactive whiteboard resources.** You can use these slide shows and other resources with an interactive whiteboard.

**Investigations eGuide.** The eGuide is the complete Investigations Guide component of the Teacher Toolkit in an electronic web-based format, allowing access from any Internet-enabled computer.

**NOTE**

The Spanish masters are available only on FOSSweb and on one of the CDs provided in the Teacher Toolkit.
Module summary. The summary describes each investigation in a module, including major concepts developed.

Module updates. These are important updates related to the teacher materials, student equipment, and safety guidelines.

Module teaching notes. These notes include teaching suggestions and enhancements to the module, sent in by experienced FOSS users.

FOSSmap and online assessments. A computerized assessment program, called FOSSmap, provides a system for students in grades 3–6 to take assessments online, and for you to review those assessments online and to assign tutorial sessions for individual students based on assessment performance. You generate a password for students to access and take the assessments online.

Most assessment items are multiple-choice, multiple-answer, or short-answer questions, but for one or two questions, students must write sentences. These open-response questions can be answered either online or using paper and pencil.

After students have completed a benchmark assessment, FOSSmap automatically codes (scores) the multiple-choice, multiple-answer, and short-answer questions. You will need to check students’ responses for short-answer questions to make sure that the questions have been coded correctly. Students’ open-response questions are systematically displayed for coding. If students have taken any part of the test via paper and pencil, you will need to enter students’ answers on the computer for multiple-choice and multiple-answer questions (the computer automatically codes the answers), and to code the short-answer and open-response questions.

Once the codes are in the FOSSmap program, you can generate and display several reports.

The Code-Frequency Report is a bar graph showing how many students received each code. This graph makes it easy to see which items might need further instruction.

In the Class-by-Item Report, each item is presented in a text format that indicates a percentage and provides names of students who selected each answer. It also describes what a code means in terms of what students know or need to work on.

The Class-by-Level Report describes four levels of achievement. It lists class percentages and students who achieved each level.
The Class-Frequency Report has bar graphs indicating how many students achieved each level. The survey and posttest are shown on the same page for easy comparison. I-Checks appear on separate pages.

The Student-by-Item Report is available for each student. It provides information about the highest code possible, the code the student received, and a note describing what the student knows or what he or she needs to work on. This report also suggests online tutorials to assign to students who need additional help.

The Student Assessment Summary bar graph indicates the level achieved by individual students on all the assessments taken up to any point in the module. This graph makes it easy to compare achievement on the survey and posttest as well as on each I-Check.

Tutorials. You can assign online tutorials to individual students, based on how each student answers questions on the I-Checks and posttest. The Student-by-Item Report, generated by FOSSmap, indicates the tutorials specifically targeted to help individual students to refine their understandings. Tutorials are an excellent tool for differentiating instruction and are available to students at any time on FOSSweb.
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 who are learning English are incorporated into the materials and strategies 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. Strategies for helping all primary 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.

**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 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.

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 module. 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. Interdisciplinary extensions 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 upper-elementary grades, 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. Six to nine weeks seems about optimum, so students might stay together throughout an entire module.

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 them in place of those in the investigations.
**Working in Collaborative Groups**

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 Reporter makes sure that everyone has recorded information on his or her science notebook sheets. This person reports group data to 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.

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

There is a set of two or three virtual investigations for each FOSS module for grades 3–6. Students who have been absent from certain investigations can access these simulations online through FOSSweb. The virtual investigations require students to record data and answer concluding questions in their science notebooks. Sometimes the notebook sheet that was used in the classroom investigation is also used for the virtual investigation.
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 you do is consistent with those guidelines. Two posters are included in the kit: Science Safety for classroom use and Outdoor Safety for outdoor activities.

Look for the safety icon in the Getting Ready and Guiding the Investigation sections that will alert you to safety considerations throughout the module.

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 1-800-258-1302 (Monday–Friday, 8 a.m.–6 p.m. EST).

Science Safety in the Classroom

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

1. Listen carefully to your teacher’s instructions. Follow all directions. Ask questions if you don’t know what to do.
2. Tell your teacher if you have any allergies.
3. Never put any materials in your mouth. Do not taste anything unless your teacher tells you to do so.
4. Never smell any unknown material. If your teacher tells you to smell something, wave your hand over the material to bring the smell toward your nose.
5. Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
6. Always protect your eyes. Wear safety goggles when necessary.
7. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
8. Never mix any chemicals unless your teacher tells you to do so.
9. Report all spills, accidents, and injuries to your teacher.
10. Treat animals with respect, caution, and consideration.
11. Clean up your work space after each investigation.
12. Act responsibly during all science activities.

Science Safety

Listen carefully to your teacher’s instructions. Follow all directions. Ask questions if you don’t know what to do.

Tell your teacher if you have any allergies. Let your teacher know if you have never been stung by a bee.

Never put any materials in your mouth.

Dress appropriately for the weather and the outdoor experience.

Stay within the designated study area and with your partner or group. When you receive the “freeze” signal, stop and listen to your teacher.

Never face directly at the Sun or at the sunlight being reflected off a shiny object.

Know if there are any skin-irritating plants in your schoolyard, and do not touch them. Most plants in the schoolyard are harmless.

Respect all living things. When looking under a stone or log, lift the side away from you so that any living thing can escape.

If a stinging insect is near you, stay calm and slowly walk away from it. Tell your teacher right away if you are stung or bitten.

Never release any living things into the environment unless you collected them there.

Always wash your hands with soap and warm water after handling chemicals, plants, or animals.

Always protect your eyes. Wear safety goggles when necessary. Tell your teacher if you wear contact lenses.

6. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.

7. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.

8. Never mix any chemicals unless your teacher tells you to do so.

9. Report all spills, accidents, and injuries to your teacher.

10. Treat animals with respect, caution, and consideration.

11. Clean up your work space after each investigation.

12. Act responsibly during all science activities.
SCHEDULING THE MODULE

The Getting Ready section for each part of an investigation helps you prepare. It provides information on scheduling the activities and introduces the tools and techniques used in the activity. Be prepared—read the Getting Ready section thoroughly.

Below is a suggested teaching schedule for the module. The investigations are numbered and should be taught in order, as the concepts build upon each other from investigation to investigation. We suggest that a minimum of 9 weeks be devoted to this module. Take your time, and explore the subject thoroughly.

Active-investigation (A) sessions include hands-on work with earth materials and tools, active thinking about experiences, small-group discussion, writing in science notebooks, and learning new vocabulary in context.

During Wrap-Up/Warm-Up (W) sessions, students share notebook entries.

Reading (R) sessions involve reading FOSS Science Resources articles.

I-Checks are short summative assessments.

<table>
<thead>
<tr>
<th>Week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
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<tr>
<td>1</td>
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<td>A</td>
<td>A</td>
<td>R/W</td>
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<td>A</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
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<td>3</td>
<td>A/Review</td>
<td>I-Check</td>
<td>Self-assess</td>
<td>A</td>
<td>R/W</td>
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<tr>
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<td>A</td>
<td>A</td>
<td>A</td>
<td>A/W</td>
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<td>A/W</td>
<td>A</td>
<td>R/Review</td>
<td>I-Check 2</td>
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<td>R/W</td>
<td>START Inv. 3 Part 2</td>
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<td>A</td>
<td>R/W</td>
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<td>9</td>
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<td>R/W</td>
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## FOSS K–8 SCOPE AND SEQUENCE

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<th>Grade</th>
<th>Physical Science</th>
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<th>Life Science</th>
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<td>Electronics</td>
<td>Planetary Science</td>
<td>Human Brain and Senses</td>
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<td>Chemical Interactions</td>
<td>Earth History</td>
<td>Populations and Ecosystems</td>
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<td>Force and Motion</td>
<td>Weather and Water</td>
<td>Diversity of Life</td>
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<td>4–6</td>
<td>Mixtures and Solutions</td>
<td>Weather on Earth</td>
<td>Living Systems</td>
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<td>Motion, Force, and Models</td>
<td>Sun, Moon, and Planets</td>
<td>Environments</td>
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<td>Energy and Electromagnetism</td>
<td>Soils, Rocks, and Landforms</td>
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<td>Measuring Matter</td>
<td>Water</td>
<td>Structures of Life</td>
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<td>Insects and Plants</td>
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<td>Plants and Animals</td>
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