INTRODUCTION

The Living Systems Module has four investigations that focus on systems as the unit of study. The idea of a system is one of the grand integrating (cross-cutting) concepts that pervades all of science. Students start by looking at Earth as the interaction of four Earth systems or subsystems—the geosphere, the atmosphere, the hydrosphere, and the biosphere. The focus of the module then turns to the biosphere as students explore ecosystems and organisms in terms of their interacting parts.

• Analyze everyday systems and subsystems.
• Analyze food chains and food webs as a way to study the biosphere.
• Make and analyze a worm habitat as a decomposition system.
• Investigate nutrient-getting systems of yeast, plants, and animals, including humans.
• Investigate and model transport systems in plants and animals.
• Investigate sensory systems in animals.
<table>
<thead>
<tr>
<th>Module Summary</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inv. 1: Systems</strong>&lt;br&gt;Students are introduced to a system as a collection of interacting parts that work together to make a whole or produce an action. They explore Earth as a system, focusing on the biosphere and describing ecosystems by looking at feeding relationships and energy transfers, described as food webs. Each group of students sets up a redworm habitat to study detritivores and the role of decomposition in ecosystems.</td>
<td>How can you identify a system? &lt;br&gt;Is planet Earth a system? &lt;br&gt;What happens when compost worms interact with organic litter?</td>
</tr>
<tr>
<td><strong>Inv. 2: Nutrient Systems</strong>&lt;br&gt;Students investigate nutrient systems of yeast, plants, and animals. They design an investigation to determine the necessary conditions for activating dry yeast. They plant wheat and observe the seedlings to determine which plants have chlorophyll. Students infer that the plants growing in light are producing food to provide nutrients to their cells. Students investigate how animals acquire nutrients by eating and digesting food.</td>
<td>What does yeast need to break its dormancy? &lt;br&gt;How do plants get the food they need? &lt;br&gt;How do animals get the nutrients they need?</td>
</tr>
<tr>
<td><strong>Inv. 3: Transport Systems</strong>&lt;br&gt;Students learn that all cells have basic needs: water, food, gas exchange, and waste disposal. They explore the transport systems that multicellular organisms have for moving nutrients and wastes. Students investigate leaf transpiration, model a human heart system, and investigate their lung volume to find out about the interacting parts of the vascular system in plants and the circulatory and respiratory system in humans.</td>
<td>How are nutrients transported to cells in a plant? &lt;br&gt;How do humans transport nutrients to all their cells? &lt;br&gt;Why do people breathe?</td>
</tr>
<tr>
<td><strong>Inv. 4: Sensory Systems</strong>&lt;br&gt;Through video, text, and simulations, students learn about the role of sensory and motor neurons in brain messages. They explore ways that animals communicate through sound, visual displays, and smell. They find out about the role that instinct and learned behavior plays in the life of animals. To bring closure to the study of systems, students find out about the North Atlantic Ocean ecosystem and its importance in the carbon cycle.</td>
<td>In dodgeball, how are you able to avoid being hit? &lt;br&gt;What features of organisms attract attention? &lt;br&gt;How do animals use their sense of hearing? &lt;br&gt;What behaviors are instinctive, and what behaviors are learned? &lt;br&gt;What are the parts of a marine ecosystem?</td>
</tr>
</tbody>
</table>
### Content

- Earth can be described as the interaction of four earth systems: the rocky part (the geosphere), the atmosphere, the water (the hydrosphere), and the complexity of living organisms (the biosphere).
- Food webs are made up of producers (organisms that make their own food), consumers (organisms that eat other organisms to obtain food), and decomposers (organisms that consume and recycle dead organisms and organic waste).

- Chlorophyll is the green pigment that absorbs sunlight in the cells of producer organisms.
- A nutrient is a substance, such as sugar or starch, that is used by a cell to produce the energy needed to perform the functions of life.
- Plants make their own food by photosynthesis. Animals obtain food by eating other organisms.
- Digestion is the process used by animals to break down complex food items into simple nutrients.

- In vascular plants, xylem tubes carry water and minerals from the plant’s roots to all the cells in a one-way flow; phloem tubes carry sugar from the leaves to all the cells that need it.
- In the human circulatory system, blood transports resources to the cells and waste from the cells.
- In humans, the respiratory system transports oxygen to the blood and carbon dioxide from the blood.

- A response is a reaction of a living thing to a stimulus.
- Animals communicate to warn others of danger, scare predators away, or locate others of their kind, including family members.
- Instinctive behaviors, such as knowing what to eat, how to find shelter, and how to migrate, help organisms survive.
- Marine ecosystems have biotic (living) and abiotic (nonliving parts). The ocean plays an important role in the carbon cycle.

### Reading

<table>
<thead>
<tr>
<th>Science Resources Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Introduction to Systems”</td>
</tr>
<tr>
<td>“Is Earth a System?”</td>
</tr>
<tr>
<td>“The Biosphere”</td>
</tr>
<tr>
<td>“Nature’s Recycling System”</td>
</tr>
<tr>
<td>Media</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science Resources Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>“There’s Yeast in My Bread!”</td>
</tr>
<tr>
<td>“Producers”</td>
</tr>
<tr>
<td>“Getting Nutrients”</td>
</tr>
<tr>
<td>“The Human Digestive System”</td>
</tr>
<tr>
<td>Media</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science Resources Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Leaf Classification”</td>
</tr>
<tr>
<td>“Plant Vascular Systems”</td>
</tr>
<tr>
<td>“The Story of Maple Syrup”</td>
</tr>
<tr>
<td>“The Human Circulatory System”</td>
</tr>
<tr>
<td>“The Human Respiratory System”</td>
</tr>
<tr>
<td>Media</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science Resources Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Structures of the Brain”</td>
</tr>
<tr>
<td>“Sensory Systems”</td>
</tr>
<tr>
<td>“Animal Communication”</td>
</tr>
<tr>
<td>“Monarch Migration”</td>
</tr>
<tr>
<td>“North Atlantic Ocean Ecosystem”</td>
</tr>
<tr>
<td>Media</td>
</tr>
</tbody>
</table>

### Assessment

- Embedded Assessment | Science notebook entries |
- Benchmark Assessment | Scientific practices |
- Investigation 1 I-Check |

- Embedded Assessment | Science notebook entries |
- Benchmark Assessment | Response sheet |
- Investigation 2 I-Check |

- Embedded Assessment | Science notebook entries |
- Benchmark Assessment | Scientific practices |
- Investigation 3 I-Check |

- Embedded Assessment | Science notebook entries |
- Benchmark Assessment | Response sheets |
- Posttest |
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, a significant amount of 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 structures and functions 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 curricula 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 12–13), 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 argument 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.
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK in Living Systems

Systems

Virtually everything is a system or part of a system, or both. What does that mean? A system is an association of objects, processes, or concepts that together constitute an entity, institution, or social convention. It’s fairly easy to understand a kitchen range as a system. Close scrutiny allows a critical observer to compile a complete inventory of parts of the system—burners, oven door, oven racks, heat-regulating dials, gas or electric service lines, hood, and so on—and to understand how each part contributes a function to the association of parts that defines a kitchen range. When parts interact in a functional way, those parts assume a higher, more compelling meaning—the whole becomes more than the sum of the parts.

It can be more difficult to discern the system in something as diverse and difficult to define as a social institution. Democracy, for instance, is a political system of governance. A political system is an association of principles, laws, social behaviors, and procedures. This kind of system is not a physical entity that you can hold or stand next to with pride, but an intellectual and psychological space that surrounds your consciousness of your place, rights, and responsibilities in the universe.

We all associate with lots of social institutions that are systems. You are doubtless a player in an educational system, maybe a church or a health club, and possibly an organized sports team. These social institutions are all systems. Professional baseball is a system of young athletes with an array of skills that qualify them to fill the nine positions on the defensive field, plus a host of managers and sundry support professionals. The system includes a collection of physical objects: baseballs, wooden bats, an assortment of gloves, and protective equipment. A subsystem of people coordinate the team’s financial activities: pay for the athletes, food, travel, housing, and in the event of a championship, champagne and outlandish award rings. And there is the official ballpark in which to play the games, with all the attendant features and services that interact to construct and maintain the ballpark infrastructure subsystem. Baseball is a complex system, and every team hires a gaggle of competent managers to attend to all the subsystems that have to be integrated to deliver a season of entertainment and frustration.
Biological Systems

Some of the most interesting and important systems on Earth are those associated with life. The largest life system on Earth is the biosphere, which includes every living organism on Earth. You are a player in that system. The biosphere is conceptually parsed out into thousands (perhaps millions) of subsystems called ecosystems. An ecosystem is all the interacting organisms in a defined geographic space and all the abiotic factors with which the organisms interact. And of course every ecosystem is itself composed of thousands of subsystems. Every kind of organism is part of a population (all the individuals of one species that interact and reproduce in an ecosystem). A population is a system, and every individual organism is a complex system.

An ecosystem is a community of living things, all the nonliving things that surround it, and the relationships among them. Ecology is the study of the interactions between a community of organisms and the environment in which the community lives.

One of the major ideas presented in this context is the mechanisms by which organisms acquire the material resources (chemicals in the form of minerals, gases, and carbohydrates) and energy to conduct their lives. In most ecosystems on Earth, energy enters the ecosystem as light from the Sun and is converted to chemical energy through the complex process of photosynthesis performed by plants, algae, some bacteria, and some protists. Once plants (producers) have
synthesized carbon dioxide and water into energy-rich carbohydrates, the energy and material in those carbohydrates is available to the consumers (the animals, fungi, bacteria, and protists) in the ecosystem, which cannot make their own food through photosynthesis. Energy captured by plants is the energy used to run the whole ecosystem. The consumers can acquire energy they need only by consuming other organisms.

The feeding relationships between a series of organisms is called a food chain. Grass plants synthesize food, rabbits eat grass, foxes eat rabbits, and mountain lions eat foxes. The waste and uneaten bodies of dead organisms fall to the base of the ecosystem, where they are reduced to basic elements—minerals, gases, and water—by decomposers like bacteria and fungi. The last of the chemical energy is wrung out of the organic materials, and the raw materials are again available for the next generations of producer organisms in the ecosystem.

Food chains describe a simple linear relationship between a few organisms in an ecosystem. Food webs describe all the feeding interactions and represent the flow of energy through the food chains. They also illustrate competition for food resources among organisms.
Systems of the Human Body

To appreciate the wonder of being human requires a deep, dedicated systemic point of view. First it is necessary to understand that life happens in cells. You are the result of a mass of several trillion individual cells all working in concert. Whipping those cells into shape to produce you is a masterpiece of coordination. Every one of those trillions of cells has a demanding set of support criteria that must be attended to continuously. No mean feat!

Cells need a steady supply of food, water, and oxygen. Full service at all times. The human system is replete with dozens of subsystems dedicated to servicing cells. Cells “eat” a very limited menu of simple chemical foods (nutrients). Leading the list is glucose, a cell’s favorite source of energy. Cell nutrients are extracted from food that we eat. The digestive system is dedicated to the process of extracting nutrient chemicals from the complex mess of organic substances we ingest. Once the nutrients are separated from the other stuff, they diffuse from the digestive system into the blood.

Nutrients move along in the blood as it flows through the circulatory system. The signature feature of the circulatory system is an extensive network of blood vessels. A critically important fixture in the network of vessels is a heart, the durable muscle that pumps the blood to the lungs and then throughout the entire body.

The vessel network includes arteries, large vessels that divide and divide, branching out and getting smaller and smaller as they reach toward every cell in your body. When the arteries near their destinations, they divide one final time into tiny capillaries.

Capillaries are so numerous, small, and delicate that they come into contact with every cell in your body. The thin walls of the capillaries allow cell nutrients to pass from the bloodstream into the cells. The blood then continues on its way. The capillaries converge with one another into larger and larger vessels. These vessels—veins—carry the spent blood back to the heart.

The veins all converge on the right atrium. From there, blood enters the right ventricle, which pumps it to the lungs, where the circulatory system merges with the respiratory system. The blood releases its load of waste carbon dioxide into the lungs and picks up a fresh charge of oxygen. The refreshed blood collects in the left atrium and then moves into the left ventricle, which pumps it out through the aorta into the body.
Round and round the blood goes, pushing several thousand trillion red blood cells on their way. Red blood cells live about 4 months, and then they die and are replaced. Your body manufactures red blood cells at the rate of 3 million per second. That’s another subsystem that is tightly coordinated to ensure that the blood always has enough red blood cells to provide oxygen and remove carbon dioxide for all your trillions of cells on a continuous basis.

The circulatory system interacts with other systems to maintain the health of your cells. It works with the respiratory system to exchange gases, and with the digestion system to acquire nutrient chemicals that cells use for energy generation, growth, and structural repair. It also works with the hepatic (liver) system and renal (kidney) system. These two systems act as selective filters for removing specific classes of waste materials from the blood. These wastes are dumped into blood as it passes through the capillaries.

The nervous system is the complex electric system that coordinates and manages all the other systems in a human. It is managed by the central nervous system, which comprises the three parts of the brain (cerebrum, cerebellum, brain stem) and the spinal cord. The peripheral nervous system includes all the millions of receptor neurons that gather information from the environment, which is sent to the brain, and the network of motor neurons that convey action instructions from the brain to muscles and other tissues.

Everything that you do (behaviors) is managed by your nervous system. You can breathe and maintain a constant heart function even while sound asleep. You have neurons distributed throughout your body that monitor these and other functions, sending instructions to the proper places to keep your heart beating and your diaphragm pulling air into your lungs.

In summary, the human organism is an amazing example of the particular condition of matter called life. At first it is not obvious that such a large organism is in fact an accumulation of diverse living units called cells, any one of which is invisible to the unaided human eye. Most of those cells are organized into systems that are dedicated to functions that guarantee the well-being of all of those cells. The quality of our lives is intimately linked to the uncompromised operation of these systems.
Two dangers that threaten these cell-support systems are smoking tobacco, which has well-documented negative effects on the performance of lungs, and obesity, which contributes hugely to heart and artery disease. The curriculum does not suggest that you intentionally engage students in sensitive subjects or preach the dangers of smoking or overeating, but embedded in the activities is the realization that life depends on the seamless functioning of these systems. That realization can lead to discussions about what might be the consequences of malfunctioning of cell-support systems.

The full functioning of the central nervous system is also critically important to the well-being of the organism. The central nervous system is easily compromised by chemicals that enter the bloodstream. Alcohol is the most well understood, because of its long history of use, but more recently human brains have had to exert their management functions under the influence of a new wave of “recreational” pharmaceuticals. We know that lecturing young people with logical reasoning about why they should adopt responsible behaviors is not effective. But with sensitive, clever handling, students might be lured into conversations where they develop the arguments for establishing behaviors that help preserve the integrity of their cell-support systems. Self-knowledge may add enough weight to such discussions to actually effect self-preservative behaviors.
Life Science Content Sequence

This table shows all the modules in the FOSS content sequence for Life Science with emphasis on the modules that inform the complex systems strand. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the Living Systems Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure and Function</th>
<th>Complex Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Brain and Senses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population and Ecosystems</td>
<td>• Reproduction is essential to the continued existence of every kind of organism.</td>
<td>• An ecosystem is a web of interactions and relationships among the organisms and abiotic factors in an area.</td>
</tr>
<tr>
<td></td>
<td>• Plants, algae, and many microorganisms use energy from light to make sugars from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen.</td>
<td>• Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers.</td>
</tr>
<tr>
<td></td>
<td>• Animals obtain food from eating plants or eating other animals.</td>
<td>• Adaptation by natural selection acting over generations is one important process by which species change over time in response to environmental conditions.</td>
</tr>
<tr>
<td>Diversity of Life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Plants and animals have structures that function in growth, survival, and reproduction.</td>
<td>• An ecosystem is the interaction of organisms with one another and the abiotic environment.</td>
</tr>
<tr>
<td></td>
<td>• Producers make their own food.</td>
<td>• Organisms have ranges of tolerance for environmental factors.</td>
</tr>
<tr>
<td></td>
<td>• Reproduction is essential to the continued existence of every kind of organism.</td>
<td>• Organisms interact in feeding relationships in ecosystems (food chains and food webs).</td>
</tr>
<tr>
<td></td>
<td>• Organisms have diverse life cycles.</td>
<td>• Individuals of the same kind differ in their characteristics; differences may give individuals an advantage in reproducing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environments</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Insects need air, food, water, and space, including shelter; different insects meet these needs in different ways.</td>
<td>• Bees and other insects help some plants by moving pollen from flower to flower.</td>
</tr>
<tr>
<td></td>
<td>• Plants and insects have structures that function in growth, survival, and reproduction.</td>
<td>• There is variation in traits within one kind of organism.</td>
</tr>
<tr>
<td></td>
<td>• Reproduction is essential to the continued existence of every kind of organism.</td>
<td>• Many characteristics of organisms are inherited from parents; other characteristics result from interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>• Organisms have diverse life cycles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adult plants and animals can have offspring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures of Life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insects and Plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Insects need air, food, water, and space, including shelter; different insects meet these needs in different ways.</td>
<td>• Bees and other insects help some plants by moving pollen from flower to flower.</td>
</tr>
<tr>
<td></td>
<td>• Plants and insects have structures that function in growth, survival, and reproduction.</td>
<td>• There is variation in traits within one kind of organism.</td>
</tr>
<tr>
<td></td>
<td>• Reproduction is essential to the continued existence of every kind of organism.</td>
<td>• Many characteristics of organisms are inherited from parents; other characteristics result from interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>• Organisms have diverse life cycles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adult plants and animals can have offspring.</td>
<td></td>
</tr>
<tr>
<td>Plants and Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals Two by Two</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Conceptual Framework

### Living Systems

<table>
<thead>
<tr>
<th>Structure and Function</th>
<th>Complex Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Food provides animals with the materials they need for body repair and growth and is digested to release the energy they need to maintain body warmth and to move.</td>
<td>- Organisms obtain gases, water, and minerals from the environment and release waste matter back into the environment.</td>
</tr>
<tr>
<td>- Humans and other animals have systems made up of organs that are specialized for particular body functions.</td>
<td>- Matter cycles between air and soil, and among plants, animals, and microbes as these organisms live and die.</td>
</tr>
<tr>
<td>- Animals detect, process, and use information about their environment to survive.</td>
<td>- Organisms are related in food webs.</td>
</tr>
<tr>
<td></td>
<td>- Some organisms, such as fungi and bacteria, break down dead organisms, operating as decomposers.</td>
</tr>
<tr>
<td></td>
<td>- Animals exhibit instinctive behaviors and learned behaviors.</td>
</tr>
</tbody>
</table>
The **Living Systems Module** aligns with the *NRC Framework*. The module addresses these 3–5 grade band endpoints described for core ideas from the national framework for life science.

**Life Sciences**

**Core idea LS1: From Molecules to Organisms: Structures and Processes—How do organisms live, grow, respond to their environment, and reproduce?**

- **LS1.A: How do the structures of organisms enable life’s functions?** [Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (Boundary: Stress at this grade level is on understanding the macroscale systems and their function, not microscopic processes.)]

- **LS1.B: How do organisms grow and develop?** [Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.]

- **LS1.C: How do organisms obtain and use the matter and energy they need to live and grow?** [Animals and plants alike generally need to take in air and water, animals must take in food, and plants need light and minerals; anaerobic life, such as bacteria in the gut, functions without air. Food provides animals with the materials they need for body repair and growth and is digested to release the energy they need to maintain body warmth and for motion. Plants acquire their material for growth chiefly from air and water and process matter they have formed to maintain their internal conditions (e.g., at night).]

- **LS1.D: How do organisms detect, process, and use information about the environment?** [Different sense receptors are specialized for particular kinds of information, which may then be processed and integrated by an animal’s brain, with some information stored as memories. Animals are able to use their perceptions and memories to guide their actions. Some responses to information are instinctive—that is, animals’ brains are organized so that they do not have to think about how to respond to certain stimuli.]
Core idea LS2: Ecosystems: Interactions, Energy, and Dynamics—How and why do organisms interact with their environment and what are the effects of those interactions?

- LS2.A: How do organisms interact with the living and nonliving environments to obtain matter and energy? [The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Either way, they are “consumers.” Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil for plants to use. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.]

- LS2.B: How do matter and energy move through an ecosystem? [Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment.]

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.A: What are the relationships among science, engineering, and technology? [Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. Knowledge of relevant scientific concepts and research findings is important in engineering.]
LIVING SYSTEMS — 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)
- Assessment

Teacher Resources. This collection of resources contains these chapters:

- FOSS Introduction
- 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 might be asked to supply small quantities of common classroom items.
FOSS Science Resources Books

FOSS Science Resources: Living Systems 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.

FOCUS QUESTION

How do animals get the nutrients they need?

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 a response sheet.

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. (What does yeast need to break its dormancy?) 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 or to develop a model such as to show how the human circulatory system works. 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.

12. Assess progress: notebook entry
Collect the notebooks at the end of the day. Look at students’ answers to the focus question to see if they can explain how to identify a system.

What to Look For
- Students write that systems have interacting parts.
- Students write that systems can be complex and may include subsystems.
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 might 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.

Embedded even deeper in the FOSS pedagogical practice is a bolder philosophical stance. Because language arts commands the greatest amount of the instructional day’s time, FOSS has devoted a lot of creative energy to defining and exploring the relationship between science learning and the development of language-arts skills. FOSS elucidates its position in the Science-Centered Language Development chapter.
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* 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.

- FOSS Introduction
- 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.
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. Tell your teacher if you wear contact lenses.
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.
Outdoor Safety

General outdoor 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. Never put any materials in your mouth.
3. Tell your teacher if you have any allergies. Let your teacher know if you’ve never been stung by a bee.
4. Dress appropriately for the weather and the outdoor experience.
5. Stay within the designated study area and with your partner or group. When you hear the “freeze” signal, stop and listen to your teacher.
6. Never look directly at the Sun or at the sunlight being reflected off a shiny object.
7. Know if there are any skin-irritating plants in your schoolyard, and do not touch them. Most plants in the schoolyard are harmless.
8. Respect all living things. When looking under a stone or log, lift the side away from you, so that any living thing can escape.
9. If a stinging insect is near you, stay calm and slowly walk away from it. Tell your teacher if you are stung or bitten.
10. Never release any living things into the environment unless you collected them there.
11. Always wash your hands with soap and warm water after handling plants, animals, or soil.
12. Return to the classroom with all the materials you brought outside.
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 far in advance of teaching each investigation.

Below is a suggested teaching schedule for the module. **Active-investigation (A)** sessions include hands-on work with living organisms and setting up experiments, active thinking about those experiments, 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 at the end of the first three investigations. Plan a review session before the I-Check and a self-assessment session after it.
## Scheduling the Module

### Suggested Teaching Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey (Dry soil)</td>
<td>START Inv. 1 Part 1</td>
<td>START Inv. 1 Part 2</td>
<td>A/R</td>
<td>A/R/W</td>
</tr>
<tr>
<td>2</td>
<td>START Inv. 1 Part 3</td>
<td>A (Redworms)</td>
<td>R</td>
<td>Review</td>
<td>I-Check 1</td>
</tr>
<tr>
<td>3</td>
<td>Self-assess</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
<td>START Inv. 2 Part 2</td>
</tr>
<tr>
<td>4</td>
<td>A/R</td>
<td>(Observe redworms)</td>
<td>A (Observe wheat plants)</td>
<td>A/R</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>(Observe wheat plants)</td>
<td>START Inv. 2 Part 3</td>
<td>A</td>
<td>Review</td>
<td>I-Check 2</td>
</tr>
<tr>
<td>6</td>
<td>START Inv. 3 Part 1</td>
<td>A/R</td>
<td>A/R</td>
<td>A/W</td>
<td>(Observe redworms and wheat seedlings)</td>
</tr>
<tr>
<td>7</td>
<td>CONT. Inv. 3 Part 1</td>
<td>A</td>
<td>A/R</td>
<td>R/W</td>
<td>START Inv. 3 Part 3</td>
</tr>
<tr>
<td>8</td>
<td>R/W</td>
<td>Review</td>
<td>I-Check 3</td>
<td>A/R/W</td>
<td>START Inv. 4 Part 1</td>
</tr>
<tr>
<td>9</td>
<td>START Inv. 4 Part 2</td>
<td>A</td>
<td>R/W</td>
<td>START Inv. 4 Part 3</td>
<td>START Inv. 4 Part 4</td>
</tr>
<tr>
<td>10</td>
<td>START Inv. 4 Part 5</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>Review</td>
</tr>
</tbody>
</table>

### NOTE

In Investigation 1, Part 3, students set up redworm habitats. Students should observe the habitats for 1–2 months. In Investigation 4, Part 5, students make final observations and dismantle the habitats.

In Investigation 2, Part 2, students set up a plant experiment. It is best to start that on a Friday so students can make observations the following Monday. Students can observe and record plant changes later that week when the plants are 6 days old.

Investigation 2, Part 3, students are introduced to painted lady butterfly larvae. The insects go through their life cycle during the rest of the module. The adults will go through their lifetime and die by the end of the module.

Have students review and take the I-Check for Investigation 2 after finishing the review of the response sheet in Part 3. It is not necessary to wait until the butterflies emerge as adults to conduct the I-Check.
# FOSS K–8 SCOPE AND SEQUENCE

<table>
<thead>
<tr>
<th>Grade</th>
<th>Physical Science</th>
<th>Earth Science</th>
<th>Life Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>6–8</td>
<td>Electronics</td>
<td>Planetary Science</td>
<td>Human Brain and Senses</td>
</tr>
<tr>
<td></td>
<td>Chemical Interactions</td>
<td>Earth History</td>
<td>Populations and Ecosystems</td>
</tr>
<tr>
<td></td>
<td>Force and Motion</td>
<td>Weather and Water</td>
<td>Diversity of Life</td>
</tr>
<tr>
<td>4–6</td>
<td>Mixtures and Solutions</td>
<td>Weather on Earth</td>
<td>Living Systems</td>
</tr>
<tr>
<td></td>
<td>Motion, Force, and Models</td>
<td>Sun, Moon, and Planets</td>
<td>Environments</td>
</tr>
<tr>
<td></td>
<td>Energy and Electromagnetism</td>
<td>Soils, Rocks, and Landforms</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Measuring Matter</td>
<td>Water</td>
<td>Structures of Life</td>
</tr>
<tr>
<td>1–2</td>
<td>Balance and Motion</td>
<td>Air and Weather</td>
<td>Insects and Plants</td>
</tr>
<tr>
<td></td>
<td>Solids and Liquids</td>
<td>Pebbles, Sand, and Silt</td>
<td>Plants and Animals</td>
</tr>
<tr>
<td>K</td>
<td>Materials in Our World</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
</tr>
</tbody>
</table>