INTRODUCTION

The Structures of Life Module consists of four investigations dealing with observable characteristics of organisms. Students observe, compare, categorize, and care for a selection of organisms. In so doing, they learn to identify properties of plants and animals and to sort and group organisms on the basis of observable properties. Students investigate structures of the organisms and learn how some of the structures function in growth and survival. In this module, students will

- Observe and compare properties of seeds and fruits.
- Investigate the effect of water on seeds by monitoring and recording changes over time.
- Observe plant structures as they appear during the plant’s life cycle.
- Care for plants and animals and compare their needs.
- Observe crayfish structures and describe their functions in terms of growth, survival, and reproduction. Compare crayfish structures to structures of other animals.
- Analyze and interpret observations of crayfish behavior.
- Investigate food chain dynamics through a simulation.
- Study skeletal systems using bones, images, and models.
### Module Summary

<table>
<thead>
<tr>
<th>Inv. 1: Origin of Seeds</th>
<th><strong>Focus Questions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students conduct a seed hunt by opening fresh fruit and locating the seeds. They describe and compare seed properties. Students examine and sort a selection of seeds—bean, pea, sunflower, and corn. They investigate the effect water has on seeds by setting up seed sprouters and observing and recording changes over a week. Students systematically find out how much water lima beans soak up in a day. Students investigate seed dispersal mechanisms of plants.</td>
<td>How are seeds alike and different?  What effect does water have on seeds?  How much water does a seed soak up?  How do seeds disperse away from the parent plant?</td>
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<thead>
<tr>
<th>Inv. 2: Growing Further</th>
<th><strong>Focus Questions</strong></th>
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<tbody>
<tr>
<td>Students examine germinated seeds to determine similarities and differences in the way the organisms grow. They set up a hydroponic garden to observe the life cycle of a bean plant. Students go outdoors to investigate the roots and shoots of various plants. They use tools to dig up plants and compare the structures above ground to those below ground. Through direct experience and readings, students learn about plant structures and functions.</td>
<td>What structures does a seedling have to help it grow and survive?  What is the sequence of the bean plant’s life cycle?  How do the roots of schoolyard plants compare to the roots of bean plants?</td>
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<thead>
<tr>
<th>Inv. 3: Meet the Crayfish</th>
<th><strong>Focus Questions</strong></th>
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<tbody>
<tr>
<td>Students observe and record some of the structures of a crustacean, the crayfish, and compare it to other organisms. They establish a feeding and maintenance schedule for the organisms. Students investigate crayfish behavior and map where the crayfish spend time within their habitat. Through readings, organism cards, and a video, students learn about adaptations of organisms in different environments. Students engage in an outdoor simulation activity to explore food chains.</td>
<td>What are the structures of a crayfish?  How do crayfish structures and behaviors help them survive?  Do crayfish display territorial behavior in their habitat?  How are the structures of crayfish and other animals alike and different?  What is needed to sustain a food chain?</td>
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<thead>
<tr>
<th>Inv. 4: Human Body</th>
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<tr>
<td>Students observe the articulated human skeletal system in action, use posters and a sense of touch to estimate and refine a count of the 206 human bones, and build skeleton puzzles from memory. Students dissect rodent bones from owl pellets and compare them to human bones. They explore joints and their role in movement focusing on opposable thumbs. Students build operational models of muscle-bone systems to see how muscles move bones. They investigate their skin by making and analyzing fingerprint patterns.</td>
<td>What are the functions of the skeletal system?  In what ways are the skeletons of a rodent and a human similar?  What makes our skeletal system flexible?  How are fingerprints alike and different?</td>
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<tr>
<td>Content</td>
<td>Reading</td>
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</tbody>
</table>
| Seeds develop in the plant part called a fruit. Different kinds of fruits have different kinds and numbers of seeds; seeds have a variety of properties. A seed is an organism, a living thing. Seeds undergo changes in the presence of water. A seed contains the embryo plant and stores food. A seed grows into a new plant (reproduction). Seed-dispersal mechanisms (wind, water, and animals) move seeds away from parent plants. | **Science Resources Book**  
“The Reason for Fruit”  
“The Most Important Seed”  
“Barbara McClintock”  
“Nature Journal—How Seeds Travel” **Media:** *How Seeds Get Here... and There* | **Embedded Assessment**  
Science notebook entry  
Response sheet  
Scientific practices  
**Benchmark Assessment**  
Survey  
Investigation 1 I-Check |
| Germination is the onset of a seed’s development. Plants need water, light, space, and nutrients to grow. The life cycle is the sequence of stages during which a seed grows into an adult (mature) plant and produces seeds, which in turn produce new plants of the same kind. The fruit of the plant develops from the flower. Roots function to take up water and nutrients so they can be transported to other parts of the plant. Different plants have different root systems. | **Science Resources Book**  
“Germination”  
“Life Cycles” **Media:** *How Plants Get Food* | **Embedded Assessment**  
Science notebook entry  
Response sheet  
**Benchmark Assessment**  
Investigation 2 I-Check |
| Crayfish have observable structures and behaviors that serve various functions in growth, survival, and reproduction. Different organisms can live in different environments; organisms have adaptations that allow them to survive in those environments. Organisms are related in feeding relationships called food chains. | **Science Resources Book**  
“Crayfish”  
“Adaptations”  
“Life on Earth”  
“Inside a Snail’s Shell”  
“A Change in the Environment”  
“Food Chains” **Media:** *All about Animal Adaptations* | **Embedded Assessment**  
Science notebook entry  
Response sheet  
Scientific practices  
**Benchmark Assessment**  
Investigation 3 I-Check |
| A skeleton is a system of interacting bones. Humans have about 206 bones. Bones have several functions: support, protection, and movement. The number and kinds of bones in an organism are characteristics inherited from the parents of the organism. Joints are the locations where bones meet. Muscles attach across joints to move bones. Fingerprints can be sorted into three groups based on basic pattern: whorl, arch and loop. | **Science Resources Book**  
“The Human Skeleton”  
“Barn Owls”  
“Skeletons on the Outside”  
“Crayfish, Snails, and Humans”  
“Your Amazing Opposable Thumbs”  
“Joints and Muscles”  
“Fingerprints”  
“Supertwins” | **Embedded Assessment**  
Science notebook entry  
Response sheet  
Scientific practices  
**Benchmark Assessment**  
Posttest |
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 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 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 12–13), a graphic and narrative description that puts this single module into a K–8 strand progression.
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 Structures of Life

The Variety of Life

Even in their most primitive and simplest forms, organisms are marvelous things. Some 1.4 million living species have been described and are known to exist on Earth. Of these, 750,000 are insects, 42,000 are vertebrates, and 250,000 are plants. The remainder include invertebrates, fungi, algae, and microorganisms. New species of organisms are being discovered every day. It has been estimated that there might be 5 to 30 million species on this planet. There might be as many as 10 million species of land-dwelling animals alone.

As we learn more and more about the universe, we continue to find the same chemicals everywhere we look. However, no convincing evidence has yet been found to indicate that life exists anywhere except on Earth. Is it possible that life is unique to our water planet? The life on Earth is a complex, exciting, beautiful, enigmatic subject for human inquiry, and everyone should have the opportunity to develop a deep and personal appreciation for the wonder of life.

What Is Life?

We all know what it is to be living, but a completely satisfactory definition of life is hard to find. We have, however, identified four characteristics common to all living organisms.

Living organisms metabolize. Life requires a steady stream of raw materials and energy. The raw materials originate in the earth and atmosphere, and the energy that drives the life process is usually solar energy, trapped in the form of carbohydrates manufactured by plants. Living organisms also generate a steady stream of by-products. All organisms require this constant maintenance and resupply activity.

Another characteristic of life is growth, a process of getting bigger and more complex. This implies that living things change. As organisms mature, they get bigger and develop new structures and functions.

Living organisms respond to stimuli. This characteristic allows them to react to things happening in their environment. Organisms can enhance their ability to continue life by avoiding unfavorable situations or seeking favorable situations. Response implies a
Structures of Life Module

There must be sensory systems, message-transmission systems, and mechanisms for response actions. Responses can be as primitive as recoiling from a hot object or as complex as a blush following an unexpected compliment.

The most incredible characteristic of life is that it reproduces itself. Organisms reproduce themselves, using myriad different strategies and mechanisms to accomplish the feat. Some simply break into two parts, each part able to live independently and function as a free individual. Others can reproduce by breaking a little piece loose to develop into a free-living individual. Still others reproduce by having a new host of individuals grow right out of the parent organism’s tissue. But far and away the most frequently seen method of reproduction requires that two individuals of a kind contribute to the creation of the new generation. The contribution is the splendid substance DNA, the carrier of the message for the construction and operation of the new living organism. The message is embedded in a complex chemical code. The code dictates whether the new organism will be a salmon, a mosquito, a geranium, or a human. The code carries the very essence of life and orchestrates the fantastic diversity of form and function seen the planet over.

Conceptual Framework

CONCEPTUAL FRAMEWORK
Life Science, Focus on Structure and Function:
Structures of Life

Structures and Function
Concept A  All living things need food, water, a way to dispose of waste, and an environment in which they can live.
- Animals and plants have structures that serve various functions in growth, survival, and reproduction.

Concept B  Reproduction is essential to the continued existence of every kind of organism. Organisms have diverse life cycles.
- Plants and animals grow and change and have predictable characteristics at different stages of development. Adult plants and animals can produce offspring.

Concept C  Animals detect, process, and use information about their environment to survive.

Complex Systems
Concept A  Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors.
- Organisms are related in food chains.

Concept B  Ecosystems are dynamic and change over time.
- When the environment changes, some organisms and populations of organisms survive, thrive, and reproduce; others move, decline, or die.

Concept C  Heredity involves passing information from one generation to the next and introducing variation in traits between individuals in a population.
- Many characteristics of organisms are inherited from parents; other characteristics result from interaction with the environment.

Concept D  Biological evolution, the process by which all living things have evolved over many generations from common ancestors, explains both the unity and diversity of species.
- Different organisms can live in different environments; organisms have adaptations that allow them to survive in that environment.
- Changes in an organism’s habitat are sometimes beneficial to it and sometimes harmful.
How Life Goes On

Life goes in circles. Often, life starts as a tiny, vulnerable system called an embryo, usually in an egg or a seed. In the proper life-supporting environment the embryo will grow and become a free-living organism, able to sustain itself and go about its business independently. When the organism is mature, it develops the ability to provide the germs of life, ova and sperm, which, after mating or pollination, form the embryo for a new generation of organisms. This is called the life cycle, and it rolls on and on and on.

One thing that all living organisms have in common is the antithesis of life—death. The process of living taxes the organism to such a degree that even the most durable living things will one day fail and fall to pieces. Some single-celled organisms may live only a few hours, some insects a few days or weeks, small birds and mammals a few years, larger mammals and reptiles a few decades, and the longest-lived trees maybe 4,000 years or more. Ultimately all organic material in an organism will be disintegrated by the action of other organisms and physical forces, rendering the once-living organism into elemental parts ready for recycling in the process of life. Some of our atoms may have passed through this arena called life many times during the history of Earth.

Environment

Everything that surrounds an organism is part of its environment. This includes the land, water, air, energy, weather, other organisms, and everything else. The environment provides resources for organisms. But at the same time, the environment puts pressure on organisms. The balance between resources and pressures determines how successful an organism will be. Environments tend to be dynamic. An organism that thrives in an environment might be pushed to the limits of survival by a change in the environment. The rate of survival rests in the match between the environment and the structural and behavioral adaptations of an organism. Organisms with adaptations that promote survival in a specific environment will thrive; when the environment changes, those adaptations may no longer serve the organism, so it will decline or fail.

The big idea of organism adaptations and their functional relationship to environments is complex. It will take many years for the majesty and universal application of these ideas to form fully in students’ minds. This module starts students on the path, looking at structures, behaviors, and functions that help organisms survive.
Organisms and Biomes

Large regions of Earth can be defined by the physical environment and the indicator (predominant) species that live there. They are known as biomes, but students will know them as unique environments. This is fine. Examples of the characteristic environments include the ocean, desert, tundra, forest, wetlands, and grasslands. Each environment imposes a set of challenges for organisms. Coral reef organisms must be saltwater tolerant, heat tolerant, and adapted for holding onto or swimming around the coral structures. Desert organisms are as different from coral reef organisms as can be imagined. Desert organisms have adaptations for living with very little water, are heat adapted, and breathe air.

All the differences in organisms seen from one environment to the next present a picture of the diversity of life on Earth. Different environments encourage different kinds of organisms, and within environments, different kinds of organisms compete for resources needed for survival. FOSS Science Resources provides a snapshot of the diversity in each of several environments. Call on students to share other organisms they know of that live in each of the environments, and direct them to books and video resources that may extend this introduction to diversity.

When Environments Change

Fires scorch environments; earthquakes, volcanoes, huge storms, and floods destroy ecosystems; droughts deprive organisms of water; global climate change imposes radical pressures on all life. And there is evidence that infrequent, but significant, disruptions caused by extraterrestrial objects, like asteroids, can change life on Earth dramatically. Arguably, the most imposing changes to environments are those imposed by human beings. Environments are raided for their resources, spoiled by waste, or destroyed and replaced by constructions of value to people.

Some organisms benefit when the environment is disrupted. For example, range fires destroy shrubs and trees, but the grasses that reemerge from hearty roots thrive as a result of reduced competition and the redistribution of minerals in the ashes. The animals that depend on grass for food, such as insects, rodents, and bison, benefit from the success of the grasslands.

Many other organisms change the environments in which they live. Ants build anthills, termites build galleries in wood, ground squirrels and prairie dogs make complex underground tunnels, and woodpeckers
Two of nature’s master builders are the corals in tropical seas and the beaver in temperate fresh water. Tiny coral polyps secrete calcium carbonate cups in which they live. Over time, billions of the cups create massive solid structures that radically change the ocean environment. Organisms that require a structure on which to attach or creep can live on the reef. In the absence of the structure provided by the reef, they cannot survive. If something happens to the reef, the reef organisms have to relocate or perish.

A single beaver striking out on his own to establish a territory and start a family can dam a creek in a few weeks, impounding millions of gallons of water in a pond. What was a riparian, terrestrial habitat is transformed into an aquatic habitat. This change benefits the aquatic organisms in the neighborhood, such as fish, frogs, water insects, water lilies, and algae. But the trees, grasses, ground squirrels, worms, soil insects, and others will be displaced.

The Human Body

The human body may be the most complex and versatile object in the world. Dozens of integrated systems coordinate to perform the myriad operations that we require of it at all times. The last investigation in this module addresses the human skeletal system, its articulations, and the muscles that power the body.

Humans take their shape from the basic framework called the skeleton. It is made of a hard, resilient tissue called bone. To the novice, the skeletons of male and female appear the same, but the experienced observer can readily note the subtle differences, primarily in the size of the pelvic opening, that distinguish one from the other. There are about 206 individual bones in our skeletons. Each has evolved to perform a specific function, and together these bones allow us to do things that are distinctly human, such as stand, walk, and run on two legs; grip, lift, and rotate objects with our hands and arms; and tilt our heads up and down and pivot them from side to side. The human thumb, which works in opposition to the fingers, has provided us with dexterity without equal in the animal world. Some would argue that this one feature has promoted humans to their preeminent position on the pyramid of life.

Bone is living material and remains so even after it has stopped growing, in the late teens or early twenties. Having an internal skeleton is a convenience because bones can grow continuously by enlarging and lengthening as the person matures. Compare this to a crayfish or an insect, which has an exoskeleton, or shell. In order to grow, it must discard its skeleton completely, expand rapidly, and regrow a new skeleton. It is a most precarious position to be in, without protection
and structure, while the new skeleton hardens. The ability of the skeleton to grow and harden is key to human development. Humans can be born small and then grow over time. The newborn’s cranium (skull) plates grow together over time to form a continuous hard protective case, filling in the soft spot, or fontanel, in the process. The cranium plates will continue to calcify for 30 or 40 years, providing evidence of the age of a skull’s owner. The newborn has about 90 more bones than the adult, but a year or so later, it has the adult number of bones. As bones grow and harden, a number of them fuse together, essentially becoming one.

Hard, rigid bones are great for structure and protection (safeguarding the brain, eyes, ear, and organs in the chest), but not for mobility. To accommodate movement, the human skeleton is articulated, or jointed. Joints are where two bones come together, and there are several classifications of joints in the human skeletal system. Bones don’t move themselves; they must be pulled by a source of power. The power is provided by muscle. Every joint has a pairing of antagonistic flexors and extensors to ensure that joints can be moved powerfully in several directions.

**Life Science for Young Learners**

Early on, students should be exposed to a number of ideas in life science.

- Plants and animals are organisms, and they exhibit a variety of strategies for life.
- Organisms are complex and have a variety of observable structures.
- Organisms, particularly animals, exhibit observable behaviors.
- Organisms have varied but predictable life cycles and reproduce their own kind.
- Organisms have requirements for life, including water, food, air, and space with shelter and a suitable temperature.

Human life is unique, as far as we can tell, because humans have the capacity to design, plan, use history, imagine nonexistent objects, and devise systems of laws and codes of behavior. We have power unknown in other life-forms. But we still share the most fundamental requirements with all other life-forms—nourishment, water, air, space, and suitable environment. Students must understand these facts so that they are prepared to assume responsibility for the well-being of the system of life on Earth.
## Life Science Content Sequence

This table shows all the modules in the FOSS content sequence for Life Science with an emphasis on the modules that inform the structure and function strand. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the Structures of Life 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>
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<tbody>
<tr>
<td>Human Brain</td>
<td>- All living things are made of cells (unicellular or multicellular). Special structures within cells are responsible for various functions.</td>
<td>- Adaptations are structures or behaviors of organisms that enhance their chances to survive and reproduce in their environment.</td>
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<tr>
<td>Pop/Ecosystems</td>
<td>- Cells have the same needs and perform the same functions as more complex organisms.</td>
<td>- Biodiversity is the wide range of existing life-forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems.</td>
</tr>
<tr>
<td>Diversity of Life</td>
<td>- All living things need food, water, a way to dispose of waste, and an environment in which they can live (macro and micro level).</td>
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<td>- Plants reproduce in a variety of ways, sometimes depending on animal behaviors and specialized features for reproduction.</td>
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<tr>
<td>Living Systems</td>
<td>- Adaptations are structures or behaviors of organisms that enhance their chances to survive and reproduce in their environment.</td>
<td>- Organisms obtain gases, water, and minerals from the environment and release waste matter back into the environment.</td>
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<tr>
<td></td>
<td>- Biodiversity is the wide range of existing life-forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems.</td>
<td>- Matter cycles between air and soil, and among plants, animals, and microbes as these organisms live and die.</td>
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<td>- Organisms are related in food webs.</td>
<td>- Some organisms, such as fungi and bacteria, break down dead organisms, operating as decomposers.</td>
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<tr>
<td>Environments</td>
<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 for motion.</td>
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<tr>
<td>Structures of Life</td>
<td>- Reproduction is essential to the continued existence of every kind of organism.</td>
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<tr>
<td></td>
<td>- Humans and other animals have systems made up of organs that are specialized for particular body functions.</td>
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<td></td>
<td>- Animals detect, process, and use information about their environment to survive.</td>
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<tr>
<td>Insects/Plants</td>
<td>- Plants and animals have structures, and animals have behaviors that help the organisms grow and survive in their habitat.</td>
<td>- Plants make their own food.</td>
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<tr>
<td>Plants and Animals</td>
<td>- Seeds and bulbs are alive.</td>
<td>- Animals eat plants and other animals.</td>
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<tr>
<td></td>
<td>- Plants need water, light, air, and space.</td>
<td>- A habitat is a place where plants and animals live. There are many different kinds of habitats.</td>
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<tr>
<td></td>
<td>- Plants don’t live forever. New plants can grow from seeds, bulbs, roots, and stems.</td>
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</tr>
<tr>
<td>Animals Two by Two</td>
<td>- Animals have identifiable structures and behaviors.</td>
<td>- Living things can survive only when their needs are met.</td>
</tr>
<tr>
<td>Trees and Weather</td>
<td>- Animals and plants have basic needs.</td>
<td>- Individuals of the same kind (plants or animals) are recognizable as similar but can also vary in many ways.</td>
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</table>
Conceptual Framework

Structures of Life

<table>
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<tr>
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<th>Complex Systems</th>
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<tr>
<td>• A seed is a living organism, containing the embryo of a plant.</td>
<td>• Organisms are related in food chains.</td>
</tr>
<tr>
<td>• Plants and animals have structures that function in growth, survival, and reproduction.</td>
<td>• Different organisms can live in different environments; organisms have adaptations that allow them to survive in that environment.</td>
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<tr>
<td>• Reproduction is essential to the continued existence of every kind of organism. Organisms have diverse life cycles.</td>
<td>• Changes in an organism’s habitat are sometimes beneficial to it and sometimes harmful.</td>
</tr>
<tr>
<td>• Plants and animals grow and change and have predictable characteristics at different stages of development.</td>
<td>• Many characteristics of organisms are inherited from parents; other characteristics result from interaction with the environment.</td>
</tr>
<tr>
<td>• Behavior of animals is influenced by internal and external cues.</td>
<td>• A skeleton is a system of interacting bones. The skeletons of humans and other mammals have many similarities.</td>
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<tr>
<td>• Bones have several functions: support, protection, and movement.</td>
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The Structures of Life 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 materials 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 animals’ 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.]

- **LS2.C:** What happens to ecosystems when the environment changes? [When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.]
Core idea LS3: Heredity: Inheritance and Variation of Traits—How are characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?

- LS3.A: How are the characteristics of one generation related to the previous generation? [Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.]

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

- LS4.C: How does the environment influence populations of organisms over multiple generations? [Changes in an organism’s habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.]

- LS4.D: What is biodiversity, how do humans affect it, and how does it affect humans? [Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their 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.]

- **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? [Over time, people’s needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), to decrease known risks (e.g., seatbelts in cars), and to meet societal demands (e.g., cell phones). When new technologies become available, they can bring about changes in the way people live and interact with one another.]
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: Structures of Life 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.
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 effect does water have on seeds?) 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 the skeletons of a rodent and a human are similar. 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 notebook sheet Comparing Seeds. Review students’ notebooks after class and check their descriptions of seed properties. Record your notes on a copy of Embedded Assessment Notes.

What to Look For

- Students record the name of the fruit and number of seeds.
- Students describe and draw the properties of each kind of seed.

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.
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.
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.

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**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.

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

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

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.

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.

Never put any materials in your mouth. Do not taste anything unless your teacher tells you to do so.

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

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

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

Treat animals with respect, caution, and consideration.

Clean up your work space after each investigation.

Outdoor 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 look 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 where you collected them.

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

Return to the classroom with all of 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.

Below is a suggested teaching schedule for the module. The investigations build upon each other from investigation to investigation but because you need to allow time for plants to grow, you should go on to Investigation 3 and 4 before completing Investigation 2.

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>
<th>Day 5</th>
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<tbody>
<tr>
<td>1</td>
<td>Survey</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
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<td></td>
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<td>R/W</td>
<td>START Inv. 1 Part 2</td>
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<td></td>
<td>(observe seeds)</td>
<td>A</td>
<td>(observe seeds)</td>
<td>A/R</td>
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<tr>
<td>2</td>
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<td>(observe seeds)</td>
<td>A</td>
<td>R/W</td>
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<td>(observe seeds)</td>
<td>(observe seeds)</td>
<td>A</td>
<td>A/R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>START Inv. 2 Part 1</td>
<td>A/R</td>
<td>set up hydroponics</td>
<td>A</td>
<td>Review 1</td>
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<td>I-Check 1</td>
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<td>3</td>
<td>START Inv. 3 Part 1</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
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<td>A</td>
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<td>5</td>
<td>START Inv. 3 Part 2</td>
<td>A</td>
<td>A</td>
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<td>6</td>
<td>START Inv. 3 Part 3</td>
<td>A</td>
<td>monitor</td>
<td>R</td>
<td>A/W</td>
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<td>A</td>
<td>R/W</td>
<td>A</td>
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<td>A</td>
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<td>A</td>
<td>R</td>
<td>Review</td>
<td>Posttest</td>
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NOTE

Read through the Getting Ready for Investigations 1 and 2 ahead of time so you know how they are linked and how to plan the schedule for germinating the bean seeds and then planting them hydroponically.

In Investigation 2, students observe the bean plants grow from seedling to mature plant with bean pods and new seeds—the complete life cycle. Investigation 2, Part 1 starts at the beginning of week 3 of instruction (first green box in schedule) and Part 2 starts 6 weeks later, at the beginning of week 9 (second green box). Plan to go on to Investigations 3 and 4 before finishing Investigation 2.
## FOSS K–8 SCOPE AND SEQUENCE

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<tr>
<th>Grade</th>
<th>Physical Science</th>
<th>Earth Science</th>
<th>Life Science</th>
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<td>Electronics</td>
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<td>Populations and Ecosystems</td>
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<td>Force and Motion</td>
<td>Weather and Water</td>
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<td>Mixtures and Solutions</td>
<td>Weather on Earth</td>
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