INTRODUCTION

The Insects and Plants Module provides experiences that heighten students’ awareness of the living world. They come to know firsthand the life cycles of a number of insects. Students see the life cycles of insects unfold in real time and compare the stages exhibited by each species. At the same time, students grow one type of plant from seed and observe it through its life cycle to produce new seeds. In this module, students will

- Provide for the needs of living insects and growing plants.
- Observe beetles, moths, and butterflies change from larvae to pupae to adult. Observe insect mating and egg laying.
- Compare structures on milkweed bugs to other kinds of insects.
- Observe incomplete and complete metamorphosis.
- Compare plant and animal life cycles.
- Make predictions about the moth and butterfly life cycles, based on observations of other insects.
- Communicate observations of the life cycle of plants and the structure, behavior, and life cycle of insects in words and drawings.
Module Summary | Focus Questions
---|---
**Inv. 1: Mealworms**
Each student receives two larval mealworms in a vial to care for and observe. Over 10 weeks, students observe the larvae grow, molt, pupate, and turn into beetles (adults), which mate, lay eggs, and die. They read an article about insects in the environment.

What do mealworms need to live? How do mealworms grow and change? What are the stages of a beetle's life cycle?

**Inv. 2: Brassica Seeds**
Each student plants tiny rapid-cycling brassica seeds in a planter cup. The brassica plants grow under continuous light and develop for a month. Students observe and record the complete life cycle from seed to seed. They plant seeds or transplant seedlings outdoors.

How did we plant the brassica seeds? How does a young plant change as it grows? What will happen to the flowers on the brassica plants? Where is a good outdoor place for growing young plants?

**Inv. 3: Milkweed Bugs**
Groups of students receive vials of milkweed bug eggs. Each group prepares a habitat for the bugs, providing air, food, water, and space, including shelter. They observe structure, pattern, and behavior as the insects advance through simple metamorphosis. Students go outdoors to search for insects living naturally on the ground and on plants in the schoolyard.

How do the yellow objects change? What do milkweed bugs need in their habitat? How do milkweed bugs grow and change? Where do insects live?

**Inv. 4: Silkworms**
Students observe the life history of one of the most commercially successful insects, silkworms. They start with eggs and observe the growth and changes to larvae, pupae, and adults, which produce eggs. They search the schoolyard for evidence of plants being eaten by insects or other animals.

What do silkworms need to live? How does a silkworm compare to a mealworm? What is the life cycle of the silkworm? What evidence is there that insects are eating plants in the schoolyard?

**Inv. 5: Butterflies**
The class observes painted lady larvae grow, pupate, and emerge as adult butterflies. Students observe the stages of complete metamorphosis and compare the behaviors of moths and butterflies. Students study pollination through video clips and outdoor plant observations.

What do caterpillars do? How is a painted lady pupa different from a silkworm pupa? What is the life cycle of a painted lady butterfly? What plants in our schoolyard have pollen?
<table>
<thead>
<tr>
<th>Content</th>
<th>Reading and Media</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| • Insects need air, food, water, and space.  
• The life cycle of the beetle is egg, larva, pupa, and adult, which produces eggs.  
• Insects have characteristic structures and behaviors.  
• Adult insects have a head, thorax, and abdomen.  
• Insects have predictable characteristics at different stages of development. | **Science Resources Book**  
"Animals and Plants in Their Habitats" | **Embedded Assessment**  
Science notebook entries  
Scientific practices  
**Benchmark Assessment**  
Investigation 1 I-Check |
| • Insects need air, food, water, and appropriate space including shelter; different insects meet these needs in different ways.  
• The life cycle of some insects is egg, nymph stages, and adult, which produces eggs.  
• Variations exist within a group of related organisms.  
• As insects grow, they molt their hard, external covering. | **Science Resources Book**  
"So Many Kinds, So Many Places"  
"Variation"  
**Media**  
*How Plants Grow* | **Embedded Assessment**  
Science notebook entries  
Scientific practices  
**Benchmark Assessment**  
Investigation 3 I-Check |
| • Insects need air, food, water, and space including shelter; different insects meet these needs in different ways.  
• The life cycle of some insects involves complete metamorphosis—egg, larva, pupa, and adult, which produces eggs. | **Science Resources Book**  
"Insect Shapes and Colors"  
"Insect Life Cycles" | **Embedded Assessment**  
Science notebook entries  
Scientific practices  
**Benchmark Assessment**  
Investigation 4 I-Check |
| • The life cycle of the butterfly involves complete metamorphosis. Butterflies construct chrysalises when they pupate.  
• Insects pollinate plants.  
• Life cycles are different for different animals. | **Science Resources Book**  
"Life Goes Around"  
"Fossils"  
**Media**  
*What Is Pollination?* | **Embedded Assessment**  
Teacher Observation  
Scientific practices  
Science notebook entries  
**Benchmark Assessment**  
Investigation 5 I-Check |
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—ideas such as the structure of matter or the relationship between the structure and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things students can and should understand about these core ideas in primary school years, and progressively more complex and sophisticated things they should know as they gain experience and develop cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum for students.

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

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

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

The sequence in each strand relates to the core ideas described in the national framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as you proceed up the columns.

Information about the FOSS learning progression appears in the conceptual framework (page 7), which shows the structure of scientific knowledge taught and assessed in this module, and the content sequence (pages 10-11), 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.

*A Framework for K–12 Science Education describes these eight scientific and engineering practices as essential elements of a K–12 science and engineering curriculum.*
Insects and Life Cycle

An incomprehensibly huge number of different kinds of insects live on Earth, and no one is certain whether the number is 10 million, 15 million, or more. A team of entomologists recently entered a tract of virgin South American rain forest, shook all the insects off one tree, and found over 2000 species of insects living there, most of which were previously undiscovered.

Insects are in the kingdom Animalia and in the phylum Arthropoda—the animals with jointed legs and external skeletons. Class Insecta is the most successful group of similar animals on Earth, no matter how you look at it. There are more kinds of insects than all other kinds of animals put together, and they dominate the planet in terms of total living mass, total numbers of individuals, and most widespread occupation of the planet’s ecosystems. Of the 26 orders of insects, many have at least one or two individual species that are familiar to us. A few common orders include dragonflies, crickets, termites, lice, aphids, beetles, butterflies, flies, fleas, and ants.

Some insects are important in culture and commerce. Silk produced by silkworms and honey produced by bees are examples of useful additions to our lives. Insects have a reputation, however, as pests. The economic impact of insects on human industry and livelihood is massive. The problem is that insects want to eat just about everything we hold dear. Moths eat clothes, termites eat buildings, beetles eat books, multitudes of bugs and beetles ravage agricultural products, and mosquitoes eat us. The money, time, and energy expended to battle insects is monumental, and the cost worldwide of countering and treating human diseases carried by insects is huge.

The success of insects can be attributed to several factors. There are incredible numbers of insects. They have adaptations for success in every conceivable environment and have diversity within every species. We have learned from decades of battling insects in our agricultural fields that, if you put pesticide on a population of carrot chompers, most of them will die, but a few will survive because of a natural resistance to the pesticide. The resistant carrot chompers are, of course, the ones that reproduce, and their offspring inherit resistance to the pesticide. Next year the pesticide is less effective, and in a couple of years the
pesticide is useless. This obsolescence of chemicals happens quickly because of the rate at which insects reproduce—at least one and possibly two or more generations in a year. Insects tend to produce large numbers of eggs, so when conditions favor a particular kind of insect, it can expand its numbers in a very short time.

Insects change form as they grow and mature. The process is called metamorphosis. Insect metamorphosis follows one of two sequences. For a butterfly, life starts as an egg laid either singly or in batches of up to several hundred. The egg hatches, and the emerging larva starts to feed on whatever food it is adapted to eat, which for many insects is very limited. The larva grows rapidly, shedding (molting) its skin several times to accommodate its increasing size, until an internal message induces the larva to stop eating, change form, and become quiet while it transforms into the adult. This resting pupal stage is sometimes protected in a chrysalis or a cocoon. The adult that comes out of the pupa is ready to mate and produce eggs for the next generation. This process of going through four distinct forms, called complete metamorphosis, can occur in as few as 4 weeks.

Some other insects hatch from the egg looking pretty much like the adult form, but tiny. As they eat and grow, the nymphs shed their skins, and with each molt they look more like the adult. With the last molt, the insect is fully mature, and it mates and produces eggs. This gradual progress toward maturity is called simple metamorphosis.

The insects in this module were chosen because they are easy to manage and culture in the typical classroom, they are safe for students to handle, they have no potential to be environmental pests, and they exhibit many of the most important insect behaviors that we want students to observe. Both common kinds of metamorphosis are seen, and the insects are exciting for students to have in their classroom.
Plant Reproduction

Flowering plants engage in sexual reproduction. This means that a male cell and a female cell must unite to produce a new life—the next generation of that plant—a new baby plant. Although plants achieve this union in a variety of ways, the story can be generalized.

The reproductive parts of the flower are in the middle. Reaching up from the center of the flower are several stamens, the male parts of the flower. Each stamen has two parts, the long, thin filament and the anther at its tip. The anther is usually orange or yellow. Thousands of pollen grains form in the anthers. Inside each pollen grain is the specialized male sex cell, the sperm.

Right in the middle of the flower is the pistil, the female part of the flower. The flattened tip of the pistil is the stigma, and the base of the pistil deep inside the center of the flower is the ovary. Inside the ovary are the ovules, the “nests” in which the specialized female sex cells, the eggs, reside. That’s a flower.

In order to produce a new plant, an egg and a sperm must unite to form a single cell that has information from both of the parent cells. The combined cell is said to be fertilized. This single fertilized cell divides and grows, eventually developing in the living embryo of a new, free-living plant.

So how do the two sex cells meet and unite? The answer is pollination. Plants rely on an agent of some kind (wind or an animal) to carry the pollen from where it is produced to a mature stigma, and usually this must be on another plant.

After successful pollination, fertilization occurs. The cell divides repeatedly to form the embryo. The parent plant supplies the resting embryo with a package of energy-rich food, the future cotyledon, and wraps the whole system in a weatherproof coat. The plant has produced a seed. Some plants have flowers that produce a single seed, like a peach flower or a cherry blossom. In this case, the ovary contains only one ovule. Other plants, like brassica plants or apple trees, have five to fifteen ovules in the ovary, and others, like tomato and watermelon flowers, have hundreds of ovules in the ovary. Each ovule has the potential to produce a new plant if it is fertilized.

At the same time the fertilized ovule is developing into a seed, the ovary that surrounds the seed is developing into a fruit. A fruit is any structure that grows around the seeds to ensure the survival and success of the next generation. Familiar examples of fruits include grapes,
lemons, cantaloupes, and pears. Scientifically speaking, a number of objects that we often refer to as vegetables are in fact fruits, including tomatoes, squash, beans, cucumbers, olives, peanuts, and eggplants. The general rule is that, if it has seeds, it is a fruit. Students revisit this concept in grade 3, Structures of Life Module.

**Inheritance**

One important thing we know about life is that offspring grow up to look pretty much like their parents. This has been known for a very long time. The information for how to develop is passed from the parents to the offspring—from one generation to the next. You inherited from your parents genetic information in the form of DNA molecules on chromosomes found in the nucleus of every cell. The same is true for almost every other living thing on Earth.

The pioneering work on inheritance was done by an Augustinian monk named Gregor Mendel (1822–1884). He spent years growing thousands of plants and animals, observing closely to see how similar they were to their parents. His most important work was done with pea plants. All his pea plants had flowers, but there was variation in some characteristics, such as flower color. Some had the trait of purple flowers, and some had the trait of white flowers. When both parent pea plants had purple flowers, the offspring had purple flowers. When both parents had white flowers, the offspring had white flowers. But what intrigued Mendel was what happened when one parent had purple flowers and one had white flowers. What color flowers would the offspring have? Purple? White? Pale purple?

Mendel found that the flowers were all either purple or white. With one purple and one white parent, some of the offspring had purple flowers and some had white flowers. None had pale purple flowers. Mendel reasoned that the offspring must be inheriting something from each parent that told the pea plant what color flowers to produce. But what exactly was inherited? Mendel lived out his life without knowing that the answer to that question was genes.

This module is a good vehicle for addressing the concepts of life cycle and the similarity of offspring to their parents, and a nice jumping-off place to learn about variation in a population and the influence of the environment on the growth and development of plants and animals.
**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 complex systems strand. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the [Insects and Plants](#) 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><strong>Human Brain and Senses</strong></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 between 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><strong>Populations and Ecosystems</strong></td>
<td></td>
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<tr>
<td><strong>Diversity of Life</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Living Systems</strong></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>
<td>• Organisms obtain gases, water, and minerals from the environment and release waste matter back into the environment.</td>
</tr>
<tr>
<td></td>
<td>• Reproduction is essential to the continued existence of every kind of organism.</td>
<td>• Matter cycles between air and soil, and among plants, animals, and microbes as these organisms live and die.</td>
</tr>
<tr>
<td></td>
<td>• Humans and other animals have systems made up of organs that are specialized for particular body functions.</td>
<td>• Organisms are related in food webs.</td>
</tr>
<tr>
<td></td>
<td>• Animals detect, process, and use information about their environment to survive.</td>
<td>• Some organisms, such as fungi and bacteria, break down dead organisms, operating as decomposers.</td>
</tr>
<tr>
<td><strong>Environments</strong></td>
<td>• Plants and animals have structures, and animals have behaviors that help the organisms grow and survive in their habitat.</td>
<td>• An ecosystem is the interactions 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>• Animals obtain food from eating plants or eating other animals.</td>
<td>• Organisms interact in feeding relationships in ecosystems (food chains and food webs).</td>
</tr>
<tr>
<td><strong>Structures of Life</strong></td>
<td></td>
<td>• Individuals of the same kind differ in their characteristics; differences may give individuals an advantage in reproducing.</td>
</tr>
<tr>
<td><strong>Insects and Plants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plants and Animals</strong></td>
<td></td>
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<tr>
<td><strong>Animals Two by Two</strong></td>
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</tr>
</tbody>
</table>
**Conceptual Framework**

**Structure and Function**
- Insects need air, food, water, and space including shelter, and different insects meet these needs in different ways.
- Plants and insects have structures that function in growth, survival, and reproduction.
- Reproduction is essential to the continued existence of every kind of organism. Organisms have diverse life cycles.
- Plants and insects grow and change and have predictable characteristics at different stages of development.
- Adult plants and animals can have offspring.

**Complex Systems**
- Bees and other insects help some plants by moving pollen from flower to flower.
- There is variation in traits within one kind of organism.
- Many characteristics of organisms are inherited from parents; other characteristics result from interaction with the environment.
INSECTS AND PLANTS — Overview

The Insects and Plants Module aligns with the NRC Framework. The module addresses these K–2 grade band endpoints described for core ideas from the national framework for life science and for engineering, technology, and the application of 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? [All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.]

- **LS1.B:** How do organisms grow and develop? [Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring survive.]

- **LS1.C:** How do organisms obtain and use the matter and energy they need to live and grow? [All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.]

- **LS1.D:** How do organisms detect, process, and use information about the environment? [Animals have body parts that capture and convey different kinds of information needed for growth and survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator). Plants also respond to some external inputs (e.g., they turn leaves toward the Sun).]

Core idea LS2: Ecosystems: Interactions, Energy, and Dynamics—How and why do organisms interact with their environment, and what are the effects of these interactions?

- **LS2.C:** What happens to ecosystems when the environment changes? [The places where plants and animals live often change, sometimes slowly and sometimes rapidly. When animals and plants get too hot or too cold, they may die. If they cannot find enough food, water, or air, they may 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? [Organisms have characteristics that can be similar or different. Young animals are very much, but not exactly, like their parents and resemble other animals of the same kind. Plants also are very much, but not exactly, like their parents and resemble other plants of the same kind.]

- **LS3.B:** Why do individuals of the same species vary in how they look, function, and behave? [Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.]

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.A:** What evidence shows that different species are related? [Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways.]

- **LS4.C:** How does the environment influence populations of organisms over multiple generations? [Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.]

- **LS4.D:** What is biodiversity, how do humans affect it, and how does it affect humans? [There are many different kinds of living things in any area, and they exist in different places on land and in water.]

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? [People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas.]
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 (five in this module)

Teacher Resources. This three-ring binder contains these chapters.
- FOSS Introduction
- Assessment
- Science Notebooks in Grades K–2
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

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

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

FOSS Science Resources: Insects and Plants 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.

Insects and Plants Module
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 (five 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 1–2 include observation of students engaged in scientific practices, review of a notebook entry (drawing or text), or a teacher observation.

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

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

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

To help with pacing, you will see icons for breakpoints. Some breakpoints are essential, and others are optional.
Active Investigation

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

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

Context: questioning and planning. Active investigation requires focus. The context of an inquiry can be established with a focus question or challenge from you or, in some cases, from students. (How do mealworms grow and change?) 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 search the schoolyard for evidence of plants being eaten by insects. 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.
17. Assess progress: notebook entry

Collect the notebooks and review students’ work. Check their work for form and substance.

What to Look For

• Students write that mealworms need food (bran), water (from carrot or potato), space (vial), and air (holes in vial cap for air).

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 after each investigation. The assessment items do not simply identify whether 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. Because 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 enhance 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 in Grades K–2
- 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*. 
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 might 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.
ORGANIZING THE CLASSROOM

Students in primary grades are usually most comfortable working as individuals with materials. The abilities to share, take turns, and learn by contributing to a group goal are developing but are not reliable as learning strategies all the time. Because of this egocentrism and the need for many students to control materials or dominate actions, the FOSS kit includes a lot of materials. To effectively manage students and materials, FOSS offers some suggestions.

Small-Group Centers

Some of the observations and investigations with insects and plants can be conducted with small groups at a learning center. For example, making milkweed bug habitats in Investigation 3, Part 2, could be conducted at a center. Limit the number of students at the center to six to ten at one time. When possible, each student will have his or her own equipment to work with. In some cases, students will have to share materials and equipment and make observations together. Primary students are good at working together independently.

As one group at a time is working at the center on a FOSS activity, other students will be doing something else. Over the course of an hour or more, plan to rotate all students through the center, or allow the center to be a free-choice station.

Whole-Class Activities

Introducing and wrapping up the center activities require you to work for brief periods with the whole class. FOSS suggests for these introductions and wrap-ups that you gather the class at the rug or other location in the classroom where students can sit comfortably in a large group.
When You Don’t Have Adult Helpers

Some parts of investigations work better when there is an aide or a student’s family member available to assist groups with the activity and to encourage discussion and vocabulary development. We realize that there are many primary classrooms in which the teacher is the only adult present. Here are some ways to manage in that situation.

• Invite upper-elementary students to visit your class to help with the activities. Remind older students to be guides and to let primary students do the activities themselves.

• Introduce each part of the activity with the whole class. Set up the center as described in the Investigations Guide, but let students work at the center by themselves. Discussion may not be as rich, but most of the centers can be done independently by students once they have been introduced to the process. Be a 1-minute manager, checking on the center from time to time, offering a few words of advice or direction.

When Students Are Absent

If a student is absent for an activity, 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 and in writing.
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. Let your teacher know if you have never been stung by a bee.


4. When you receive the “freeze” signal, stop and listen to your teacher.

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

6. Respect all living things. When looking under stones or logs, lift the sides away from you so that any living thing can escape.

7. 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.

8. Never release any living thing into the environment unless you collected it there.

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

10. Return to the classroom with all of the materials you brought outside.

### Science Safety

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

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

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

9. Never release any living thing into the environment unless you collected it there.

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

11. Clean up your work space after each investigation.

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

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

The scheduled sessions involve *active-investigation* as students observe organisms in habitats, discussions about changes in the stages of the life cycles, writing in science notebooks, and learning new vocabulary in context. During *wrap-up/warm-ups* at the end of each part, students share notebook entries, and during *reading* sessions students read FOSS *Science Resources* articles. *I-Checks* are summative assessments at the end of each investigation.

It is hard to keep organisms on a strict schedule. The general plan described below shows a new organism being introduced each week so that all of the investigations are conducted concurrently starting in week 5. Parts 2 and 3 of each investigation are conducted when students see something interesting or observe changes in their insects.
## FOSS K–8 Scope and Sequence

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