



INTRODUCTION

Chemistry is the study of the structure of matter and the changes or transformations that take place within those structures. Learning about the properties and behaviors of substances and systems of substances gives us knowledge about how things go together and how they can be taken apart and gives us the opportunity to use and develop models that explain phenomena too small to see directly. Learning about changes in substances can lead to the development of new materials and new ways to produce energy and resources such as clean drinking water.

The **Mixtures and Solutions Module** has five investigations that introduce students to fundamental ideas about matter and its interactions. Students come to know that matter is made of particles too small to be seen and develop the understanding that matter is conserved when it changes state—from solid to liquid to gas—when it dissolves in another substance, and when it is part of a chemical reaction. Students have experiences with mixtures, solutions of different concentrations, and reactions forming new substances. They also engage in engineering experiences with separation of materials. Students gain experiences that will contribute to the understanding of crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; systems and system models; and energy and matter.

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The NGSS Performance Expectations addressed in this module include:

Physical Sciences

5-PS1-1
5-PS1-2
5-PS1-3
5-PS1-4

Engineering, Technology, and Applications of Science

3-5-ETS1-1
3-5-ETS1-2
3-5-ETS1-3

► NOTE

The three modules for grade 5 in FOSS Next Generation are

Mixtures and Solutions

Earth and Sun

Living Systems



MIXTURES AND SOLUTIONS — Overview

Module Summary

Students make mixtures of water and solid materials and separate the mixtures with screens and filters. They find that water and salt make a special kind of mixture, a solution, which cannot be separated with a filter but only through evaporation. Students are challenged with a problem: how to separate a mixture of three dry solid materials. The investigation concludes with students going outdoors to see what natural materials make solutions with water.

Focus Questions

How can a mixture be separated?

Where does the solid material go when a solution is made?

How can you separate a mixture of dry materials?

Are there materials outdoors that will dissolve in water?

Students make multisensory observations of sealed black boxes in an effort to determine what is inside. They develop models and try to reach consensus with other students who investigated the same boxes. Students construct physical models of black boxes in an effort to replicate the behaviors of the original black boxes. Students investigate melting and freezing in terms of models and conservation of mass and clarify the difference between the processes of melting and dissolving.

What is the process to develop a model of the black box?

How does a drought-stopper system work?

What is the difference between dissolving and melting?

Content Related to Disciplinary Core Ideas	Reading/Technology	Assessment
<ul style="list-style-type: none"> • A mixture is two or more materials intermingled. • An aqueous solution is a mixture in which a substance disappears (dissolves) in water to make a clear liquid. • Mixtures can be separated into their constituents by using screens, filters, and evaporation. • The mass of a mixture is equal to the mass of its constituents. • Possible solutions to a problem are limited by available materials and resources (constraints). • The success of a designed solution is determined by considering the desired features of a solution (criteria). 	<p>Science Resources Book</p> <p>“Mixtures” “Taking Mixtures Apart” “Science Practices” “Engineering Practices” “Extracts” “The Story of Salt” (optional)</p> <p>Video</p> <p><i>Elements, Compounds, and Mixtures</i></p> <p>Online Activities</p> <p>“Tutorial: Mixtures” “Tutorial: Solutions” “Separating Mixtures” “Virtual Investigation: Separating Mixtures”</p>	<p>Embedded Assessment</p> <p>Science notebook entry Response sheet Performance assessment</p> <p>Benchmark Assessment</p> <p><i>Survey</i> <i>Investigation 1 I-Check</i></p> <p>NGSS Performance Expectations</p> <p>5-PS1-1 5-PS1-2 3–5-ETS1-1 3–5-ETS1-2 3–5-ETS1-3</p>
<ul style="list-style-type: none"> • Models are explanations of objects, events, or systems that cannot be observed directly. • Models are representations used for communicating and testing. • Developing a model is an iterative process, which may involve observing, constructing, analyzing, evaluating, and revising. • Dissolving is an interaction between two (or more) substances: a solute which dissolves, and a solvent, which does the dissolving and into which the solute disappears. • Melting is a change in a single substance from solid to liquid caused by heat (energy transfer). • The amount of matter is conserved when it changes form. 	<p>Science Resources Book</p> <p>“Scientists and Models” “Beachcombing Science” “Celsius and Fahrenheit” “Solid to Liquid” “Liquid and Gas Changes”</p> <p>Video</p> <p><i>Changes in Properties of Matter</i></p> <p>Online Activity</p> <p>“Black Box”</p>	<p>Embedded Assessment</p> <p>Science notebook entries Response sheet</p> <p>Benchmark Assessment</p> <p><i>Investigation 2 I-Check</i></p> <p>NGSS Performance Expectations</p> <p>5-PS1-1 5-PS1-2</p>

MIXTURES AND SOLUTIONS — Overview

Module Summary

Focus Questions

Students observe and compare soft-drink solutions that differ in the amount of powder (water held constant) and in the amount of water (powder held constant) in order to develop the concept of concentration. They make salt solutions of different concentrations and compare them, using a balance. Students determine the relative concentrations of three mystery solutions made from the same solid material by comparing the mass of equal volumes of the solutions. Finally, students layer salt solutions to determine their relative concentrations.

- Are all solutions made with soft-drink powder and water the same?**
- How can you determine which salt solution is more concentrated?**
- How can you determine the relative concentrations of three mystery solutions?**
- What is the relationship between salt-solution concentration and density?**

Students make a saturated solution by adding salt to water until no more salt will dissolve. They also make a saturated Epsom salts solution. Using a balance, they compare the solubility of the two solid materials by comparing the mass of the salt and Epsom salts dissolved in the saturated solutions. Students use the property of solubility to identify an unknown material. They analyze local water samples, using separation techniques and design a way to remove salt from ocean water.

- Is there a limit to the amount of salt that will dissolve in 50 mL of water?**
- Does it always take the same amount of solid materials to saturate 50 mL of water?**
- What is the identity of the mystery substance?**
- What is in our water samples?**
- What is a design to remove salt from ocean water?**

Students make three solutions with water, calcium chloride, baking soda, and citric acid. They systematically mix pairs of those solutions and observe changes that occur. The changes (formation of a gas and a white precipitate) are identified as evidence of a chemical reaction. Students repeat the reactions in sealed zip bags to observe the volume of gas produced.

- What is the effect of mixing two substances with water?**
- How can we identify the products from the baking soda and calcium chloride reaction?**
- What happens when you mix substances with water in a bag?**

Inv. 3: Concentration

Inv. 4: Reaching Saturation

Content Related to Disciplinary Core Ideas	Reading/Technology	Assessment
<ul style="list-style-type: none"> Concentration is the amount of dissolved solid material per unit volume of water. Solutions with a lot of solid dissolved in a volume of water are concentrated; solutions with little solid dissolved in a volume of water are dilute. When equal volumes of two salt solutions are weighed, the heavier one is more concentrated. Density is mass per unit volume. More concentrated salt solutions are denser. Solutions form layers based on density. 	<p>Science Resources Book “Solutions Up Close” “Concentrated Solutions” “The Air” “Famous Scientists” “Carbon Dioxide Concentration in the Air” “The Frog Story”</p> <p>Video <i>Why Are Oceans Salty?</i></p> <p>Online Activities “Tutorial: Conservation of Mass” “Tutorial: Concentration” “Virtual Investigation: Saltwater Concentration” “Tutorial: Density”</p>	<p>Embedded Assessment Science notebook entries Response sheet Performance assessment</p> <p>Benchmark Assessment <i>Investigation 3 I-Check</i></p> <p>NGSS Performance Expectations 5-PS1-1 5-PS1-2</p>
<ul style="list-style-type: none"> A substance is a single, pure material. Solutions are composed of a solvent (liquid) and a solute (solid), which is dissolved in the solvent. Solubility is the property that indicates how readily a solute dissolves in a solvent. A solution is saturated when as much solid material as possible has dissolved in the liquid. Solubility varies from substance to substance. Substances form predictable, identifiable crystals. Engineers plan designs, select materials, construct products, evaluate results, and improve ideas. 	<p>Science Resources Book “The Bends” “A Sweet Solution” “Sour Power” “East Bay Academy for Young Scientists” “Drinking Ocean Water” “Creative Solutions”</p> <p>Video <i>The Water Cycle</i></p> <p>Online Activities “Tutorial: Saturation” “Virtual Investigation: Solubility”</p>	<p>Embedded Assessment Response sheet Science notebook entries Performance assessment</p> <p>Benchmark Assessment <i>Investigation 4 I-Check</i></p> <p>NGSS Performance Expectations 5-PS1-1 5-PS1-3 3–5-ETS1-1 3–5-ETS1-2</p>
<ul style="list-style-type: none"> Some mixtures result in a chemical reaction. During reactions, starting substances (reactants) change into new substances (products). A gas or precipitate is evidence of a reaction. Some products of reactions are soluble and can be identified by crystal structure after evaporation. Calcium carbonate reacts with acid. 	<p>Science Resources Book “Ask a Chemist” “When Substances Change” “Air Bags”</p> <p>Videos <i>Chemical Reactions</i> <i>Changes in Properties of Matter</i></p> <p>Online Activities “Fizz Quiz” “Tutorial: Reaction or Not?”</p>	<p>Embedded Assessment Science notebook entry Response sheet</p> <p>Benchmark Assessment <i>Posttest</i></p> <p>NGSS Performance Expectations 5-PS1-1; 5-PS1-2 5-PS1-3; 5-PS1-4</p>

FOSS COMPONENTS

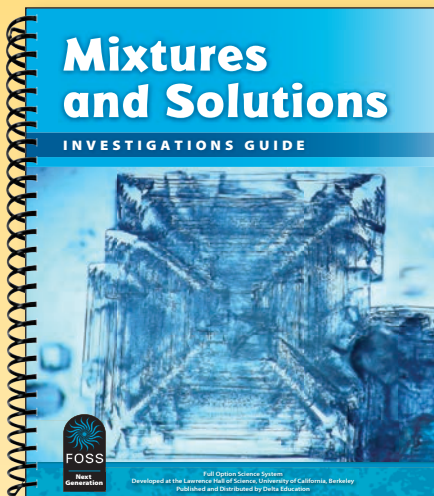
Teacher Toolkit for Each Module

The FOSS Next Generation Program has three modules for grade 5—Mixtures and Solutions, Living Systems, and Earth and Sun.

Each module comes with a *Teacher ToolKit* for that module. 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
- Framework and NGSS
- Materials
- Technology
- Investigations (five in this module)
- Assessment



<p style="text-align: center;">INVESTIGATION 4 — Reaching Saturation</p> <p>SCIENCE AND ENGINEERING PRACTICES Analyzing and interpreting data Constructing explanations</p> <p>NOTE You can provide each group with five strips of paper, each showing one of the five pieces of data.</p> <p>Epsom salts insoluble soluble</p> <p>TEACHING NOTE This notebook entry has not been identified as an assessment opportunity, but a quick look over students' shoulders may provide informal information about their progress with the idea that saturation is variable and material specific.</p> <p>272</p> <p style="text-align: right;">Full Option Science System</p>	<p style="text-align: center;">Part 2: Epsom Salts Saturation</p> <p>16. Assess progress: response sheet Use notebook sheet 15, <i>Response Sheet—Investigation 4</i>, for a closer look at students' understanding of solubility. Plan to have students spend some time reflecting on their responses after you have reviewed them. For more information about next-step and self-assessment strategies, see the Assessment chapter.</p> <p>What to Look For</p> <ul style="list-style-type: none"> • Students draw the liquid level higher in each bottle that contains more sugar. • Students draw a model that indicates dissolved materials in all three bottles, becoming more concentrated as more sugar is added. • Students show some undissolved sugar on the bottom of Bottle 2 (the saturated solution). • Students know solubility varies from substance to substance. (Epsom salts would be different.) <p>WRAP-UP/WARM-UP</p> <p>17. Share notebook entries Conclude Part 2 or start Part 3 by having students share notebook entries. Ask students to open their science notebooks to the most recent entry. Read the focus question together.</p> <p>► Does it always take the same amount of solid materials to saturate 50 mL of water?</p> <p>Ask students to pair up with a partner to</p> <ul style="list-style-type: none"> • share their claims regarding the amount of different materials that are required to saturate a unit of water; • discuss the evidence to support their claims. <p>18. Engage in argumentation Ask this question and provide three possible responses.</p> <p>► What happens to the mass of a cup of tea when you add a teaspoon of sugar?</p> <ul style="list-style-type: none"> • The sweetened tea will have less mass than the tea and the sugar when they are separated. • The sweetened tea will have the same mass as the tea and the sugar when they are separated. • The sweetened tea will have more mass than the tea and the sugar when they are separated. <p>Have students select one of the claims and support it with evidence.</p> <p>Mixtures and Solutions Module—FOSS Next Generation</p> <p style="text-align: right;">273</p>
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FOSS Science Resources book. One copy of the student book of readings is included in the *Teacher Toolkit*.

Teacher Resources. These chapters can be downloaded from FOSSweb and are also in the bound *Teacher Resources* book.

- FOSS Program Goals
- Science Notebooks in Grades 3–5
- Science-Centered Language Development
- FOSS and Common Core ELA—Grade 5
- FOSS and Common Core Math—Grade 5
- Taking FOSS Outdoors
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

WARNING — This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

Liquid Layers

Use the straws to record the colors of the salt solutions you tried to layer.

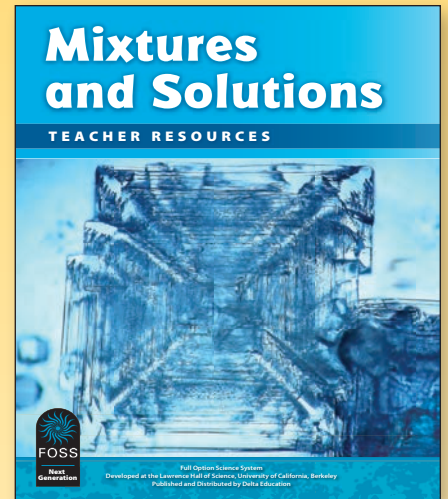
When you succeed in layering all four solutions, put them in order in the table below, from most concentrated to least concentrated.

Color	Least concentrated
	Most concentrated

Which solution is most dense? Which is least dense?
Why do you think so?


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Mixtures and Solutions Module
Investigation 3: Concentration
No. 13—Notebook Master



Equipment Kit for Each Module or Grade Level

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 three uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom items.

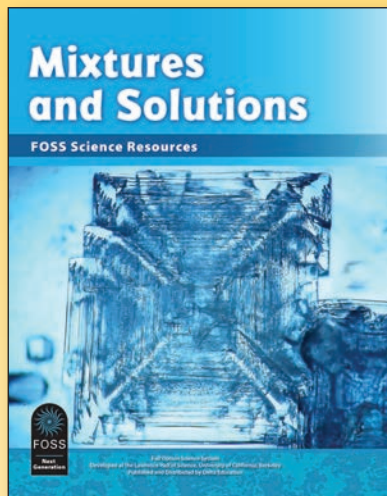


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Mixtures and Solutions Module—FOSS Next Generation

7

MIXTURES AND SOLUTIONS — Overview



FOSS Science Resources Books

FOSS Science Resources: Mixtures and Solutions is a book of original readings developed to accompany this module. The readings are referred to as articles in *Investigations Guide*. Students read the articles in the book as they progress through the module. The articles cover specific concepts, usually after the concepts have been introduced in the active investigation.

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

You can see that matter is conserved during the reaction. The number of carbon particles, hydrogen particles, and oxygen particles is the same on both sides of the arrow. In other words, the matter in the reactants is exactly the same as the matter in the products.

The natural gas reaction is a fast reaction. The change from reactants to products occurs in a flash. The products are both gases, CO_2 and water vapor, so the reaction is "clean." The only concern is the waste product CO_2 , which enters the air.

Fireworks

Another fast reaction is a stunning fireworks display. This kind of reaction is called an **explosion**. To qualify as an explosion, the reaction must happen very fast and must produce light, heat, and sound energy, plus a lot of gas. Because the gases expand so rapidly, explosions come with a loud kaboom. The people who design fireworks know what substances to put into each charge to produce different colors. The green color is the product of one substance, the red color is from another substance, and so on. The result is a thrilling experience for your eyes and ears.



Air Bags

The automotive air bag was invented in 1952 as a safety device for people. Twenty years later, air bags started to appear in American cars as an extra. Today, all cars sold in the United States have air bags in front, one for the driver and one for the passenger. Many cars have additional air bags in the ceiling and doors.

An air bag is a fabric bag that inflates like a big balloon the moment a car crashes into something. The bag has to inflate fully in a few thousandths of a second! How is that possible?

It's a chemical reaction. When a car smacks into a solid object, sensors in a triggering device start the action. A pulse of electricity flows to the igniter, and a wire gets hot. The hot wire starts a very fast reaction, which produces a large volume of gas, usually nitrogen. The expanding gas bursts open the steering wheel or dashboard, and the bag pops out. It has to be fully inflated before the driver's or passenger's head and chest reach the steering wheel or dashboard. That's fast inflation!

Technology

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each module has digital resources for students and families—interactive simulations, virtual investigations, and online activities. For teachers, FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Program, and technical support. You do not need an account to view this general FOSS Program information. In addition to the general information, FOSSweb provides digital access to PDF versions of 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 Learning

The Lawrence Hall of Science and Delta Education strive to develop long-term partnerships with districts and teachers through thoughtful planning, effective implementation, and ongoing teacher support. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS.

► NOTE

To access all the teacher resources and to set up customized pages for using FOSS, log in to FOSSweb through an educator account. See the Technology chapter in this guide for more specifics.

► NOTE

Look for professional development opportunities and online teaching resources on www.FOSSweb.com.

FOSS INSTRUCTIONAL DESIGN

FOSS is designed around active investigations that provide engagement with science concepts and science and engineering practices. Surrounding and supporting those firsthand investigations are a wide range of experiences that help build student understanding of core science concepts and deepen scientific habits of mind.

The Elements of Active Investigation



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

- Active investigation, firsthand experiences with objects, organisms, and materials in the natural and designed worlds
- Recording in science notebooks to answer the focus question
- Reading in *FOSS Science Resources* books
- Online activities to review or extend the investigation
- Outdoor experiences to collect data from the local environment or apply knowledge
- Assessment to monitor progress and motivate student learning

In practice, these components are seamlessly integrated into a curriculum 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.

A **learning cycle** is an instructional model based on a constructivist perspective that calls on students to be actively involved in their own learning. The model systematically describes both teacher and learner behaviors in a systematic approach to science instruction.

The most recent model is a series of five phases of intellectual involvement known as the 5Es: Engage, Explore, Explain, Elaborate, and Evaluate. The body of foundational knowledge that informs contemporary learning-cycle thinking has been incorporated seamlessly and invisibly into the FOSS curriculum design.



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 much salt will dissolve in a given volume of water?) 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 how to separate a dry mixture. 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 to lead students to a comprehensive understanding of concepts. Through investigations and readings, 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.

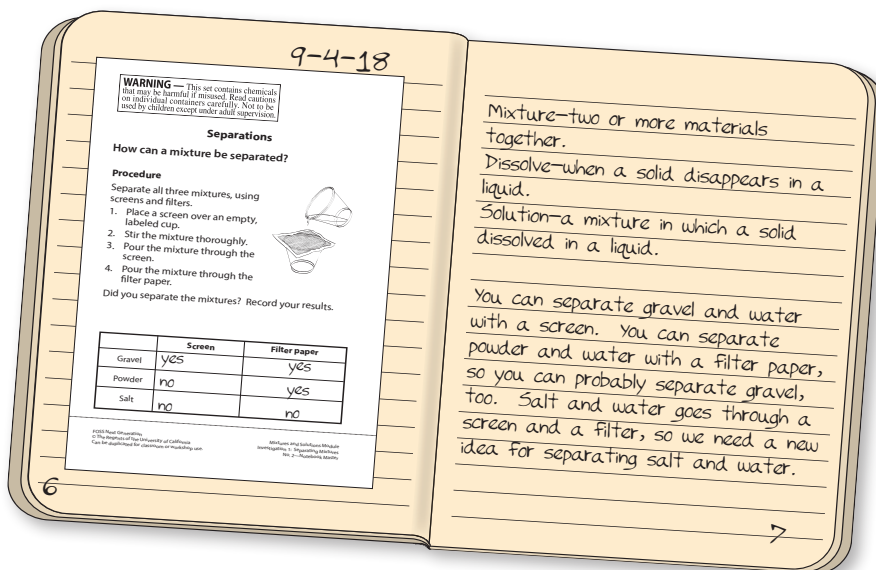
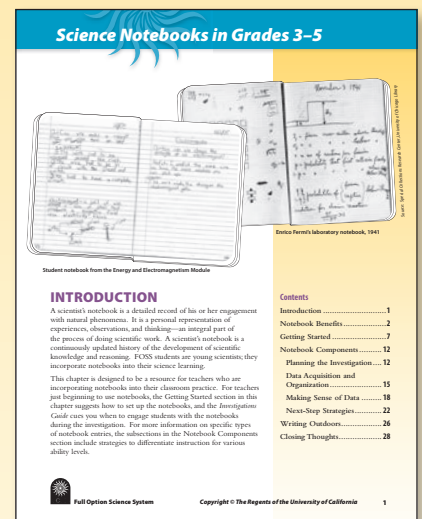
Students then organize data so they will be easier to think about. Tables allow efficient comparison. Organizing data in a sequence (time) or series (size) can reveal patterns. Students process some data into graphs, providing visual display of numerical data. They also organize data and process them 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 prior knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing a summary of their learning as well as questions raised during the activity in their science notebooks.

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 exhibitions of the assessment system.

You will find the duplication masters for grades 1–5 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 in the composition book. Look to the chapter in *Teacher Resources* called Science Notebooks in Grades 3–5 for more details on how to use notebooks with FOSS.





Reading in FOSS Science Resources

The *FOSS Science Resources* books are primarily devoted to expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time to connect to the Common Core State Standards for ELA. 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.

Recommended strategies to engage students in reading, writing, speaking, and listening around the articles in the *FOSS Science Resources* books are included in the flow of Guiding the Investigation. In addition, a library of resources is described in the Science-Centered Language Development chapter in *Teacher Resources*.

The chapter FOSS and the Common Core ELA in *Teacher Resources* shows how FOSS provides opportunities to develop and exercise the Common Core ELA practices through science. A detailed table identifies these opportunities in the three FOSS modules for the fifth grade.



Engaging in Online Activities through FOSSweb

The simulations and online activities on FOSSweb are designed to support students' learning at specific times during instruction. Digital resources include streaming videos that can be viewed by the class or small groups. Resources may also include virtual investigations and tutorials that students can use to review the active investigations and to support students who need more time with the concepts or who have been absent and missed the active investigations.

The Technology chapter provides details about the online activities for students and the tools and resources for teachers to support and enrich instruction. There are many ways for students to engage with the digital resources—in class as individuals, in small groups, or as a whole class, and at home with family and friends.



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 predominantly diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called **embedded assessment**, is an integral part of instruction, and occurs on a daily basis. You observe action during class in a performance assessment or review notebooks after class. Performance assessments look at students' engagement in science and engineering practices or their recognition of crosscutting concepts, and are indicated with the second assessment icon. 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 specific items on an I-Check with the class provides additional opportunities 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. Bullet points in Guiding the Investigation tell 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, but identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding.



► TECHNOLOGY COMPONENTS OF THE FOSS ASSESSMENT SYSTEM

FOSSmap for teachers and online assessment for students are the technology components of the FOSS assessment system. Students in grades 3–5 can take assessments online. FOSSmap provides the tools for you to review those assessments online so you can determine next steps for the class or differentiated instruction for individual students based on assessment performance. See the Assessment chapter for more information on these technology components.



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.

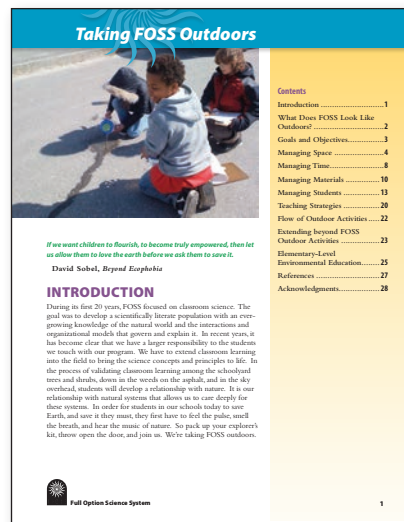
In addition to transfer and application, students can learn things outdoors that they are not able to learn indoors. The most important object of inquiry outdoors is the outdoors itself. To today's youth, the outdoors is something to pass through as quickly as possible to get to the next human-managed 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 classroom 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 *Teacher Resources*.



NOTE
The kit includes a set of four conservation posters so you can discuss the importance of natural resources with students.



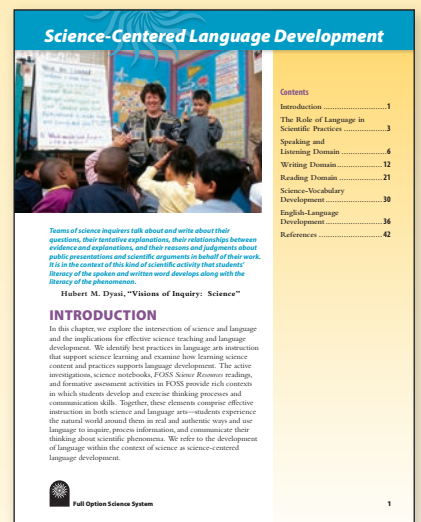
Science-Centered Language Development and Common Core State Standards for ELA

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. 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 identified in contemporary standards for English language arts.

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. We identify effective practices in language-arts instruction that support science learning and examine how learning science content and engaging in science and engineering practices support language development.

Specific methods to make connections to the Common Core State Standards for English Language Arts are included in the flow of Guiding the Investigation. These recommended methods are linked to the CCSS ELA through ELA Connection notes. In addition, the FOSS and the Common Core ELA chapter in *Teacher Resources* summarizes all of the connections to each standard at the given grade level.



DIFFERENTIATED INSTRUCTION

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 and provides many opportunities at one time for differentiated instruction.

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.

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 or online activities. 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.

The next-step strategies used during the self-assessment sessions after I-Checks provide many opportunities for differentiated instruction. For more on next-step strategies, see the Assessment chapter.

There are additional 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. In addition, online activities including tutorials and virtual investigations are effective tools to provide differentiated instruction.

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 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.

FOCUS QUESTION

What is the effect of mixing two substances with water?

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

DISCIPLINARY CORE IDEAS

MS1.A: Structure and properties of matter

CROSSCUTTING CONCEPTS

Energy and Matter

TEACHING NOTE

This focus question can be answered with a simple yes or no, but the question has power when students support their answers with evidence. Their answers should take the form “Yes, because ____.”

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.

The investigation is summarized for the teacher in the At-a-Glance chart at the beginning of each investigation.

Investigation-specific **scientific background** information for the teacher is presented in each investigation chapter organized by the focus questions.

The **Teaching Children about** section makes direct connections to the NGSS foundation boxes for the grade level—Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts. This information is later presented in color-coded sidebar notes to identify specific places in the flow of the investigation where connections to the three dimensions of science learning appear. The Teaching Children about section ends with information about teaching and learning and a conceptual-flow graphic of the content.

The **Materials** and **Getting Ready** sections provide scheduling information and detail exactly how to prepare the materials and resources for conducting the investigation.

Teaching notes and **ELA Connections** 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. 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. ELA Connection boxes provide connections to the Common Core State Standards for English Language Arts.

The **Getting Ready** and **Guiding the Investigation** sections have several features that are flagged 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.

FOSS Investigation Organization

The **safety** icon alerts you to potential safety issues related to chemicals, allergic reactions, and the use of safety goggles.

The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups.

The **new-word** icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully.

The **vocabulary** icon indicates where students should review recently introduced vocabulary.

The **recording** icon points out where students should make a science-notebook entry.

The **reading** icon signals when the class should read a specific article in the *FOSS Science Resources* book.

The **technology** icon signals when the class should use a digital resource on FOSSweb.

The **assessment** icons appear when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some are performance assessments—observations of science and engineering practices, indicated by a second icon which includes a beaker and ruler.

The **outdoor** icon signals when to move the science learning experience into the schoolyard.

The **engineering** icon indicates opportunities for an experience incorporating engineering practices.

The **math** icon indicates an opportunity to engage in numerical data analysis and mathematics practice.

The **EL note** provides a specific strategy to use to assist English learners in developing science concepts.

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



EL NOTE

POSSIBLE BREAKPOINT



MANAGING THE CLASSROOM

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.

Managing Materials

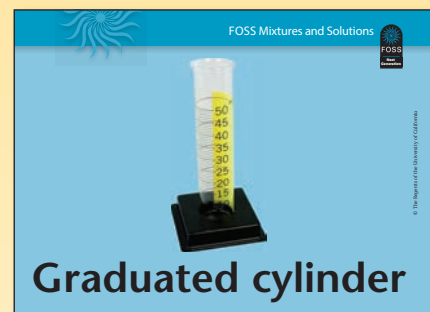
The Materials section lists the items in the equipment kit and any teacher supplied materials. It also describes things to do to prepare a new kit and how to check and prepare the kit for your classroom. Individual photos of each piece of FOSS equipment are available for printing from FOSSweb, and can help students and you identify each item.

The FOSS Program designers suggest using a central materials distribution system. You organize all the materials for an investigation at a single location called the materials station. As the investigation progresses, one member of each group gets materials as they are needed, and another returns the materials when the investigation is complete. You place the equipment and resources at the station, and students do the rest. Students can also be involved in cleaning and organizing the materials at the end of a session.

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.

Students who have been absent from certain investigations can access online activities through FOSSweb. Some of the activities may require students to record data and answer concluding questions in their science notebooks.



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.

Safety Data Sheets (SDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any SDS, call Delta Education at 1-800-258-1302 (Monday–Friday, 8 a.m.–5 p.m. ET).



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 protect your eyes. Wear safety goggles when necessary. Tell your teacher if you wear contact lenses.
- 7 Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
- 8 Never mix any chemicals unless your teacher tells you to do so.
- 9 Report all spills, accidents, and injuries to your teacher.
- 10 Treat animals with respect, caution, and consideration.
- 11 Clean up your work space after each investigation.
- 12 Act responsibly during all science activities.



Outdoor Safety

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



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.

SCHEDULING THE MODULE

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

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

Reading (R) sessions involve reading *FOSS Science Resources* articles. Reading can be completed during language-arts time to make connections to Common Core State Standards for ELA (CCSS ELA).

During **Wrap-Up/Warm-Up (W)** sessions, students share notebook entries and engage in connections to CCSS ELA. These sessions can also be completed during language-arts time.

I-Checks are short summative assessments at the end of each investigation. Students have a short notebook review session the day before and a self-assessment of selected items the following day. (See the Assessment chapter for the next-step strategies for self-assessment.)

NOTE

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 and review the teacher preparation video on FOSSweb.

Week	Day 1	Day 2	Day 3	Day 4	Day 5
	Survey				
1	START Inv. 1 Part 1	START Inv. 1 Part 2			START Inv. 1 Part 3
	A/W	A	A	R/W	A
2	R/W	START Inv. 1 Part 4	R/Review	I-Check 1	Self-assess
		A			
3	START Inv. 2 Part 1			START Inv. 2 Part 2	
	A	A	A/W	A	R/W
4	START Inv. 2 Part 3				
	A/R	R	Review	I-Check 2	Self-assess
5	START Inv. 3 Part 1		START Inv. 3 Part 2		START Inv. 3 Part 3
	A	R/W	A	R/W	A
6	R/W	START Inv. 3 Part 4	R/Review	I-Check 3	Self-assess
		A			
7	START Inv. 4 Part 1		START Inv. 4 Part 2	START Inv. 4 Part 3	
	A	R/W	A	A	A
8	R/W	START Inv. 4 Part 4			
		A	A/R	A/R	Review
9	I-Check 4	Self-assess	START Inv. 5 Part 1		START Inv. 5 Part 2
			A	R/W	A
10			START Inv. 5 Part 3		
	A	R/W	A/R	Review	Posttest

FOSS CONTACTS

General FOSS Program Information

www.FOSSweb.com

www.DeltaEducation.com/FOSS

Developers at the Lawrence Hall of Science

foss@berkeley.edu

Customer Service at Delta Education

<http://www.DeltaEducation.com/contact.aspx>

Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

FOSSmap (Online component of FOSS assessment system)

<http://fossmap.com/>

FOSSweb account questions/help logging in

School Specialty Online Support

loginhelp@schoolspecialty.com

Phone: 1-800-513-2465, 8:30 a.m.–6:00 p.m. ET
5:30 a.m.–3:00 p.m. PT

FOSSweb Tech Support

support@fossweb.com

Professional development

<http://www.FOSSweb.com/Professional-Development>

Safety issues

www.DeltaEducation.com/SDS

Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

For chemical emergencies, contact Chemtrec 24 hours per day.

Phone: 1-800-424-9300

Sales and Replacement Parts

www.DeltaEducation.com/BuyFOSS

Phone: 1-800-338-5270, 8:00 a.m.–5:00 p.m. ET