INTRODUCTION

Life has existed on Earth for a very, very long time, more than 3.5 billion years, in fact. Over the millennia, an amazing variety of life has evolved. From humble single-celled beginnings in water to incredibly complex and large multicellular organisms that exist in the widest range of habitats imaginable, the diversity of life that currently exists boggles the mind.

Middle school students are ready to consider what it means to be a living organism. What are the characteristics that scientists use to define life? Are those characteristics hard and fast or are they flexible? Does something as outlandish as an archaeon that lives in boiling hot springs or a virus that depends upon other life-forms to reproduce fit into the definition students create? Students consider these questions as they encounter life throughout the course.

As these students will inherit Earth, their understanding of life may lead to a more robust and informed response to the rapid loss of diversity.
# Diversity of Life

## Overview

<table>
<thead>
<tr>
<th>Investigation Summary</th>
<th>Time</th>
<th>Parts</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What Is Life?</strong></td>
<td>Assessment 1 Session (optional)</td>
<td>1. Living or Nonliving 2. Is Anything Alive in Here?</td>
<td>How do you know if something is living?</td>
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<td><strong>The Microscope</strong></td>
<td>Active Inv. 5 Sessions</td>
<td>1. Meet the Microscope 2. Field of View 3. Microscopic Life</td>
<td>How do objects appear when they are viewed through a microscope? How can we estimate the size of an object by looking at it through the microscope? What evidence can we find that brine shrimp are living organisms?</td>
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<td><strong>The Cell</strong></td>
<td>Active Inv. 6 Sessions</td>
<td>1. Discovering Cells 2. Paramecia 3. Microworlds 4. Human Cheek Tissue</td>
<td>What microscopic structures make up organisms such as elodea? How are elodea and the paramecium alike, and how are they different? Is there life in the minihabitats? If so, where did it come from? What microscopic structures make up organisms such as humans (you)?</td>
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**Inv. 1**

Students begin their investigation of life by thinking about the characteristics and requirements that all life has. They start developing a definition of life that will guide them throughout the course.

**Inv. 2**

Students learn to use a tool, the compound microscope, that opens up the world of microorganisms and cells. They use the diameter of the field of view to begin estimating the size of organisms that are invisible to the naked eye.

**Inv. 3**

Students discover cells and think about what it means to be a single-celled or multicellular organism. They add “made of cells” to their definition of life. They learn that cells are made of structures that enable the functions of life.
### Module Matrix

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| • Any free-living thing is an organism.  
• All organisms exhibit common characteristics and have certain requirements: they grow, need energy (food) and water, exchange gases, respond to the environment, reproduce, eliminate waste, and need a suitable environment in which to live.  
• Something can be dead only if it was once living.  
• Some organisms can become dormant to survive in an unsuitable environment. | **Science Notebook Entry**  
Living/Nonliving Card Sort  
Five Materials Observation  
Life in Different Environments  
**Science Resources Book**  
“The Characteristics of Life on Earth” (optional) | **Benchmark Assessment**  
Survey (optional)  
**Embedded Assessment**  
Quick write  
Science and engineering practices  
Science notebook entry |
| • A compound optical microscope is composed of a two-lens system (eyepiece and objective lens), a stage on which to mount the material being observed, a light source (lamp or reflected), and a focusing system.  
• A microscope’s optical power is the product of the magnification of the eyepiece and the objective lens.  
• The field of view (FOV) is the diameter of the circle of light seen through the microscope. As the power increases, the FOV decreases.  
• A microscope may reverse and invert images. | **Science Notebook Entry**  
The Microscope  
Microscope Use and Practice  
Microscope Images  
Field of View and Magnification  
Estimating Size  
Brine Shrimp  
Evidence of Life  
**Science Resources Book**  
“The History of the Microscope” (optional) | **Embedded Assessment**  
Science notebook entry  
Response sheet  
Science and engineering practices |
| • The cell is the basic unit of life. All living things are made up of one or more cells.  
• Every cell has structures that enable it to carry out life’s functions.  
• Both single-celled and multicellular organisms exhibit all the characteristics of life.  
• Some organisms can become dormant to survive in an unsuitable environment.  
• Asexual reproduction is a method of reproduction that results in offspring with identical genetic information. | **Science Notebook Entry**  
Looking at Elodea  
Plant Cell Structures and Functions  
Paramecia  
Protist Cell Structures and Functions  
Minihabitat Safari  
Human Cheek Tissue  
Animal Cell Structures and Functions  
Cell Tracking  
**Science Resources Book**  
“The Amazing Paramecium” (optional)  
“Cells!” | **Embedded Assessment**  
Science and engineering practices  
Response sheet  
**Benchmark Assessment**  
Investigations 1–3 I-Check
### Investigation Summary

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<td><strong>Domains</strong> Students learn about the levels of complexity (from atom to cell) in a card sort and begin to apply their burgeoning understanding of life to unfamiliar organisms. They apply their “life” criteria to determine if these specimens are actually living. Students are introduced to the domain system of classification.</td>
<td>Active Inv. 8 Sessions Reading 1 Session Assessment 1 Session</td>
<td>1. Comparing Living Things 2. Bacteria 3. Fungi 4. Archaea: The Three Domains</td>
<td>What are the building blocks of cell structures? What evidence is there that bacteria are living organisms? What evidence is there that fungi are living organisms? What are the characteristics of archaea?</td>
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<td><strong>Plants: The Vascular System</strong> Students conduct an investigation to understand how the vascular system transports water throughout a vascular plant. They are introduced to photosynthesis and aerobic cellular respiration, two important life processes. Students extend the levels of complexity to include multicellular organisms, moving from cells to tissues, to organs, to organ systems, and finally to multicellular organisms.</td>
<td>Active Inv. 6 Sessions Reading 1 Session Assessment 1 Session</td>
<td>1. What Happened to the Water? 2. Looking at Plant Structures 3. Transpiration and Photosynthesis</td>
<td>What happened to the water? How is water transported through a plant? How do plants use water?</td>
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<td>• Cells are made of cell structures which are, in turn, made of molecules, which are made of atoms. • Bacteria, fungi, and archaea demonstrate all the characteristics of life. • Life is classified into three different domains (Archaea, Bacteria, Eukaryota), depending upon cellular and molecular characteristics.</td>
<td><strong>Science Notebook Entry</strong>  Observing Bacteria  Observing Fungi  Bacterial Cell Structures and Functions  Fungal Cell Structures and Functions  Archaea Classification History Notes  <strong>Science Resources Book</strong>  “Levels of Complexity Research Pages”  “Bacteria around Us”  “Bacteria: The Bad, the Good, and the New Frontiers” (optional)  “Archaea Family Album”</td>
<td><strong>Embedded Assessment</strong>  Science and engineering practices  Response sheet  Quick write  Science notebook entry  <strong>Benchmark Assessment</strong>  Investigation 4 I-Check</td>
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<td>• Transpiration is the process by which water is carried through vascular plants from the roots to stomata, ensuring that all the cells have access to water. • The vascular system of plants consists of xylem and phloem. • Plants use photosynthesis and aerobic cellular respiration to make usable energy from the Sun’s energy. • Cells are the building blocks of tissues, which are the building blocks of organs, which are the building blocks of organ systems, which are the building blocks of multicellular organisms.</td>
<td><strong>Science Notebook Entry</strong>  Answer focus question  Celery Investigation Data A and B  Leaf Observations  Multicellular Levels of Complexity  <strong>Science Resources Book</strong>  “The Water-Conservation Problem”  “Water, Light, and Energy”</td>
<td><strong>Embedded Assessment</strong>  Science notebook entry  Response sheet  Science and engineering practices  <strong>Benchmark Assessment</strong>  Investigation 5 I-Check</td>
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| **Plant Reproduction and Growth**  | **Active Inv.** 7 Sessions **Assessment** 1 Session | 1. Lima Bean Dissection  
2. Environmental and Genetic Factors  
3. Flowering-Plant Reproduction  
4. Flowers and Pollinators | How do the structural adaptations of seeds help them survive?  
How do environmental factors affect the germination and early growth of different food crops?  
What is the purpose of a flower?  
What adaptations do flowering plants have to accomplish pollination? |
| **Insects**  | **Active Inv.** 4 Sessions | 1. Structure, Function, and Behavior  
2. Insect Systems | How do the structures and behaviors of the Madagascar hissing cockroach enable life’s functions?  
How is the insect transport system like plant and human transport systems and how is it different? |
| **Diversity of Life**  | **Active Inv.** 5 Sessions **Reading** 1 Session **Assessment** 2 Sessions | 1. Bioblitz  
2. What Is Life? | What kind of plant and animal life exists in our schoolyard (neighborhood)?  
How do you know if something is living? |

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### Overview

- **Inv. 6: Plant Reproduction and Growth**
  - Students dissect a seed and then plant various grains to investigate how the environmental factor of salinity affects their germination and growth. They enter into the world of flowering plant reproduction and discover the relationship between flowers and pollinators.
  - **Active Inv.** 7 Sessions  
  - **Assessment** 1 Session

- **Inv. 7: Insects**
  - Students encounter the Madagascar hissing cockroach, which extends the world of multicellular organisms. They compare the vascular system of vascular plants to the transport systems of insects and humans.
  - **Active Inv.** 4 Sessions

- **Inv. 8: Diversity of Life**
  - Students conduct a bioblitz to learn about the biodiversity that exists in their area. They conclude their study of life by considering the question of viruses.
  - **Active Inv.** 5 Sessions  
  - **Reading** 1 Session  
  - **Assessment** 2 Sessions
### Module Matrix

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| ● Environmental and genetic factors affect the germination and growth of plants. | **Science Notebook Entry**  
Seed Dissection  
Seed Hunt (optional)  
Germination and Growth in Different Salinities  
Comparing Growth  
Parts of a Flower  
Flower Dissection A and B  
Plant-Reproduction Sequence Cards  
Pollination Syndrome A and B  | **Embedded Assessment**  
Science and engineering practices  
Science notebook entry  
Response sheet  
**Benchmark Assessment**  
Investigation 6 I-Check |
| ● Flowering plants reproduce sexually, producing seeds, which contain dormant new plants.  
● Flowering plants have characteristics that attract pollinators to ensure successful pollination and reproduction.  
● Pollinators are attracted to flowers that meet their needs. | **Science Resources Book**  
“Seeds on the Move” (optional)  
“Breeding Salt-Tolerant Wheat”  
“The Making of a New Plant”  
“Flower Information”  
“Flowers and Pollinators” |                                                                                                                                                        |
| ● The structures and behaviors of an organism have functions that enhance the organism’s chances to survive and reproduce in its habitat.  
● Cells are the building blocks of tissues, which are the building blocks of organs, which are the building blocks of organ systems, which are the building blocks of multicellular organisms.  
● Insects have open circulatory systems that transport substances to and away from their cells. | **Science Notebook Entry**  
Insect Observations A and B  
Structure/Behavior/Function Summary  
Comparing Systems  | **Embedded Assessment**  
Science and engineering practices  
Science notebook entry  
Group response |
| ● Biodiversity is the variety of life that exists in a particular habitat or ecosystem.  
● Measuring biodiversity includes measuring both the variety of organisms and the number of organisms in a habitat or ecosystem.  
● Scientific debate regarding whether viruses are living organisms is ongoing.  
● All life on Earth is related. | **Science Notebook Entry**  
Secret Garden Questions  
Bioblitz Summary and Reflections  
Are Viruses Living Organisms?  
Tree of Life  
**Science Resources Book**  
“Biodiversity at Home and Abroad” (optional)  
“Viruses: Living or Nonliving?” | **Embedded Assessment**  
Science and engineering practices  
Science notebook entry  
**Benchmark Assessment**  
Posttest |
The Diversity of Life Course for grades 6–8 emphasizes the use of knowledge and evidence to describe life in all its diversity. This course supports the following principles set forth in A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council, 2012).

Science and Engineering Practices
Develop students’ abilities to do and understand scientific practices.

- Asking questions (for science) and defining problems (for engineering).
- Developing and using models.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Using mathematics and computational thinking.
- Constructing explanations (for science) and designing solutions (for engineering).
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

Crosscutting Concepts
Develop students’ understandings of concepts that bridge disciplinary core ideas and provide an organizational framework for connecting knowledge from different disciplines into a coherent and scientifically based view of the world.

- Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
- Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.
• **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

• **Energy and matter: Flows, cycles, and conservation.** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

• **Structure and function.** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

• **Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

### Life Sciences

**Core Idea LS1: From Molecules to Organisms: Structures and Processes**

• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). Unicellular organisms (microorganisms), like multicellular organisms, need food, water, a way to dispose of waste, and an environment in which they can live. Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues or organs that are specialized for particular body functions. (LS1.A)

• Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features (such as attractively colored flowers) for reproduction. Plant growth can continue throughout the plant’s life through production of plant matter in photosynthesis. Genetic factors as well as local conditions affect the size of the adult plant. The growth of an animal is controlled by genetic factors, food intake, and interactions with other organisms, and each species has a typical adult size range. (LS1.B)
• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. Animals obtain food from eating plants or eating other animals. Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. In most animals and plants, oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not require oxygen. (LS1.C)

Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics
• Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (LS2.C)

Core Idea LS3: Heredity: Inheritance and Variation of Traits
• In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (LS3.B)

Core Idea LS4: Biological Evolution: Unity and Diversity
• Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems. (LS4.D)

Physical Sciences
Core Idea PS3: Energy
• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. Both the burning of fuel and cellular digestion in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (PS3.D)
Next Generation Science Standards

This course supports the following principles set forth in Next Generation Science Standards (2013).

Life Sciences

- MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
FOSS CONCEPTUAL FRAMEWORK

FOSS has conceptual structure at the course level. The concepts are carefully selected and organized in a sequence that makes sense to students when presented as intended. In the last half decade, research has been focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching—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 we can and should understand about them in our primary school years, and progressively more complex and sophisticated things we should know about them as we gain experience and develop our cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing the learning progressions involves identifying successively more sophisticated ways of thinking about core ideas 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*, 2012).

The FOSS modules (grades K–5) and courses (grades 6–8) are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, which represent a core scientific idea, as shown in the columns in the table: matter/energy and change, atmosphere and Earth/rocks and landforms, structure and function/complex systems. The sequence of modules and courses 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.

In addition to the science content framework, every course provides opportunities for students to engage in and understand science practices, and many courses explore issues related to engineering practices and the use of natural resources.
The science content used to develop the FOSS courses describes what we want students to learn; the science and engineering practices describe how we want students to learn. Practices involve a number of habits of mind and philosophical orientations, and these, too, will develop in richness and complexity as students advance through their science studies. Science and engineering practices involve behaviors, so they can be best assessed while in progress. Thus, assessment of practices is based on teacher observation. The indicators of progress include students involved in the many aspects of active thinking, students motivated to learn, and students taking responsibility for their own learning.
DIVERSITY OF LIFE IN MIDDLE SCHOOL

Life scientists who ponder the origins of life on Earth generally agree that life has been on board for about 3.5 billion years. The conditions on this planet are perhaps unique: the presence of water, the right distance from the Sun, molecules that formed the precursors to organic life, all the things that make it possible for life (as we know it) to exist. In fact, these are the conditions that scientists are searching for on other planets in the quest for life beyond the solar system.

What did the first life on Earth look like? Well, probably not much more than a membrane filled with seawater and chemicals. A single cell that could survive and replicate in the as yet extreme conditions that constituted Earth’s environment, something on the order of a bacterium or archaeon. Or, as some current theories posit, perhaps the first replicating life-forms were more akin to what we recognize today as viruses. Regardless, the first 3 billion years or so of life was microbial, single-celled, and evolving until some of those cells worked together and the first multicellular life appeared.

The history of life from that time forth, however, does not appear to be a simple straight line with a few branches off it. Rather, it is characterized by stops and starts, extinctions and new organisms, a confusion from which the incredible diversity we see today has sprung. Scientists like to think of the history of life as a kind of tree of life, but one that looks more like a bush of life, or a “mangrove of life,” with a tangle of roots at its base leading to three trunks: bacteria, archaea, and eukaryotes.

To untangle those roots, we have to have some common understanding. And this is where our studies begin: What characteristics do all organisms share? That is where the Diversity of Life Course takes us: along the path to understanding that key concept, a concept that opens doors to the fascinating array of life that exists on Earth.
Why Study Organisms and Cells?

The student’s case. It’s been heard so many times . . . the middle schooler’s mantra: “Why do I have to learn this? What does this have to do with my life?” They ask these questions, not to be argumentative, but because they are awakening to a larger world and feeling the first sting of realization that soon they will have to make their way in it. “I’ll need a job, and I’m not going to be a biologist. I really don’t want to do this.”

These questions betray the fact that middle schoolers have acquired a more complex worldview. They have progressed from a life guided by concrete experiences and events in the present to a more worldly view interwoven with powerful abstractions, extending from past to future. Now the curriculum can advance a level to take advantage of the new abilities of students. Students are ready for some serious thought focused on life.

Middle schoolers know that life is a wonderful thing, so now is a good time to find out where it resides. Life happens in cells. The cell is the chalice that holds the treasured spark. Cells are alive. Everything that is alive is a cell or is made of cells. Cell biology is the study of life at its fundamental level.

Students will get to know the lifestyle of a few cells—protists such as paramecia. These single-celled organisms live simple lives, but they do pretty much the same things we do when it comes to basic life functions. They require water and a source of energy. They eliminate waste and engage in gas exchange. They reproduce and grow and respond to stimuli. There you have it—humans and paramecia, and every other organism for that matter, march to the same drummer when it comes to the essential activities required for survival. This powerful lesson will provide students with a humane perspective when thinking about life on Earth.

The flip side of all this uniformity in life is the diversity in forms. Organisms can be aquatic, terrestrial, marine, or aerial. Life occupies every conceivable place on this planet, speaking volumes about the versatility and plasticity of life. Just look around at the diversity right in your neighborhood. It is phenomenal.

Even more impressive is the diversity of life you don’t see. More than half the biomass on Earth is microscopic. You just don’t see the billions of organisms living on, in, and all around you at all times. This concept may be difficult for students to grasp fully, but it is another of the facts of life that they will be exposed to.
Speaking of facts of life . . . students study flowers. These pinnacles of adaptation convey the story of sexual reproduction, something of interest to all students. Embedded in the study of pollination is the story of natural selection and genetics. These topics are not pursued in depth, but as students grapple with the difficult concept of adaptation, they are setting foot on the path that will lead to deeper exploration of these important concepts in the near future.

Explaining how you know something is a lot harder than just knowing it. This metacognitive process—thinking about your thinking—is difficult. Students will stumble and resist in the beginning. But by the end of the course, students should be more confident in their ability to find and observe evidence and to use the evidence to come up with inferences. And if they stop to think about it, they will be impressed by how their thinking has changed. They will no longer look at a cat or a plant or even mold in the same way.

The teacher’s case. Middle school teachers know that middle school students are in a universe of turmoil. Bodies, emotions, and social relationships are at odds. One day (or minute) they will be composed and ready to learn—actually quite mature—and the next they will be hopelessly distracted and sensitive. On the settled days, students will engage in analytical problem solving, dealing effectively with abstractions. But on the squirrelly days students will have better success with concrete experiences. Middle schoolers need both, and successful teachers know how to manage the balance of learning modalities to maximize student success.

The Diversity of Life Course provides variety to keep both students and teachers interested. At different times students work alone, in pairs, in groups of four, and as a class. Sometimes the activities are fairly rigorous, and other times the atmosphere is decidedly social. The tempo will vary (students shouldn’t be allowed to fall into predictable patterns), the teaching strategies will vary (middle schoolers think they get bored easily), the other students with whom they work will vary (social relationships rule middle schoolers’ lives), and the place where inquiry happens will vary (they love to be on the move).
Can I Teach This? I’m Not a Biologist

FOSS assumes that teachers using this course possess no more than a minimal level of biological science content knowledge, a functional vocabulary of basic biology, and familiarity with the divisions of life and some rudiments of biological processes. Additional knowledge is an asset but is not a prerequisite for teaching the course effectively. The specific content dealt with in each investigation is discussed in the Scientific and Historical Background section of each chapter. You may not have a thorough understanding of the material when students start the course, but you will have a pretty good understanding of the objects and principles at the end.

The Diversity of Life Course focuses on how we know what a living organism is. As you help students develop the characteristics that define life, they will explore different forms of life. You can guide them to a scientific understanding that they can use as evidence to support their arguments about what life is. They will use microscopes to discover cells and differentiate between the cells of different organisms. They will use evidence to determine if they are more like bacteria, bread mold, or archaea. Students consider what makes single-celled and multicellular organisms such as insects different. How do systems fit in? And finally, students take what they have firmly established and consider something altogether different: viruses. Do the “life criteria” still apply?

The important thing to remember is that the investigations are designed to support the kind of classroom environment in which teachers and students learn together. It is an exploration, and you are finding things out together. When the inquiry is moving along as planned, you are the guide and the provocateur, urging students to follow the path that has been suggested by their own discoveries. That way when questions come up, the class as a community of learners is responsible for finding the answer.

We have included resources in the kit that will support the experience. Some of these include

- Living/Nonliving cards (student card sets and teacher card sets)
- Microscope kits
- Levels of Complexity cards (student card sets)
- Secret Garden (DVD)

In addition to these resources, FOSSweb has extensive resources, including animations, interactive simulations, and slide shows.
FOSS MIDDLE SCHOOL 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 have been assembled. Everything we know about the content of the course and how to teach the subject in a middle school classroom is presented here, along with the resources that will assist the effort. Each middle school Teacher Toolkit has three parts.

Investigations Guide. This spiral-bound document contains these chapters.

- Overview
- Materials
- Investigations (eight in this course)

Teacher Resources. This collection of resources contains these chapters.

- FOSS Middle School Introduction
- Assessment
- Science Notebooks in Middle School
- Science-Centered Language Development in Middle School
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters
- Notebook Answers

The chapters in Teacher Resources can also be found on FOSSweb as PDFs.

FOSS Science Resources. This is the student book of readings, images, and data that are integrated into the instruction.

Equipment Kit
The FOSS Program provides the materials needed for the investigations 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 five sequential uses (five periods in one day) before you need to restock. You will be asked to supply small quantities of common classroom items.
FOSS Science Resources Books

*FOSS Science Resources: Diversity of Life* is a book of original readings developed to accompany this course, along with images and data to analyze during investigations. The readings are referred to as articles in the *Investigations Guide*. Students read the articles in the book as they progress through the course, sometimes during class and sometimes as homework. The articles cover a specific concept, usually after that concept has been introduced in an active investigation.

The articles in *FOSS Science Resources* and the discussion questions 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 course has an interactive site where students can find instructional activities, interactive simulations, virtual investigations, and other resources. 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 *Teacher Resources* 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 courses 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 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. Put our experience to work in your classroom, and see how easy it is to engage students in active learning.
FOSS INSTRUCTIONAL DESIGN
Each FOSS investigation follows a similar cycle to provide multiple exposures to science concepts. The cycle 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
- 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 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
Courses are subdivided into investigations (eight to ten). Investigations are further subdivided into two to four parts. Each part of each investigation is driven by a focus question. The focus question, 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’ inquiry and makes the goal of each part explicit for teachers. Each part concludes with students preparing a written answer to the focus question in their notebooks.

Investigation-specific scientific and historical 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 facilitates finding the exact information you need for each part of the investigation.

The Getting Ready and Guiding the Investigation sections have several features that are flagged or presented in the sidebar. 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 sidebar. An arrow points to the place in the lesson where the note applies. These notes constitute a second voice in the curriculum—an educative element. The first (traditional) voice is the message you deliver to students.
supports your work teaching students at all levels, from management to inquiry. The second educative voice is designed to help you understand the science content and pedagogical reasoning at work behind the instructional scene.

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

The **vocabulary** icon indicates where students should record vocabulary in their science notebooks.

The **recording** icon points out where students should make a science notebook entry. Students can record on prepared notebook sheets or on plain sheets in a bound notebook.

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

The **reading** icon signals when the class should read a specific article or refer to data in *FOSS Science Resources*. Some readings are critical to instruction and should take place in class. A reading guide is provided for each such reading.

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

The **assessment** icon appears when there is an opportunity to assess student progress by using embedded or benchmark assessments. Assessments focusing on students’ conceptual development are indicated by the paper icon, and assessments focusing on science and engineering practices are indicated by the beaker and ruler icon.

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

The **homework** icon indicates science learning experiences that extend beyond the classroom.

The **outdoor** icon indicates science learning experiences that extend into the schoolyard.

To help with scheduling, 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 you know if something is living? At other times, students are asked to plan a method for investigation. This might include determining the important data to gather and the necessary tools. 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, they observe systems and interactions, and they 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.

Online activities throughout the course provide students with opportunities to collect data, manipulate variables, and explore models and simulations beyond what can be done in the classroom. Seamless integration of the online activities forms an integral part of students’ active investigations in FOSS.

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 notebooks. Data recording is the first of several kinds of student writing.
Students then organize data so that 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 notebooks a summary of their learning as well as questions raised during the activity.

**Science Notebooks**

Research and best practice have led us 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. And the student notebook entries stand as a credible and useful expression of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for middle school presented in a notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) in a bound composition book. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets. Full-size masters that can be filled in electronically and are suitable for projection are available on FOSSweb.
Reading in Science Resources
Reading is a vital component of the FOSS Program. Reading enhances and extends information and concepts acquired through direct experience.

Readings are included in the FOSS Science Resources: Diversity of Life book. Students read articles on the characteristics of life, cells, bacteria, photosynthesis and aerobic cellular respiration, environmental and genetic factors, flowering-plant reproduction, insects, biodiversity, and viruses as well as accessing data and information for use in investigations.

Some readings can be assigned as homework or extension activities, whereas other readings have been deemed important for all students to complete with a teacher’s support in class.

Each in-class reading has a reading guide embedded in Guiding the Investigation. The reading guide suggests breakpoints with questions to help students connect the reading to their experiences from class, and recommends notebook entries. Each of these readings also includes one or more prompts that ask students to make additional notebook entries. These prompts should help students who missed the in-class reading to process the article in a more meaningful way. Some of the most essential articles are provided as notebook masters. Students can highlight the article as they read, add notes or questions, and add the article to their science notebooks.

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.

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 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 one or two investigations. These **I-Checks** are actually hybrid tools: they provide summative information about students’ achievement, and because they occur soon after teaching an investigation, they can be used diagnostically as well. Reviewing a specific item on an I-Check with the class provides another opportunity for students to clarify their thinking.

The embedded assessments are based on authentic work produced by students during the course of participating in the FOSS activities. Students do their science, and you look at their notebook entries. Within the instructional sequence, you will see the heading **What to Look For** in red letters. Under that, you will see bullet points telling you specifically what students should know and be able to communicate.

If student work is incorrect or incomplete, you know that there has been a breakdown in the learning/communicating process. The assessment system then provides a menu of next-step strategies to resolve the situation. Embedded assessment is assessment for learning, not assessment of learning.

### 12. Assess progress: notebook entry

Ask students to turn to the focus question from Part 1 in their notebooks.

> **What happened to the water?**

Have students draw a line of learning below their original responses and record any new thoughts.

Collect a sample of the notebooks to review student responses.

**What to Look For**

- **Students state that water moves through a plant to every cell via the process of transpiration.**
- **Students relate how water travels up a plant from the roots, through the xylem, and into the veins in the leaves and exits the plant through stomata.**
- **Students recognize that guard cells open and close stomata, depending upon environmental conditions.**
- **Students realize that an incredible amount of water can move through a plant in a typical day.**

Plan to spend 15 minutes reviewing the sample of student responses. Using **Embedded Assessment Notes** as a tool, review the student responses, and tally the number of students who got or didn’t get the one or two concepts that you chose to analyze. Record any misconceptions that are evident from student responses.

After your review, return the notebooks. Plan time for next-step strategies (if needed) before the I-Check.
Assessment of learning is the domain of the benchmark assessments. Benchmark assessments are delivered at the beginning of the course (survey), at the end of the course (posttest), and after one or two investigations (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments.

The assessment items do not simply identify whether a student knows a piece of science content. They also identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding. Since the output from the benchmark assessments is descriptive and complex, it can be used for formative as well as summative assessment.

Completely incorporating the assessment system into your teaching practice involves realigning your perception of the interplay between good teaching and good learning, and usually leads to a considerably different social order in the classroom, with redefined student-student and teacher-student relationships.

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 in Middle School 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. Science provides a real and engaging context for developing literacy, and language-arts skills and strategies to support conceptual development and scientific practices. 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.

The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, and gives suggestions for additional literacy strategies. The Science-Centered Language Development in Middle School chapter is a library of resources and strategies for you to use.
MANAGEMENT STRATEGIES

FOSS has tried to anticipate the most likely learning environments in which science will be taught and designed the curriculum to be effective in those settings. The most common setting is the 1-hour period (45–55 minutes) every day, one teacher, in the science room. Students come in wave after wave, and they all learn the same thing. Some teachers may have two preps because they teach seventh-grade and eighth-grade classes. The Diversity of Life Course was designed to work effectively in this traditional hour-a-day format.

The 1-hour subdivisions of the course adapt nicely to the block-scheduling model. It is usually possible to conduct two of the 1-hour sessions in a 90-minute block because of the uninterrupted instructional period. A block allows students to set up an experiment and collect, organize, and process the data all in one sequence. Block scheduling is great for FOSS; students learn more, and teachers are responsible for fewer preps.

Interdisciplinary teams of teachers provide even more learning opportunities. Students will be using mathematics frequently and in complex ways to extract meaning from their inquiries. It has been our experience, however, that middle school students are not skilled at applying mathematics in science because they have had few opportunities to use these skills in context. In an interdisciplinary team, the math teacher can use student-generated data to teach and enhance math skills and application.

The integration of other subject areas, such as language arts, into the science curriculum is also enhanced when interdisciplinary teams are used.

Managing Time

Time is a precious commodity. It must be managed wisely in order to realize the full potential of your FOSS curriculum. The right amount of time should be allocated for preparation, instruction, discussion, assessment, research, and current events. Start from the premise that there will not be enough time to do everything, so you will have to budget selectively. Don’t scrimp on the prep time, particularly the first time you use the curriculum. Spend enough time with the Investigations Guide to become completely familiar with the lesson plans. Take extra time at the start of the course to set up your space efficiently; you will be repaid many times over later. As you become more familiar with the FOSS Program and the handling of the materials, the proportion of time devoted to each aspect of the program may shift, so that you are spending more and more time on instruction and enrichment activities.
Effective use of time during the instructional period is one of the keys to a great experience with this course. The Investigations Guide offers suggestions for keeping the activities moving along at a good pace, but our proposed timing will rarely exactly match yours. The best way we know for getting in stride with the curriculum is to start teaching it. Soon you will be able to judge where to break an activity or push in a little enrichment to fill your instructional period.

**Managing Space**
The **Diversity of Life Course** will work in the ideal setting: flat-topped tables where students work with materials in groups of four; theater seating for viewing multimedia (darkened); eight computers networked and linked to the Internet along the far wall; and a library at the back. But we don’t expect many teachers to have the privilege of working in such a space. So we designed FOSS courses to work effectively in a number of typical settings, including the science lab and regular classroom. We have described, however, the minimum space and resources needed to use FOSS. Here’s the list, in order of importance.

- A computer with Internet access, and a large-screen display monitor or projector.
- Flat tables or desks appropriate for students to work in groups of four.
- Stations to set up microscopes where students can work in pairs.
- Standard metric measuring tools and classroom supplies, including an electronic balance.
- A whiteboard, blackboard, overhead, or chart paper and marking pens.
- A surface for materials distribution.
- A place to clean and organize equipment.
- A place to store safety goggles that students can get to easily.
- A convenient place to store the kit.
- A computer lab or multiple computers.

Once the minimum resources are at hand, take a little time to set up your science area. This investment will pay handsome dividends later since everyone will be familiar with the learning setup.

- Organize your computer and be sure the multimedia is running smoothly.
• Position your LCD and/or overhead projector(s) where everyone can see comfortably.
• Think about the best organization of furniture. This may change from investigation to investigation.
• Plan where to set up your materials stations.
• Know how students will keep notes and record data, and plan where students will keep their notebooks.

Managing Students
A typical class of middle school students is a wonderfully complex collection of personalities, including the clown, the athlete, the fashion statement, the worrier, the achiever, the pencil sharpener, the show-off, the reader, and the question–answerer. Notice there is no mention of the astrophysicist, but she could be in there, too. Management requires delicate coordination and flexibility—some days students take their places in an orderly fashion and sit up straight in their chairs, fully prepared to learn. Later in the week, they are just as likely to have the appearance of migrating waterfowl, unable to find their place, talkative, and constantly moving.

FOSS employs a number of strategies for managing students. Often a warm-up activity is a suitable transition from lunch or the excitement of changing rooms to the focused intellectual activities of the Diversity of Life Course. Warm-ups tend to be individual exercises that review what transpired yesterday with a segue to the next development in the curriculum. This gives students time to get out their notebooks, grind points on their pencils, settle into their space, and focus.

Students most often work in groups in this course. Groups of four are generally used, but at other times, students work in pairs.

Suggestions for guiding students’ work in collaborative groups are described later in this chapter.

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 and share the science notebook entries made for that day. The science notebooks should be a valuable tool for students to share in order to catch up on missed classes.

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

And finally, encourage the student to use the resources on FOSSweb at school or at home for the missed class.
Managing Technology

The *Diversity of Life Course* includes an online component. The online activities and materials are not optional. For this reason, it is essential that you have in your classroom at minimum one computer, a large-screen display monitor or projection system, and a connection to the Internet. Sometimes you will use multimedia to make presentations to the entire class. Sometimes small groups or individuals will use the online program to work simulations and representations.

The important attribute of the online component is that it is interactive. Students can manipulate variables to see what happens. They can ask the important question What would happen if . . . , and then find out, using the online simulations.

**Option 1: the computer lab.** If you have access to a lab where all students can work simultaneously as individuals, pairs, or small groups, schedule time in the lab for your classes. Plan on sessions in the computer lab for Investigations 4, 6, and 7.

**Option 2: classroom computers.** With four to eight computers in the science classroom, you can set up a multitasking environment with half the students working on the multimedia and half engaged in reading or small-group discussions. Then swap roles. This could take one or two periods, depending on the activity.

**Option 3: learning centers.** If you have access to only one computer system, plan to use it with the whole class with a projection system for large-group viewing, followed by opportunities for small groups of students to explore the simulations. Try to organize your classroom for several activities, one of which will be a computer station.

**Option 4: home access.** Students can access FOSSweb from home by visiting www.FOSSweb.com and accessing the class pages with the account information you provide for student use.

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.
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.


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.
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 middle school, 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. Five to eight weeks seems about optimum, so students might work in two groups throughout an entire course.

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 those in place of these 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 Recorder collects data as it happens and makes sure that everyone has recorded information on his or her science notebook sheets.

The Reporter shares group data with 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.
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 that you do is consistent with those guidelines. Two posters are included in the kit, FOSS Safety and Outdoor Safety, for classroom use.

Look for the safety icon in the Getting Ready and Guiding the Investigation sections, which will alert you to safety considerations throughout the course.

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

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

1. Always follow the safety procedures outlined by your teacher. Follow directions, and ask questions if you’re unsure of what to do.
2. Never put any material in your mouth. Do not taste any material or chemical unless your teacher specifically tells you to do so.
3. Do not smell any unknown material. If your teacher tells you to smell a material, wave a hand over it to bring the scent toward your nose.
4. Avoid touching your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals. Tell your teacher if you have any allergies.
5. Always wash your hands with soap and warm water immediately after using chemicals (including common chemicals, such as salt and dyes) and handling natural materials or organisms.
6. Do not mix unknown chemicals just to see what might happen.
7. Always wear safety goggles when working with liquids, chemicals, and sharp or pointed tools. Tell your teacher if you wear contact lenses.
8. Clean up spills immediately. Report all spills, accidents, and injuries to your teacher.
9. Treat animals with respect, caution, and consideration.
10. Never use the mirror of a microscope to reflect direct sunlight. The bright light can cause permanent eye damage.
## FOSS K–8 SCOPE AND SEQUENCE

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