INTRODUCTION

Look around ... you're in an ecosystem. How do you know? Because there are organisms everywhere. An ecosystem is an organizational unit of life on Earth, defined by a physical environment and the organisms that live there.

Organisms depend on their ecosystem for survival. Energy and matter, in the form of food, flow through an ecosystem. The critical role of photosynthetic organisms in creating food is what allows the rest of the organisms in the ecosystem to exist. Disruption to one element of the ecosystem produces waves and ripples that touch every member of the system. Changes may produce pressures in the ecosystem. When change is precipitous, a population may be exterminated.

One powerful change agent in just about every ecosystem on Earth is humans. Human mobility, technology, and institutions place pressures on many ecosystems. The first step toward placing less disruptive pressure on natural systems is understanding how they work and what they need to remain healthy.

This course provides students with the first steps along the path of ecological understanding, with the hope that their future steps will be considered and measured, serving the interests of all life.
# POPULATIONS AND ECOSYSTEMS — Overview

<table>
<thead>
<tr>
<th>Investigation Summary</th>
<th>Time</th>
<th>Parts and Focus Questions</th>
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<tbody>
<tr>
<td><strong>Milkweed Bugs</strong></td>
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</table>
| In an 8-week investigation, students raise milkweed bugs in a supportive habitat to study the insect's reproductive biology. The information from this study is used to study milkweed-bug population dynamics in Investigation 7. | 1 Session assessment survey (optional) 3 Class sessions | Part 1 **Introducing Milkweed Bugs**, 1 session  
What does a population of milkweed bugs need to survive in a classroom?  
Part 2 **Milkweed-Bug Habitat**, 1 session  
What needs to be considered when building a habitat for milkweed bugs?  
Part 3 **Observing Milkweed-Bug Habitats**, 1 session  
How do milkweed bugs reproduce and grow? |
| **Sorting Out Life**   |      |                           |
| Students use ecosystem sorting cards to reflect on organizing concepts in ecology and develop the vocabulary associated with those concepts. Through a Jane Goodall video, students become familiar with a specific population study of chimpanzees. Students are introduced to one of ten ecoscenarios representing major biomes of Earth that will be studied throughout the course. | 6 Class sessions 1 Session assessment | Part 1 **Ecosystem Card Sort**, 1 session  
What is the relationship between individuals, populations, communities, and abiotic factors in an ecosystem?  
Part 2 **Video Population Study**, 2 sessions  
How is the milkweed-bug-habitat study similar to and different from Jane Goodall's population study?  
Part 3 **Ecocenarios**, 3 sessions  
What are the defining characteristics of your ecosystem? |
| **Mono Lake**         |      |                           |
| Students use Mono Lake, an important alkaline lake, as a simple ecosystem case study. Students study the functional roles of populations to construct a food web. Students construct a food web for their ecocenario. | 6 Class sessions 1 Session assessment | Part 1 **A Visit to Mono Lake**, 1 session  
What are the different biotic and abiotic components of the Mono Lake ecosystem?  
Part 2 **Mono Lake Food Web**, 3 sessions  
How do the organisms at Mono Lake interact?  
Part 3 **Ecocenario Food Webs**, 2 sessions  
How do the organisms in your ecocenario interact? |

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**Full Option Science System**
### Course Matrix

<table>
<thead>
<tr>
<th>Content Related to DCIs</th>
<th>Literacy/Technology</th>
<th>Assessment</th>
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</table>
| • An organism is any living thing.  
• An organism’s habitat is where it lives—the place where it can meet all of its requirements for life.  
• A kind of organism that is different from all other kinds of organisms is called a species.  
• A population is all the individuals of a species in an area at a specified time. | **Science Resources Book**  
“Observations and Inferences”  
“Milkweed Bugs” | **Benchmark Assessment**  
Survey (optional)  
**NGSS Performance Expectations**  
MS-LS2-1 |
| • An individual is one single organism.  
• A community is all the interacting populations in a specified area.  
• An ecosystem is a system of interacting organisms and nonliving factors in a specified area.  
• Biotic factors are living factors in an ecosystem; abiotic factors are nonliving factors.  
• Ecosystems around the world have different sets of biotic and abiotic factors.  
• Ecosystems provide ecosystem services for humans.  
• Biomes are large areas on Earth with similar abiotic factors. | **Science Resources Book**  
“Life in a Community” (optional)  
“Ecocenarios Introductions” (optional)  
“Defining a Biome”  
**Online Activities**  
“Ecocenarios”  
“Biomes”  
**Video**  
*Among the Wild Chimpanzees* | **Benchmark Assessment**  
Investigations 1–2 I-Check  
**NGSS Performance Expectations**  
MS-LS2-1  
MS-LS2-2 (foundational) |
| • Mono Lake is an example of an alkaline-lake ecosystem.  
• A sequence of organisms that eat one another is a food chain.  
• All the feeding relationships in an ecosystem define the food web for that ecosystem.  
• The Mono Lake ecosystem is defined by the interactions among the organisms and abiotic factors that exist in the Mono Lake basin.  
• All ecosystems are defined by the interactions among the organisms and abiotic factors that exist in the region. | **Science Resources Book**  
“An Introduction to Mono Lake”  
**Online Activities**  
“Mono Lake Interactive Food Web”  
“Ecocenarios”  
**Video**  
*The Mono Lake Story* | **Benchmark Assessment**  
Investigation 3 I-Check  
**NGSS Performance Expectations**  
MS-LS2-2  
MS-LS2-3 |
### Investigation Summary

#### Minihabitats
Students construct aquatic and terrestrial ecosystems in the classroom and observe them over time to understand ecosystem interactions. They use a scientific log to observe, describe, and monitor changes in biotic and abiotic factors.

<table>
<thead>
<tr>
<th>Time</th>
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</tr>
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</table>
| 4 Class sessions | **Part 1  The Physical Environment**, 1 session  
What abiotic factors should be considered when setting up terrestrial and aquatic habitats?  
**Part 2  Introducing Life**, 2 sessions  
What interactions are likely for the organisms in the minihabitat?  
**Part 3  Observing Minihabitats**, 1 session  
What changes have taken place in the terrariums and the class aquariums? |

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#### Producers
Students explore the effect of light on photosynthesis by studying wheat plants. Students learn that through photosynthesis, producers increase the biomass of an ecosystem. Students investigate the producers in specific ecosystems and identify their roles. Students model and measure the energy transferred from food.

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<tr>
<th>Time</th>
<th>Parts and Focus Questions</th>
</tr>
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</table>
| 7 Class sessions | **Part 1  Growing Producers**, 1 session  
What is the effect of light on producers?  
**Part 2  Biomass and Producers**, 2 sessions  
What do producers need to grow and increase biomass?  
**Part 3  Ecocenario Producers**, 1 session  
What are the roles of specific producers in the ecosystem?  
**Part 4  Energy Transfer from Food**, 3 sessions  
How can we model and measure energy transfer from food? |

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#### Following the Energy
Students learn how energy provided by producers is used by all organisms. They explore how food energy moves from one trophic level to another through feeding relationships. Students simulate feeding relationships and determine what is needed to sustain a food chain. They investigate the role of decomposers in ecosystems.

<table>
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</table>
| 6 Class sessions | **Part 1  Using Energy**, 1 session  
What are the kinds of work you do that require energy?  
**Part 2  Food-Chain Game**, 2 sessions  
What is needed to sustain a food chain?  
**Part 3  Trophic Levels**, 2 sessions  
How does biomass and energy flow through an ecosystem?  
**Part 4  Decomposers**, 1 session  
What happens to the energy stored in the biomass of an organism when it dies? |

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Full Option Science System
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<th>Content Related to DCIs</th>
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<tr>
<td>• An aquatic ecosystem functions in water.</td>
<td><strong>Science Resources Book</strong></td>
<td><strong>Benchmark Assessment</strong></td>
</tr>
<tr>
<td>• A terrestrial ecosystem functions on land.</td>
<td>“Minihabitat Organisms”</td>
<td><strong>NGSS Performance Expectations</strong></td>
</tr>
<tr>
<td>• Organisms depend on the abiotic elements in their ecosystem.</td>
<td>“Biosphere 2: An Experiment in Isolation” (optional)</td>
<td>MS-LS2-1, MS-LS2-4</td>
</tr>
<tr>
<td></td>
<td><strong>Online Activity</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Minihabitat Organisms”</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td>• Photosynthesis is the process by which energy-rich molecules (food) are made from water, carbon dioxide, and light.</td>
<td><strong>Science Resources Book</strong></td>
<td><strong>NGSS Performance Expectations</strong></td>
</tr>
<tr>
<td>• Producers increase the biomass of an ecosystem through photosynthesis.</td>
<td>“Energy and Life”</td>
<td>MS-LS1-6</td>
</tr>
<tr>
<td>• Photosynthesis and aerobic cellular respiration make stored energy available to organisms.</td>
<td>“Where Does Food Come From?” (optional)</td>
<td>MS-LS1-7</td>
</tr>
<tr>
<td>• Ecosystems are defined by the producers present.</td>
<td>“What Does Water Do?” (optional)</td>
<td>MS-LS2-3</td>
</tr>
<tr>
<td>• Food is energy-rich organic matter that organisms need to conduct life processes.</td>
<td>“Wangari Maathai: Being a Hummingbird” (optional)</td>
<td></td>
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<tr>
<td>• Energy transferred from food is measured in kilocalories.</td>
<td><strong>Online Activities</strong></td>
<td></td>
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<tr>
<td></td>
<td>“Ecosenarios” (optional)</td>
<td></td>
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<tr>
<td></td>
<td>“Biomes” (optional)</td>
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<tr>
<td>• Every activity undertaken by living organisms involves expenditure of energy.</td>
<td><strong>Science Resources Book</strong></td>
<td><strong>Benchmark Assessment</strong></td>
</tr>
<tr>
<td>• Feeding relationships identify trophic roles: producers, consumers, and decomposers.</td>
<td>“Rachel Carson and the Silent Spring” (optional)</td>
<td><strong>NGSS Performance Expectations</strong></td>
</tr>
<tr>
<td>• Biomass moves through an ecosystem from one trophic level to the next.</td>
<td>“Trophic Levels”</td>
<td>MS-LS1-6</td>
</tr>
<tr>
<td>• Only a small fraction of the biomass consumed at a trophic level is used to produce biomass at that level—much is used for energy and much is lost to the environment.</td>
<td>“Decomposers” (optional)</td>
<td>MS-LS2-1, MS-LS2-2, MS-LS2-3</td>
</tr>
<tr>
<td>• Decomposers recycle food molecules to basic particles for use by organisms in the ecosystem.</td>
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| **Population Size**                               | 7 Class sessions 1 Session assessment | Part 1 **Reproductive Potential**, 3 sessions
How many milkweed bugs could be in your habitat at the end of a year? |
|                                                   |               | Part 2 **Limiting Factors**, 2 sessions
What are the limiting factors that affect algae and brine shrimp populations at Mono Lake? |
|                                                   |               | Part 3 **Population Dynamics**, 2 sessions
How does predicted population growth compare to actual population growth? |
| **Human Impact**                                  | 6 Class sessions 1 Session assessment | Part 1 **Biodiversity**, 2 sessions
Why is biodiversity important in an ecosystem? |
|                                                   |               | Part 2 **Invasive Species**, 2 sessions
What can happen when a species is introduced to an ecosystem? |
|                                                   |               | Part 3 **Mono Lake Revisited**, 2 sessions
What impact have people had on Mono Lake? |
| **Ecoscenarios**                                  | 6 Class sessions 1 Session assessment | Part 1 **Human Involvement**, 1 session
How have humans affected your ecoscenario, and what efforts have humans made to lessen this impact? |
|                                                   |               | Part 2 **Evaluating Solutions**, 3 sessions
How have humans affected your ecoscenario, and what efforts have humans made to lessen this impact? |
|                                                   |               | Part 3 **Presentations**, 2 sessions
How have humans affected your ecoscenario, and what efforts have humans made to lessen this impact? |

**Inv. 7**

**Human Impact**

Students explore the importance of biodiversity on the health of the ecosystem. They investigate how humans have interacted with the ecosystem and put stresses on biodiversity. Students then learn how humans can reverse these stresses and help restore ecosystems.

**Ecoscenarios**

Students return to their ecoscenarios and use the knowledge developed in previous investigations to analyze the effects of human interactions in their ecosystem. They are given several engineering solutions and evaluate which they feel is the best solution to preserve or restore the ecosystem.
### Course Matrix

#### Content Related to DCIs
- Reproductive potential is the theoretical unlimited growth of a population over time.
- A limiting factor is any biotic or abiotic component of the ecosystem that controls the size of a population.
- Both lab experimentation and field observation contribute to the study of populations.
- Biotic and abiotic factors can limit population size.

- Biodiversity is the variety of organisms in an ecosystem.
- A biodiversity index is a measure of the health of an ecosystem. A healthy ecosystem is resilient to change.
- Introduced species compete with native species in an ecosystem.
- If an introduced species has no consumers in a new ecosystem, it can thrive and become invasive.
- Humans affect ecosystems in both positive and negative ways.

- Humans rely on ecosystems for ecosystem services (provisioning, regulating, cultural, and supporting systems).
- Ecosystems are dynamic systems of complex interactions.
- Disruptions to abiotic factors in ecosystems can cause shifts in populations.
- Changes in ecosystems can affect services essential to humans.
- Solutions can be engineered and implemented to mitigate human impact.

#### Literacy/Technology
- **Science Resources Book**
  - "Limiting Factors"
  - "Mono Lake throughout the Year"
- **Online Activities**
  - "Milkweed Bugs, Unlimited"
  - "Milkweed Bugs, Limited"

- **Science Resources Book**
  - "Biodiversity"
  - "Invasive Species" (optional)
  - "Mono Lake in the Spotlight"
- **Videos**
  - *Hawaii: Strangers in Paradise*
  - *The Mono Lake Story*

- **Science Resources Book**
  - "Ecoscenario Introductions"
- **Online Activity**
  - "Ecoscenario Research Center"
  - Understanding the Situation
  - Ecoscenario Solutions
  - Images for Posters

#### Assessment
- **Benchmark Assessment**
  - *Investigation 7 I-Check*
- **NGSS Performance Expectations**
  - MS-LS2-1
  - MS-LS2-2
  - MS-LS2-4

- **Benchmark Assessment**
  - *Investigation 8 I-Check*
- **NGSS Performance Expectations**
  - MS-LS2-4
  - MS-ESS3-3
  - MS-ESS3-4

- **Benchmark Assessment**
  - *Posttest*
- **NGSS Performance Expectations**
  - MS-LS2-4; MS-LS2-5
  - MS-ESS3-3; MS-ESS3-4
  - MS-ETS1-1; MS-ETS1-2

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*Populations and Ecosystems Course, Second Edition*
POPULATIONS AND ECOSYSTEMS — Overview

A FRAMEWORK FOR K–12 SCIENCE EDUCATION

The Populations and Ecosystems Course for grades 6–8 emphasizes the use of knowledge and evidence to describe the interactions and interrelationships for all ecosystems of Earth. 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.
A Framework for K–12 Science Education

- **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**

- 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**

- Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism
requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonlively, are shared. (LS2.A)

- Food webs are models that demonstrate how matter and energy are transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (LS2.B)

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. 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 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. Biodiversity includes genetic variation within a species, in addition to species variation in different habitats and ecosystem types (e.g., forests, grasslands, wetlands). Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (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)

Earth and Space Sciences
Core Idea ESS3: Earth and Human Activity

- Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. ... Renewable energy resources, and the technologies to exploit them, are being rapidly developed. (ESS3.A)

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (ESS3.C)

Engineering, Technology, and Applications of Science
Core Idea ETS1: Engineering Design

- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (e.g., familiarity with the local climate may rule out certain plants for the school garden). (ETS1.A)
Core Idea ETS2: Links among Engineering, Technology, Science, and Society

- All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of both people and the natural environment. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. Technologies that are beneficial for a certain purpose may later be seen to have impacts (e.g., health-related, environmental) that were not foreseen. In such cases, new regulations on use or new technologies (to mitigate the impacts or eliminate them) may be required. (ETS2.B)
NEXT GENERATION SCIENCE STANDARDS

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

**Life Sciences**

- 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-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

**Earth and Space Sciences**

- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.
POPLATIONS AND ECOSYSTEMS — Overview

Engineering, Technology, and Applications of Science

• MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

• MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
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 a 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.
POPULATIONS AND ECOSYSTEMS IN MIDDLE SCHOOL

Life is everywhere, represented by innumerable kinds of individuals and in astronomically large numbers. Each unit of free-living life is an organism. A microscopic single-celled bacterium has equal status with the blue whale and the giant sequoia tree in this regard.

Organisms live in essential relationships with others of their kind in units called populations. Populations are reproducing groups of organisms of the same species living together. Every organism is a member of a population.

Populations always live in relationships with other populations in communities, not for companionship, but for the resources needed to maintain life. These resources, including energy and chemical building blocks, are essential for every organism. Organisms have functions that benefit other organisms, not for altruistic reasons, but because the consequences of self-serving actions have secondary effects that benefit others.

Communities of organisms exist in an environment. The totality of the community and the environment in which organisms live constitutes an ecosystem. Ecosystems are large, complex units of organization in the study of life. Ecologists are the scientists who try to understand the interactions among all the factors in the ecosystem. They try to determine the lines of influence between the organisms and the physical factors in the environment.

Why Study Populations and Ecosystems?

The student’s case. It’s been heard many times . . . the middle schoolers’ 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 an ecologist. I really don’t want to do this.”

Such utterances betray the fact that middle schoolers have acquired a complex worldview. They have progressed from a life guided by concrete experiences and events in the present to a more global 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. They are ready for some serious thought focused on how life is organized on Earth and their own impact on it.

At the start of this course, the word population may be synonymous with human population in students’ minds. They know that the
world is filled with lots of different kinds of organisms—spiders, blueberry bushes, fish, bacteria, on and on—but the notion that they, too, are organized into populations may be a fresh concept. They will discover that populations can be dynamic, changing in response to the availability of resources.

Students will observe a pair of milkweed bugs reproduce to form a small population. As the offspring grow up and engage in typical activities, the population will take on a character of its own. Students will get to know a population very different from the population of *Homo sapiens*, but at the same time a population with which we share a great many similarities, including the continual striving for the fundamental requirements of life: gases, water, energy, and space.

Through direct observations of living organisms, video field trips, simulations, and readings, students will become aware of countless other populations. Time and again students will encounter the same issues concerning the survival of those populations.

The larger picture places populations in the environments that support them. The complex interactions between organisms and their environment define an ecosystem. The handful of ecosystems that students will visit in this course is a minute sampling of the chaos of different ecosystems found around the globe.

An understanding of the big idea of ecosystem is one element of 21st-century citizenship. Ecosystems are relatively closed complex systems composed of multitudes of interacting organisms in a specific environment. They have evolved over extended periods of time and have unique ways of accomplishing their essential functions. They may be thrown into disequilibrium by change. Part of a responsible relationship with life on Earth is respecting the diversity of ecosystems and making decisions that honor and protect the natural systems in which we act.

**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 less-focused 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 **Populations and Ecosystems 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 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).

**Less is more.** For middle school students, it is much more important for them to know a lot about a few things than it is to know a little about a lot of things. By engaging a subject in depth, students learn how to learn while they are learning. They learn how to answer not only “What do I know?” but also “How do I know that?” This second question requires the kind of analytical thinking and logical discourse that helps students develop thinking skills that will serve them well in all endeavors.

**Can I Teach This? I’m Not an Ecologist**

FOSS assumes that teachers using this course possess no more than a minimal level of content knowledge in the fields of population biology and ecology, a functional vocabulary of basic biology, and familiarity with contemporary ecological issues. 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 of the nine investigations. Teachers may not have a thorough understanding of the material when they start the course, but they will have a pretty good understanding of the issues and principles at the end.

The **Populations and Ecosystems Course** introduces students to how matter and energy flow through an ecosystem. Humans are integral members of the ecosystem. They have the ability to manipulate the ecosystem to meet the needs of the human population.

By raising a population of milkweed bugs and maintaining an aquarium and a terrarium, students have firsthand experience with these concepts. You will need to delegate a certain amount of space in the science room to the visitors. There is, however, no adequate substitute for living organisms in the classroom for which students assume responsibility and from which students accrue insight and knowledge. Students will be making regular observations and maintaining a continuous record of changes and events in the lives and situations of the organisms. The ideas brought forward during the inquiry into living organisms will be reinforced and extended with additional resources of familiar kinds: print materials, videos, and online simulations and resources.
The other big idea presented in *Populations and Ecosystems* is the web of interactions between a biotic (living) community and the abiotic (nonliving) environment in which it lives.

Every organism engages in actions in the ecosystem, the most important of which may be its role in energy transfer. Energy drives life. Energy passes through the ecosystem. Energy originates in the environment (nearly always from sunshine), is transformed into organic-chemical bonds during photosynthesis, passes from organism to organism in trophic (feeding) relationships, and ultimately dissipates back into the environment as heat. Energy passes through an ecosystem only once, whereas matter recycles.

The basic building blocks of life are recycled. Simple chemicals—water, gases, and minerals—are taken up from the environment by organisms, used to construct the incredibly complex structures typical of life, and are systematically disassembled into simple chemicals, which are redistributed in the environment. The matter from which life is manufactured recycles.

The big idea that we expect to shine through the experience is that trophic relationships are universal—they happen pretty much the same in every ecosystem.

As students learn about different ecosystems and the complex organization of biotic and abiotic factors, they will discover that the balance of a healthy ecosystem is fragile. Human interactions with the environment can disrupt this balance. But human interactions can also restore the balance. Students will investigate how scientists have engineered solutions to human-caused problems. They will be given the opportunity to evaluate and decide on a course of action they deem appropriate to combat these problems.

The most important thing to remember is that the investigations are designed to support the kind of classroom environment in which teachers and students learn together. Relax and enjoy your brief excursion into the most wonderful and provocative subject for inquiry: life. Keep in the back of your mind the big ideas you will uncover as you go along.

- Individuals in a population vary.
- The population indicates the condition of a species.
- The biotic and abiotic environments affect the character of an ecosystem.
- Energy passes through ecosystems in trophic relationships; matter recycles.
- Biodiversity is essential for a healthy ecosystem.
- Humans are a part of the ecosystem and have the ability to change the ecosystem.
- Humans can engineer solutions to problems and attempt to restore ecosystem health.
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 has 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 (nine 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
- Taking FOSS Middle School Outdoors
- 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.
POPOPULATIONS AND ECOSYSTEMS — Overview

FOSS Science Resources Books

FOSS Science Resources: Populations and Ecosystems 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 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 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. It
POPOPULATIONS AND ECOSYSTEMS — Overview

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-sized 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 FOSS Science Resources: Populations and Ecosystems. Students read articles on roles within ecosystems, photosynthesis and cellular respiration, trophic levels, factors that limit populations, and issues surrounding biodiversity and health of ecosystems 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.

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.

### 28. Assess progress: notebook entry

Sample student responses to the focus question to assess student understanding. The sample should give you a snapshot of the range of student explanations.

**What to Look For**

- Energy is transferred from food when it is metabolized in the body.
- The amount of energy transferred can be measured in calories.
- Burning food is a model of aerobic cellular respiration because both processes release energy from food.

Plan to spend 15 minutes reviewing a 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 concept that you chose to analyze.
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 Populations and Ecosystems 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 *Populations and Ecosystems Course* will work in the ideal setting: flat-topped tables where students work with materials in groups of four; theater seating for viewing online activities (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.
- Standard metric measuring tools and classroom supplies.
- 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 because everyone will be familiar with the learning setup.

- Organize your computer and be sure the online activities are 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 Populations and Ecosystems 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 Populations and Ecosystems 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 online materials 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 2, 3, 5, and 9.

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 online 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 at 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 chapter 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 in Middle School 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.
The **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, Science 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.

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. 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 NEXT GENERATION K–8
### SCOPE AND SEQUENCE

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Full Option Science System