NOURISHING THE PLANET IN THE 21ST CENTURY

A Curriculum Module for Elementary Science Grades 3-4

Reviewed by the Smithsonian Institution

BSCS

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Introduction

INTRODUCTION TO NOURISHING THE PLANET IN THE 21ST CENTURY

During the past 50 years, the population of Earth has more than doubled, yet the amount of land devoted to farming has stayed about the same. During the same time, the developed world has seen impressive gains in agricultural productivity. This so-called Green Revolution saw farmers in North America produce 300 to 400 percent more food from essentially the same land that was cultivated in 1960. These increased yields have saved over 20 million square miles of land from being plowed. This represents a great deal of land that can be used for other purposes.[1]

Farmers were able to increase their crop yields by breeding better plant varieties, adopting better water management practices, and using commercial fertilizers more wisely. Today, at least one-third of the world's food supply and an increasing supply of energy in the form of products such as ethanol are produced using commercial fertilizers to replace soil nutrients removed by crop harvesting. Fertilizer management practices play a large role in increasing crop production by ensuring the appropriate type of nutrient is used at the right time, applied in the proper amount to meet plant needs, and placed where the plant can most easily use it. When properly followed, these practices also minimize nutrient losses to the environment.

It is estimated that Earth will hold 8 to 9 billion people by 2050.[5] How will we feed all these additional people in a sustainable manner? In the developed world, the increases in plant productivity supported by the Green Revolution are reaching their potentials. At the same time, and a world away, infrastructure and population growth pressures are forcing farmers in sub-Saharan Africa to grow crop after crop, "mining," or depleting, the soil of nutrients while giving nothing back. With little access to fertilizers, the farmers are forced to bring less-fertile soils on marginal land into production, at the expense of Africa's native ecosystems.

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Many Americans are generations removed from the farm and take their food supply for granted. They want their food to taste good, to be reasonably priced, and to be healthy and nutritious. At the same time, they want agricultural systems to be truly sustainable by protecting the environment and setting aside land for wildlife.

Difficult decisions will have to be made. Making more land available for farming also means having less land available for other uses such as housing, recreation, and wildlife habitats. Agricultural practices, if not carried out properly, can harm the environment by introducing excessive amounts of nutrients into rivers, lakes, and coastal waters. In agriculture, as in many other industries, science has determined best-management practices—practices that seek to ensure efficient use of resources and to minimize impacts on the environment. They enable profitability for farmers while guarding the public interest.

The public needs to have a voice in setting policies that affect how the world's food is produced. To make rational decisions about these matters, the world's citizens need to recognize what options are available. Today's young people need to recognize the economic, social, and environmental consequences of the options they will confront as adults facing the challenge of nourishing Earth's growing population.

What Are the Objectives of the Module?

Nourishing the Planet in the 21st Century has four objectives. The first is to help students understand some basic aspects of plant growth and interaction with the environment. Although elementary science curricula is likely to include some aspects of this, often it emphasizes just growing some seeds without looking deeply at the interrelationships between plants, their needs, and the effects that plants have on the soil in which they grow.

The second objective is to engage students in the nature of science through inquiry. As students ask and answer questions, make predictions, or analyze data, they model the process scientists use to find out more about the natural world.

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A third objective is to provide students with an opportunity to practice and refine their critical-thinking skills. Such abilities are important, not just for scientific pursuits, but for making decisions in everyday life. Our fast-changing world requires today's young people to be lifelong learners. They must be able to evaluate information from a variety of sources and assess its usefulness. Students must be able to use evidence to establish causal relationships.

Why Teach the Module?

Elementary school science classes offer an ideal setting for integrating many areas of student interest. In this module, students participate in activities that integrate inquiry into science, plant biology, critical thinking, and mathematics. By using seeds and plants for a real-life context, the lessons are engaging and the knowledge gained can be applied immediately to students' lives.

What's in It for the Teacher?

Nourishing the Planet in the 21st Century meets many of the criteria by which teachers and their programs are assessed:

- The module is standards-based and meets science content, teaching, and assessment standards as expressed in the *National Science Education Standards*.[4] It pays particular attention to the standards that describe what students should know and be able to do with respect to *scientific inquiry*.
- It is an *integrated* module, drawing most heavily from the subjects of science and mathematics.

In addition, the module provides a means for *professional development*. Teachers can engage in new and different teaching practices such as those described in this module without completely overhauling their entire program. In *Designing Professional Development for Teachers of Science and Mathematics*, Loucks-Horsley, Hewson, Love, and Stiles write that supplements such as this one "offer a window through which teachers get a glimpse of what new teaching strategies look like in action." By experiencing a short-term module, teachers can "change how they think about teaching and embrace new approaches that stimulate students to problem-solve, reason, investigate, and construct their own meaning for the content."[3] This supplemental module can encourage reflection and discussion and stimulate teachers to improve their practices by focusing on student learning through inquiry.

Introduction

Table 001 correlates topics often included in science curricula with the major concepts presented in this module. This information is presented to help you make decisions about incorporating this material into the curriculum.

TABLE 001. CORRELATION OF *NOURISHING THE PLANET IN THE 21ST CENTURY* TO ELEMENTARY SCHOOL SCIENCE TOPICS

TOPICS	LESSON 1	LESSON 2	LESSON 3	LESSON 4	LESSON 5
Organisms and their environment	✓	✓	✓	✓	✓
Organisms have basic needs for survival, growth, and reproduction.	✓	✓	✓	✓	✓
Variation among individuals within a population	✓				✓
Organisms have structures that are related to their function.	✓		✓	✓	✓
Human activities impact the world around us resulting in benefits and costs.				✓	✓
Scientific inquiry	✓	✓	✓	✓	✓

Introduction

IMPLEMENTING THE MODULE

The five lessons in this module are designed to be taught in sequence (as a supplement to the standard curriculum) or as individual lessons that support and enhance your treatment of specific concepts in elementary school science. Implementing the Module offers general suggestions about using these materials in the classroom. You will find specific suggestions in the procedures provided for each lesson.

What Are the Goals of the Module?

Nourishing the Planet in the 21st Century helps students achieve several major goals associated with scientific literacy:

- To understand a set of basic concepts related to plant growth.
- To experience the process of scientific inquiry and develop an enhanced understanding of the nature and methods of science.
- To hone critical-thinking skills.
- To begin to understand the relationship between science and events in their everyday lives.

What Are the Science Concepts and How Are They Connected?

The lessons are organized into a conceptual framework that allows students to move from what they already know about plants and the environment to a more complete and accurate perspective on the topic. To express their prior knowledge about plants, students begin the unit by sorting plants into categories (Lesson 1, *Plants Around You*). They also begin thinking about what plants need to be healthy and what comprises a plant's environment, ideas that will continue throughout subsequent lessons. Students plant a variety of seeds to explore differences and similarities among different types of plants. Students then explore one part of a plant's environment, the soil. They learn how soils differ in composition and properties (Lesson 2, *Properties of Soils*). Students can extend their understanding of plant needs through an optional activity in which students plant seeds in different types of soil. Students then focus on the structure and function of plant roots. Through demonstrations and investigations, students learn how water and nutrients move into the roots and then throughout the plant (Lesson 3, *Plant-Soil Interactions*). As students continue to think about the relationships between plants and their environment, students analyze data to learn how plant growth affects the level of nutrients in the soil (Lesson 4, *Plant Growth Affects the Soil*).

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After students learn that plant growth removes nutrients from the soil, they then learn that fertilizers are one way in which nutrients may be replaced in soil. Students also return to thinking about the interaction between plants and their environment. Plants need specific environmental conditions for their optimal growth. Students synthesize what they have learned about plant growth and the environment by planning a garden (Lesson 5, *How Does Your Garden Grow?*). Table 002 illustrates the scientific content and conceptual flow of the lessons.

TABLE 002. SCIENCE CONTENT AND CONCEPTUAL FLOW OF THE LESSONS

LESSON	**Learning Focus**	**Major Concepts**
1: *Plants Around You*	Engage	• Plants have specific parts that relate to their function. • Plants have specific needs for healthy growth. • A plant's environment includes the living and nonliving things around them.
2: *Properties of Soils*	Explore	• Soils vary in their compositions. • Soils contain materials from both nonliving and living sources. • Soils contain differing amounts of air space. • Soils differ in their abilities to hold and transmit water.
3: *Plant-Soil Interactions*	Explain	• Plants take in water and nutrients from the soil through the plant's root system. • Plants transport water from the roots to the rest of the plant. • The systems in plants that transport water and nutrients throughout the plant have similarities to the human circulatory system.
4: *Plant Growth Affects the Soil*	Elaborate	• Plants remove nutrients from the soil. • Fertilizers replace nutrients removed from the soil by plants. • Different kinds of plants need different environmental conditions for optimal growth.
5: *How Does Your Garden Grow?*	Evaluate	• Growing a successful garden requires knowledge of plants and their environment, including the soil. Gardeners make decisions based on their location, their soil, and other environmental factors.

*See *How Does the BSCS 5E Instructional Model Promote Active, Collaborative, Inquiry-based Learning?*

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How Does the Module Correlate with the National Science Education Standards?

Nourishing the Planet in the 21st Century supports teachers in their efforts to reform science education in the spirit of the National Academy of Science's 1996 *National Science Education Standards (NSES)*.[4] The content is explicitly standards-based. Table 003 lists the specific content standards that this module addresses.

The suggested teaching strategies in all of the lessons support you as you work to meet the teaching standards outlined in the *National Science Education Standards*.[4] This module helps science teachers plan an inquiry-based science program by providing short-term objectives for students. It also includes planning tools for teaching the module, such as Table 002, *Science Content and Conceptual Flow of the Lessons* (page 009) and Table 006, *Suggested Timeline* (page 030). The focus on active, collaborative, and inquiry-based learning in the lessons helps support the development of student understanding and nurtures a community of science learners.

The structure of the lessons enables you to guide and facilitate learning. All the activities encourage and support student inquiry, promote discourse among students, and challenge students to accept and share responsibility for their learning. The use of the BSCS 5E Instructional Model, combined with active, collaborative learning, allows you to respond effectively to students with diverse backgrounds and learning styles. The module is fully annotated, with suggestions for how you can encourage and model the skills of scientific inquiry and foster curiosity, openness to new ideas and data, and skepticism.

TABLE 003 *NSES* CONTENT STANDARDS: GRADES K-4

Content Standard A: Science as Inquiry

As a result of activities in grades K–4, all students should develop:

CONTENT STANDARD	CORRELATION TO *NOURISHING THE PLANET IN THE 21ST CENTURY*
ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY	
Ask a question about objects, organisms, and events in the environment.	Lessons 1,2,3,4,5
Plan and conduct a simple investigation.	Lessons 1,2,3,4,5
Employ simple equipment and tools to gather data and extend the senses.	Lessons 1,2,3,4,5
Use data to construct a reasonable explanation.	Lessons 1,2,3,4,5
Communicate investigations and explanations.	Lessons 1,2,3,4,5
UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY	
Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).	Lessons 1,2,3,4
Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.	Lessons 2,3
Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.	Lessons 2,3,4

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TABLE 003: *NSES* CONTENT STANDARDS: GRADES K-4

Content Standard C: Life Sciences

As a result of activities in grades K–4, all students should develop:

CONTENT STANDARD	CORRELATION TO *NOURISHING THE PLANET IN THE 21ST CENTURY*
THE CHARACTERISTICS OF ORGANISMS	
Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.	Lessons 2,3,4,5
Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.	Lessons 1,3
LIFE CYCLES OF ORGANISMS	
Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.	Lessons 1,4,5
ORGANISMS AND THEIR ENVIRONMENT	
An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.	Lessons 1,4,5
All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.	Lessons 3,4
Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms.	Lessons 4,5

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TABLE 003: *NSES* CONTENT STANDARDS: GRADES K-4

Content Standard D: Earth Sciences

As a result of activities in grades K–4, all students should develop:

CONTENT STANDARD	CORRELATION TO *NOURISHING THE PLANET IN THE 21ST CENTURY*
PROPERTIES OF EARTH MATERIALS	
Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.	Lessons 2,4,5
Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.	Lessons 2,4,5

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TABLE 003: *NSES* CONTENT STANDARDS: GRADES K-4

Content Standard F: Science in Personal and Social Perspectives

As a result of activities in grades K–4, all students should develop:

CONTENT STANDARD	CORRELATION TO *NOURISHING THE PLANET IN THE 21ST CENTURY*
TYPES OF RESOURCES	
Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population.	Lesson 2
CHANGES IN ENVIRONMENTS	
Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life.	Lessons 1,3,4,5

Source: National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

Introduction

How Does the BSCS 5E Instructional Model Promote Active, Collaborative, Inquiry-based Learning?

Because learning does not occur by way of passive absorption, the lessons in this module promote active learning. Students are involved in more than listening and reading. They are developing skills, analyzing and evaluating evidence, experiencing and discussing, and talking to their peers about their own understanding. Students work collaboratively with others to solve problems and plan investigations. Many students find that they learn better when they work with others in a collaborative environment than when they work alone in a competitive environment. When active, collaborative learning is directed toward scientific inquiry, students succeed in making their own discoveries. They ask questions, observe, analyze, explain, draw conclusions, and ask new questions. These inquiry-based experiences include both those that involve students in direct experimentation and those in which students develop explanations through critical and logical thinking.

The viewpoint that students are active thinkers who construct their own understanding from interactions with phenomena, the environment, and other individuals is based on the theory of *constructivism*. A constructivist view of learning recognizes that students need time to:

- express their current thinking;
- interact with objects, organisms, substances, and equipment to develop a range of experiences on which to base their thinking;
- reflect on their thinking by writing and expressing themselves and comparing what they think with what others think; and
- make connections between their learning experiences and the real world.

This module provides a built-in structure for creating a constructivist classroom: the BSCS 5E Instructional Model.[2] The BSCS 5E Model sequences learning experiences so that students have the opportunity to construct their understanding of a concept over time. The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engage, Explore, Explain, Elaborate, and Evaluate. The following paragraphs illustrate how the five Es are implemented across the lessons in this module.

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ENGAGE

Students come to learning situations with prior knowledge. This knowledge may or may not be congruent with the concepts presented in this module. The Engage lesson provides the opportunity for teachers to find out what students already know, or think they know, about the topic and concepts to be covered. During the Engage phase, it is important for students to recognize their own current thinking about the topic. The Engage lesson in this module, Lesson 1, *Plants Around You,* is designed to:

- pique students' curiosity and generate interest;
- determine students' current understanding about the similarities or differences among plants;
- encourage students to think about the relationships and interactions between plants and their environment;
- encourage students to compare their ideas with those of others; and
- enable teachers to assess what students do or do not understand about the stated outcomes of the lesson.

EXPLORE

In the Explore phase of the module, Lesson 2, *Properties of Soils,* students investigate the compositions of soils. Students perform experiments designed to provide a common set of experiences within which they can begin to construct their understanding. Students:

- interact with materials and ideas through classroom and small-group discussions;
- observe, describe, record, compare, and share their ideas and experiences; and
- acquire a common set of experiences so that they can compare results and ideas with their classmates.

EXPLAIN

The Explain lesson (Lesson 3, *Plant-Soil Interactions*) provides opportunities for students to connect and consider how plant structure is important for function. An Explain lesson encourages students to:

- explain in their own words how a specific part of the plant (the roots) is important for taking in water and nutrients from the soil (function);
- listen to and compare the explanations of others with their own;
- become involved in student-to-student discourse in which they explain their thinking to others and debate their ideas;
- record their ideas and current understanding; and
- compare their current thinking with what they previously thought.

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ELABORATE

In Elaborate lessons, students apply or extend previously introduced concepts and experiences to new situations. In the Elaborate lesson in this module (Lesson 4, *Plant Growth Affects the Soil*), students:

- make conceptual connections between new and former experiences, connecting aspects of their plant and soil investigations with their concepts of scientific inquiry;
- draw reasonable conclusions from evidence and data;
- deepen their understanding of the relationships between plants and their environment;
- understand how knowing about a plant's specific needs is important for a successful garden; and
- communicate their understanding to others.

EVALUATE

The Evaluate lesson is the final phase of the instructional model, but it only provides a "snapshot" of what the students understand and how far they have come from where they began. In reality, the evaluation of students' conceptual understanding and ability to use skills begins with the Engage lesson and continues throughout each phase of the instructional model. When combined with the students' written work and performance of tasks throughout the module, however, the Evaluate lesson provides a summative assessment of what students know and can do.

The Evaluate lesson in this module, Lesson 5, *How Does Your Garden Grow?*, provides an opportunity for students to:

- demonstrate what they understand about plants and their needs by planning a garden;
- share their current thinking with others; and
- assess their own progress by comparing their current understanding with their prior knowledge.

Introduction

To review the relationship of the BSCS 5E Instructional Model to the concepts presented in the module, see Table 002 (page 009).

When you use the BSCS 5E Instructional Model, you engage in practices that are different from those of a traditional teacher. In response, students learn in ways that are different from those they experience in a traditional classroom. The following charts, Table 004, *What the Teacher Does* and Table 005, *What the Students Do*, outline these differences.

TABLE 004. WHAT THE TEACHER DOES

Phase	**That Is Consistent with the 5E Instructional Model**	**That Is Inconsistent with the 5E Instructional Model**
Engage	• Piques students' curiosity and generates interest • Determines students' current understanding (prior knowledge) of a concept or idea • Invites students to express what they think • Invites students to raise their own questions	• Introduces vocabulary • Explains concepts • Provides definitions and answers • Provides closure • Discourages students' ideas and questions
Explore	• Encourages student-to-student interaction • Observes and listens to the students as they interact • Asks probing questions to help students make sense of their experiences • Provides time for students to puzzle through problems	• Provides answers • Proceeds too rapidly for students to make sense of their experiences • Provides closure • Tells the students that they are wrong • Gives information and facts that solve the problem • Leads the students step-by-step to a solution

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TABLE 004. WHAT THE TEACHER DOES

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Explain	• Encourages students to use their common experiences and data from the Engage and Explore lessons to develop explanations • Asks questions that help students express understanding and explanations • Requests justification (evidence) for students' explanations • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Introduces terminology and alternative explanations after students express their ideas	• Neglects to solicit students' explanations • Ignores data and information students gathered from previous lessons • Dismisses students' ideas • Accepts explanations that are not supported by evidence • Introduces unrelated concepts or skills
Elaborate	• Focuses students' attention on conceptual connections between new and former experiences • Encourages students to use what they have learned to explain a new event or idea • Reinforces students' use of scientific terms and descriptions previously introduced • Asks questions that help students draw reasonable conclusions from evidence and data	• Neglects to help students connect new and former experiences • Provides definitive answers • Tells the students that they are wrong • Leads students step-by-step to a solution

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TABLE 004. WHAT THE TEACHER DOES

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Evaluate	• Observes and records as students demonstrate their understanding of the concepts and performance of skills • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Interviews students as a means of assessing their developing understanding • Encourages students to assess their own progress	• Tests vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussion unrelated to the concept or skill

TABLE 005. WHAT THE STUDENTS DO

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Engage	• Become interested in and curious about the concept or topic • Express current understanding of a concept or idea • Raise questions such as, "What do I already know about this?" "What do I want to know about this?" "How could I find out?"	• Ask for the "right" answer • Offer the "right" answer • Insist on answers or explanations • Seek closure

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TABLE 005. WHAT THE STUDENTS DO

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Explore	• Explore materials and ideas • Conduct investigations in which they observe, describe, and record data • Try different ways to solve a problem or answer a question • Acquire a common set of experiences so that they can compare results and ideas • Compare their ideas with those of others	• Let others do the thinking and exploring (passive involvement) • Work quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) • Stop with one solution • Demand or seek closure
Explain	• Explain concepts and ideas in their own words • Base their explanations on evidence acquired during previous investigations • Record their ideas and current understanding • Reflect on and perhaps revise their ideas • Express their ideas using appropriate scientific language • Compare their ideas with what scientists know and understand	• Propose explanations from "thin air" with no relationship to previous experiences • Bring up irrelevant experiences and examples • Accept explanations without justification • Ignore or dismiss other plausible explanations • Propose explanations without evidence to support their ideas

TABLE 005. WHAT THE STUDENTS DO

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Elaborate	• Focus their attention on conceptual connections between new and former experiences • Use what they have learned to explain a new event or idea • Use scientific terms and descriptions previously introduced • Answer questions that help them draw reasonable conclusions from evidence and data	• Ignore previous information or evidence • Draw conclusions from "thin air" • Use terminology inappropriately and without understanding

Introduction

TABLE 005. WHAT THE STUDENTS DO

Phase	That Is Consistent with the 5E Instructional Model	That Is Inconsistent with the 5E Instructional Model
Evaluate	• Make conceptual connections between new and former experiences • Use what they have learned to explain a new object, event, organism, or idea • Use scientific terms and descriptions • Draw reasonable conclusions from evidence and data • Communicate their understanding to others • Demonstrate what they understand about the concepts and how well they can implement a skill • Compare their current thinking with that of others and perhaps revise their ideas • Assess their own progress by comparing their current understanding with their prior knowledge • Ask new questions that take them deeper into a concept or topic area	• Disregard evidence or previously accepted explanations in drawing conclusions • Offer only yes-or-no answers or memorized definitions or explanations as answers • Fail to express satisfactory explanations in their own words • Introduce new, irrelevant topics

Introduction

How Does the Module Support Ongoing Assessment?

Because teachers will use this module in a variety of ways and at a variety of points in the curriculum, the most appropriate mechanism for assessing student learning is one that occurs informally at various points within the lessons, rather than just once at the end of the module. Accordingly, integrated within the lessons in the module are specific assessment components. These embedded assessments include one or more of the following strategies:

- Performance-based activities, such as interpreting graphs or participating in a discussion about risks and benefits.
- Oral presentations to the class, such as reporting experimental results.
- Written assignments, such as answering questions or writing about demonstrations.

These strategies allow you to assess a variety of aspects of the learning process such as students' prior knowledge and current understanding, problem-solving and critical-thinking skills, level of understanding of new information, communication skills, and ability to synthesize ideas and apply understanding to a new situation.

How Can Teachers Promote Safety in the Science Classroom?

Even simple science demonstrations and investigations can be hazardous unless teachers and students know and follow safety precautions. Teachers are responsible for providing students with active instruction concerning their conduct and safety in the classroom. Posting rules in a classroom is not enough; teachers also need to provide adequate supervision and advance warning if there are dangers involved in the science investigation. By maintaining equipment in proper working order, teachers ensure a safe environment for students.

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You can implement and maintain a safety program in the following ways:

- Provide eye protection for students, teachers, and visitors. Require that everyone participating wear regulation goggles in any situation where there might be splashes, spills, or spattering. Teachers should always wear goggles in such situations.
- Know and follow the state and district safety rules and policies. Be sure to fully explain to the students the safety rules they should use in the classroom.
- At the beginning of the school year, establish consequences for students who behave in an unsafe manner. Make these consequences clear to students.
- Do not overlook any violation of a safety practice, no matter how minor. If a rule is broken, take steps to assure that the infraction will not occur a second time.
- Set a good example by observing all safety practices. This includes wearing eye protection during all investigations when eye protection is required for students.
- Know and follow waste disposal regulations.
- Be aware of students who have allergies or other medical conditions that might limit their ability to participate in activities. Consult with the school nurse or school administrator.
- Anticipate potential problems. When planning teacher demonstrations or student investigations, identify potential hazards and safety concerns. Be aware of what could go wrong and what can be done to prevent the worst-case scenario. Before each activity, verbally alert the students to the potential hazards and distribute specific safety instructions as well.
- Supervise students at all times during hands-on activities.
- Provide sufficient time for students to set up the equipment, perform the investigation, and properly clean up and store the materials after use.
- Never assume that students know or remember safety rules or practices from their previous science classes.

Introduction

How Can Controversial Topics Be Handled in the Classroom?

Teachers sometimes feel that the discussion of values is inappropriate in the science classroom or that it detracts from the learning of "real" science. The lessons in this module, however, are based upon the conviction that there is much to be gained by involving students in analyzing issues of science, technology, and society. Society expects all citizens to participate in the democratic process, and our educational system must provide opportunities for students to learn to deal with contentious issues with civility, objectivity, and fairness. Likewise, students need to learn that science intersects with life in many ways.

In this module, students are given a variety of opportunities to discuss, interpret, and evaluate basic science and health issues, some in the light of their values and ethics. As students encounter issues about which they feel strongly, some discussions might become controversial. The degree of controversy depends on many factors, such as how similar students are with respect to socioeconomic status, perspectives, value systems, and religious beliefs. In addition, your language and attitude influence the flow of ideas and the quality of exchange among the students.

Introduction

The following guidelines may help you facilitate discussions that balance factual information with feelings:

- Remain neutral. Neutrality may be the single-most important characteristic of a successful discussion facilitator.
- Encourage students to discover as much information about the issue as possible.
- Keep the discussion relevant and moving forward by questioning or posing appropriate problems or hypothetical situations. Encourage everyone to contribute, but do not force reluctant students to enter the discussion.
- Emphasize that everyone must be open to hearing and considering diverse views.
- Use unbiased questioning to help students critically examine all views presented.
- Allow for the discussion of all feelings and opinions.
- Avoid seeking consensus on all issues. Discussing multifaceted issues should result in the presentation of divergent views, and students should learn that this is acceptable.
- Acknowledge all contributions in the same evenhanded manner. If a student seems to be saying something for its shock value, see whether other students recognize the inappropriate comment and invite them to respond.
- Create a sense of freedom in the classroom. Remind students, however, that freedom implies the responsibility to exercise that freedom in ways that generate positive results for all.
- Insist upon a nonhostile environment in the classroom. Remind students to respond to ideas instead of to the individuals presenting those ideas.
- Respect silence. Reflective discussions are often slow. If a teacher breaks the silence, students may allow the teacher to dominate the discussion.
- At the end of the discussion, ask students to summarize the points made. Respect students regardless of their opinions about any controversial issue.

Introduction

USING THE STUDENT LESSONS

The heart of this module is the set of five classroom lessons. These lessons are the vehicles that will carry important concepts related to scientific inquiry to your students. The lessons have been constructed to be easily implemented in the classroom. As you look at the lessons, you will see a specific structure. The features in each lesson are described below.

Format of the Lessons

As you review the lessons, you will find that all contain common major features.

At a Glance provides a convenient summary of the lesson.

- *Overview* provides a short summary of student activities.
- *Major Concepts* states the central ideas the lesson is designed to convey.
- *Objectives* lists specific understandings or abilities students should have after completing the lesson.

In Advance provides instructions for collecting and preparing the materials required to complete the activities in the lesson.

- *Photocopies* lists the paper copies and overhead transparencies that need to be made from masters, which are found at the end of each lesson.
- *Materials* lists all the materials (other than photocopies) needed for each of the activities in the lesson.
- *Preparation* outlines what you need to do to be ready to teach the lesson.

Procedure outlines the steps in each activity of the lesson. It includes implementation hints and answers to discussion questions. Within the Procedure section, annotations provide additional commentary.

identifies where assessments are embedded in the lesson.

identifies parts of the lesson that address the *National Science Education Standards*.

identifies tips from the field test teachers.

Introduction

Many of the lessons include **optional activities**. These optional activities allow flexibility based on your schedule and the amount of time you can devote in the classroom. By participating in the optional activities, students can deepen or broaden their understanding of the main ideas in the lesson. Students will explore all the major concepts without doing the optional activities, but the additional activities are likely to enrich their experience and allow them to make additional connections among ideas.

The **Lesson Organizer** provides a brief summary of the lesson. It outlines procedural steps for each activity and includes icons that denote where masters or transparencies are used. The Lesson Organizer is intended to be a memory aid for you to use only after you become familiar with the detailed procedures for the activities. It can be a handy resource during lesson preparation as well as during classroom instruction.

Masters required for teaching the activities are located at the end of each lesson.

Timeline for the Module

The following timelines outline plans for completing the lessons in this module. The first timeline (Table 006) includes the optional activities. The second timeline (Table 007) is shorter and does not include optional activities. Each timeline assumes that you will teach the activities on consecutive days. These are estimates; your class may require more time for completing the activities or for discussing issues raised in this module. You will also need to adjust the plan if you teach science less frequently. If you do not teach science everyday, the timeline can give you guidance on the amount of time needed for each lesson. Some activities (such as the seed germination investigation in Lesson 1) will require students to check their investigations and record data each day, but those follow-up activities should not require a great deal of time each day. The procedure in each lesson also provides information about when specific steps should be done or strategies for timing specific activities in the lesson.

Introduction

TABLE 006. TIMELINE INCLUDING OPTIONAL ACTIVITIES

Timeline	Activity
2-3 weeks ahead	Obtain supplies for lessons
1 weeks ahead	Photocopy masters, prepare overhead transparencies, gather materials
1-5 days ahead	Prepare cups for seed planting in Lesson 1, set up grow lamps if appropriate
Day 1 Friday	**Lesson 1** Activity 1: *Thinking About Plants*
Day 2 Monday	**Lesson 1** Activity 2: *Growing a Garden*
Day 3 Tuesday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 2** Activity 1: *Properties of Soils*
Day 4 Wednesday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 2**, Activity 1: *Properties of Soils* (continued)
Day 5 Thursday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 2** Optional Activity: *Does Soil Matter?* **Lesson 3** Activity 1: *How Does a Plant Grow?* (set up)
Day 6 Friday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 1** Activity 2: Step 8 (optional)

TABLE 006. TIMELINE INCLUDING OPTIONAL ACTIVITIES

Timeline	Activity
Day 7 Monday	**Lesson 3** Activity 1: *How Does a Plant Grow?* (examine seedlings) Activity 2: *From Soil to Roots* (examination of roots)
Day 8 Tuesday	**Lesson 3** Activity 2: *From Soil to Roots* (continued)
Day 9 Wednesday	**Lesson 3** Activity 3: *From Roots to the Plant*
Day 10 Thursday	**Lesson 4** Activity 1: *Plants, Soil, Nutrients, and Fertilizer*
Day 11 Friday	**Lesson 4** Activity 2: *What Should I Grow in My Garden?*
Day 12 Monday	**Lesson 4** Optional Activity: *Fertilizer—How Much?*
Day 13 Tuesday	**Lesson 5** Activity 1: *Planning a Garden*
Day 14 Wednesday	**Lesson 5** Activity 1: *Planning a Garden* (continued)

Introduction

TABLE 007. TIMELINE WITHOUT OPTIONAL ACTIVITIES

Timeline	Activity
2-3 weeks ahead	Obtain supplies for lessons
1 week ahead	Photocopy masters, prepare overhead transparencies, gather materials
1-5 days ahead	Prepare cups for seed planting in Lesson 1, set up grow lamps if appropriate
Day 1 Friday	**Lesson 1** Activity 1: *Thinking about Plants*
Day 2 Monday	**Lesson 1** Activity 2: *Growing a Garden*
Day 3 Tuesday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 2** Activity 1: *Properties of Soils*
Day 4 Wednesday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 2** Activity 1: *Properties of Soils* (continued)
Day 5 Thursday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 3** Activity 1: *How Does a Plant Grow?* (set up)
Day 6 Friday	**Lesson 1** Activity 2: check seed germination (5-10 minutes) **Lesson 1** Activity 2: Step 8 (optional)

Introduction

TABLE 007. TIMELINE WITHOUT OPTIONAL ACTIVITIES

Timeline	Activity
Day 7 Monday	**Lesson 3** Activity 3: *From Roots to the Plant*
Day 8 Tuesday	**Lesson 4** Activity 1: *Plants, Soil, Nutrients, and Fertilizer*
Day 9 Wednesday	**Lesson 4** Activity 2: *What Should I Grow in My Garden?*
Day 10 Thursday	**Lesson 5** Activity 1: *Planning a Garden*
Day 11 Friday	**Lesson 5** Activity 1: *Planning a Garden* (continued)

REFERENCES

1. Borlaug, N. (2000). The Green Revolution revisited and the road ahead. Retrieved June 7, 2005 from www.nobelprize.org.

2. Bybee, R. W. (1992). Achieving scientific literacy: From purposes to practice. Portsmouth, NH: Heinemann Press.

3. Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). Designing professional development for teachers of science and mathematics. Thousand Oaks, CA: Corwin Press.

4. National Research Council. (1996). National science education standards. Washington, DC: National Academy Press.

5. United Nations. (1998). World population prospects. New York.

6. United States Department of Agriculture. Nutrient content of crops. Retrieved February 1, 2011 from http://plants.usda.gov/npk/main.

GLOSSARY

Commercial fertilizer: commercially prepared mixtures of plant nutrients that include nitrogen, phosphorus, and potassium applied to the soil to restore fertility and increase crop yields. Commercial fertilizers contain nutrients in known amounts that plants can immediately use.

Crop: food crops, lawns, garden, and ornamental plants such as flowers.

Fertilizer: substance used to increase the level of nutrients in soil.

Inorganic: composed of material from nonliving sources; rocks, sand, and minerals are examples of inorganic materials.

Nutrient: any of 17 essential mineral and nonmineral elements necessary for plant growth.

Nutrient deficiency: a condition where the amount of a nutrient essential to the health of an organism is lacking or present in an insufficient amount.

Organic: living or once-living organisms; derived from living organisms.

Organic fertilizer: a fertilizer that undergoes little or no processing and includes plant, animal, and/or mineral materials.

Percolation: the process by which water moves downward through openings in the soil.

Permeability: the ability of soil to allow the passage of water.

Porosity: the percentage of soil volume that is not occupied by solids.

Lesson 1 **ENGAGE**

PLANTS AROUND YOU

Nourishing the Planet in the 21st Century

At a Glance

OVERVIEW

As a way to begin thinking about plants and plant growth, students sort plants into groups according to similarities. They then consider what they know about the different parts of the plants and what plants need for healthy growth. They then speculate what happens if the plants don't have the right balance of these things. Students begin a gardening project to gain experience with plant growth and to deepen their understanding of how plants and their environment interact.

MAJOR CONCEPTS

- Plants have specific parts that relate to their function.
- Plants have specific needs for healthy growth.
- A plant's environment includes the living and nonliving things around them.

OBJECTIVES

After completing this lesson, students will be able to:

- Categorize plants or plant materials into groups.
- Describe things, such as light and soil that plants need for growth.
- Define environment.
- Draw conclusions from a seed sprouting investigation.

In Advance

PHOTOCOPIES

ACTIVITY 1: *Thinking about Plants*	no photocopies or transparencies
ACTIVITY 2: *Growing a Garden*	**Master 1.1,** ***My Garden Record*** (1 copy per student) **Master 1.2,** ***Time for Seed Sprouting*** (optional; 1 transparency)

MATERIALS

ACTIVITY 1: *Thinking about Plants*	**FOR THE CLASS:** • variety of plants and plant materials (see *Preparation* for more details)
GROUP 1: *Growing a Garden*	**FOR EACH STUDENT:** • cup or pot • seeds • potting soil • pencil • crayons (optional for drawing) **FOR THE CLASS:** • spray bottle • permanent marker **FOR THE TEACHER:** • electric drill or other implement to put holes in bottom of cups • trays to hold cups or pots that will catch water

Preparation

ACTIVITY 1:
THINKING ABOUT PLANTS

For this activity, you will want a variety of plants and plant materials. You will want to include things that are currently growing, such as a houseplant or even hydroponically grown lettuce that has the roots still attached (available in some grocery stores). You can also have a variety of fruits (apples, oranges, kiwi), vegetables (broccoli, carrots, lettuce, radishes), or grains (rice, barley, oats). To add diversity of plant types, you could also collect photos of plants that are not easily obtained or handled (either because of location or size, such as cactus or water lilies. The photos should show the plants that are living in their natural environment. For example, it would be better to have a picture of a rose bush than a picture of a rose in a vase. Include a variety of edible and non-edible plants.

Preparation

ACTIVITY 2:

GROWING A GARDEN

Students will begin this activity in this lesson and continue it as they move through the remainder of the unit. They will monitor their plants at various points and relate the concepts from the following lessons to what is happening in their plants.

NOTE TO TEACHERS: ***This lesson requires the greatest amount of preparation on your part. The information that follows provides some guidance for options. The procedure is written so that each student will plant his or her own cup with seeds. This helps engage students in the lesson and students in the field test enjoyed being able to compare what they were seeing with what other students were seeing. If you feel that space or time won't permit for each student to plant seeds, students could work in teams of 2-3 students.***

You will need to decide how best to make this work in your classroom. The items specified in this unit are suggestions, but you may need to modify them slightly depending on what you can obtain in your area and what space is available. You may have a sunny windowsill or perhaps even a greenhouse. Fluorescent lights suspended over the seedlings can work well. The lights should be 2–3 inches from the young plants. You can use bricks to hold the lights and add or remove bricks to adjust the height. (Seeds do not need light to germinate; the young plants need light after they emerge from the soil.)

Clear plastic cups work well for growing the seedlings in part because students can see the soil and the developing root systems of the plants. You can usually find different sizes in your grocery store. Nine-ounce cups (approximately 3 inches tall and 3.75 inches across at the top) or 10-ounce cups (approximately 4 inches tall and 3 inches across at the top) work well. The shorter cups work well for most plants that the students will investigate, but the taller ones may be advantageous for some plants. [For example, because of their roots, carrot plants (a short-variety) may do better in the taller cups.]

Preparation

USE THE FOLLOWING STEPS TO PREPARE THE CUPS FOR PLANTING THE SEEDS.

1. Put 2–3 holes in the bottom of each cup for drainage. Although you can use a variety of things to punch holes, an electric drill is perhaps the easiest way. (If you don't have one, you might check with your school's maintenance personnel for help.)
2. Add potting soil to the cups. Add soil until the level reaches approximately ¼ to ½ inch from the top of the cup. (The soil will compact significantly after you water.)
3. Water the soil thoroughly. When watered, the soil will fill in any air pockets. The soil doesn't need to be very wet when students plant their seeds, but having this done ahead of time will make the students' work easier.
4. After the students place their seeds, they can simply add a thin layer of potting soil on top of the seeds. In this way, students avoid the common pitfall of planting seeds too deeply. In addition, they can simply use the spray bottle to wet the top layer of soil. In this way, the seeds remain evenly distributed in the cup and don't get washed to the side of the cup or end up in one spot. You may need to water more thoroughly afterwards, but this method may be easier for young students.

The steps in this preparatory procedure should save class time. Students still get the experience of planting seeds but with some of the work done ahead of time, the procedure should be more efficient.

You can decide how many types of seeds you want to provide for students. It will be informative for students and more engaging if they can see different types of plants grow. Some seeds are larger than others, making them easier to handle. Some seeds will germinate faster than others. During development of the module, the following seeds were tested for germination and growth in cups (set up as described above and in the lesson). You can choose other seeds to try, but the following information is provided to give you some ideas and some general information.

Preparation

SEEDS/PLANTS	SEED SIZE	APPROXIMATE GERMINATION TIME (DAYS)*
Peas	large	3-5 days
Radishes (2 varieties)	medium	4-7 days
Carrots (short variety)	small	10-25 days
Fennel	small/medium	14 days
Beets	medium	5-25 days
Coriander (cilantro)	medium	7-10 days
Parsley	small	21-28 days
Bell pepper	medium	10-12 days
Lettuce (leaf)	small	7-14 days
Lettuce (romaine)	small	5-10 days
Chives	small	8-12 days
Chard	small/medium	10-15 days

***NOTE:** These times are based on information on the seed packet. During testing, many of the seeds germinated much faster than some of the times listed.

Preparation

Your choice of seeds for students to use will depend on the time available to continue this investigation, space available, and the willingness of your students to adapt to variation (some students will have plants to look at before others). The advantage of having a variety of seeds is that students can see that plants differ in leaf shape, size, color, texture, and growth pattern. Also, the plants included in the table above vary in the part of the plant that we eat. For many it is the leaf, but for others it is the root, stem, or fruit.

In general, you should not expect the seeds to grow into mature plants using this setup. Some plants will adapt better to growing in the cups than others. A plant such as lettuce will grow fairly well in the cup (in part because it grows quickly). A plant such as a pepper will eventually outgrow the cup and would need to be repotted in a larger container before you would get a fruit to develop. If you plant a vegetable whose root is the part we eat (such as a carrot, beet, or radish), students may be able to see the early development of the root after several weeks, but it is unlikely that the plant will grow as well as if it were in a more optimal setting.

NOTE TO TEACHERS: The procedure is written so that each student plants one type of seed in one cup. If you have the space and wish to have each student plant two types of seeds (two cups), one strategy would be for each student to have one seed that germinates fairly quickly and the other seed is one that takes a longer time. Another strategy would be for each student to plant the same kind of seed in one cup. For example, each student could plant radish seeds in his or her first cup so that everyone is growing radish seeds in one cup. Students could plant different seeds in their second cups so they can see a wide variety of plant types. If each student has one cup with the same kind of seed, they can collect and analyze data about seed germination. (See optional Step 8.)

TIP FROM THE FIELD TEST: If you do Step 8, you might want to plant seeds on a Monday so students can watch the germination over several days before the weekend. Radish seeds work well for developing a timeline for germination because they sprout in just a few days. If you plant radish seeds on Monday, most of them are likely to germinate by Friday.

Procedure

ACTIVITY 1:
THINKING ABOUT PLANTS

1. Begin the lesson by displaying a variety of plants, vegetables, fruits, and grains (see *Preparation*) to the class. Ask a few students what they notice about the materials on the table.

   At this stage, look for students' initial ideas. This will help you gauge what their current thinking is about plants. If you are using pictures, you may want to point out that students should think about the plant (or plant product) illustrated and not just that it is a picture.

   For example, if you have a picture of a tree, they should think about the tree rather than it is a picture compared with other real plant materials that are on the table.

2. Ask students if they could sort the materials into categories. Ask students to think about one way that they might be able to put the materials into categories. Have students write their categories on a piece of paper and list things that would fit into each of their categories.

   Allow about 2–3 minutes for this step. Students can work individually or in pairs for this step.

Procedure

3. Ask students if they could sort the materials into categories. Ask students to think about one way that they might be able to put the materials into categories. Have students write their categories on a piece of paper and list things that would fit into each of their categories.

Students may have a variety of ideas about how to sort the materials. At this stage, accept all reasonable ideas, but probe students' thinking if there are items on the table that don't make sense in their categorization scheme.

Possible categories might include:

- Edible vs. non-edible materials
- Living vs. not living (previously living)
- Growing vs. not growing (currently)
- Color
- Vegetable vs. fruit
- Tree vs. non-tree
- Parts of the plant (leaves vs. roots, for example)

Some categories are likely to be more useful than others. Some categories that students propose may have examples that don't really fit and students won't know how to categorize. This may be an opportunity to ask them if they would revise their decision about a categorization scheme now that they have run into difficulties placing the examples.

Procedure

4. Propose to the class that it might be good to think more about sorting by growing vs. not currently growing. Ask, "What parts of a plant are necessary for a plant to grow?"

Students should suggest that plants need roots, stems, and leaves to grow. The vegetables you show in class probably do not have all the parts of the plant that are necessary for growth. For example, a stalk of broccoli obviously was growing at one point (when it was attached to the rest of the plant), but as a separate stalk would not currently be growing because it doesn't have the roots attached.

CONTENT STANDARD C, LIFE SCIENCE: Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.

5. Continue the discussion by asking if there are other things a plant needs to be able to grow. Write a list of student responses on the board or chart paper.

If students have trouble getting started with this list, start off by asking if plants need light to grow. This should spark other ideas to add to the list.

Procedure

6. Write the word "environment" on the board or chart paper. Explain to students that the environment is a word that describes all the living and non-living things surrounding an organism. Would the things that the students listed in Step 5 part of a plant's environment?

For a plant, its environment would include soil, air, light, water, appropriate temperatures, other plants, animals, and insects living around or on the plant. Students are likely to have mentioned some of these in the previous step, but they may not realize that other plants, animals, or insects are part of a plant's environment.

Some things in the environment are required for plants to grow. For example, plants require water and light for growth. Other things are in the environment but may not be requires. For example, plants don't always require the animals and insects that normally live in their environment to grow.

TIP FROM THE FIELD TEST: Students will continue to think about environment in later lessons. Writing "environment" and its definition on chart paper for students to refer to later can help reinforce their understanding of this term as they move through the activities in this unit.

CONTENT STANDARD C, LIFE SCIENCE: An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.

CONTENT STANDARD F, SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES: Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life.

Procedure

7. Continue the discussion by asking students, "What happens if plants don't have the things they need to grow?" Follow that with "What do you think would happen if they don't have the right amounts of the things they need?"

Accept reasonable responses and ask them to explain their thinking if appropriate. Students may bring up examples of plants not growing well if there is not enough (or even too much) water. The students' answers to these questions will help you gauge their current understanding. Explain to students that they will continue to investigate these questions in the following lessons.

Procedure

ACTIVITY 2:
GROWING A GARDEN

1. Begin the activity by asking students where the food they eat comes from. After getting responses from several volunteers, follow this up by asking if people might grow some of their own food.

   Students' life experiences will influence how they answer this question. Most students will probably say that their food comes from the grocery store or maybe a restaurant. Other students may have experiences with growing some vegetables in a family garden, and still others on their family's farm.

2. Ask, "Do you think it would be fun to grow some vegetables and see what makes them grow?"

   If you know of any community gardens in your area, you may ask if students have heard about them. Students may have heard about the vegetable garden at the White House. In 2009, Mrs. Obama, working with students from elementary schools, started a vegetable garden. The garden produced a variety of vegetables, some of which were served to the President's family as well as to visiting leaders from other countries. In 2010, the garden was expanded to grow more plants.

Procedure

3. Inform students that they will start growing some plants to study how they grow and what makes them grow best. Explain that they will start this activity now, and over several weeks they will watch the plants grow and investigate what keeps them healthy.

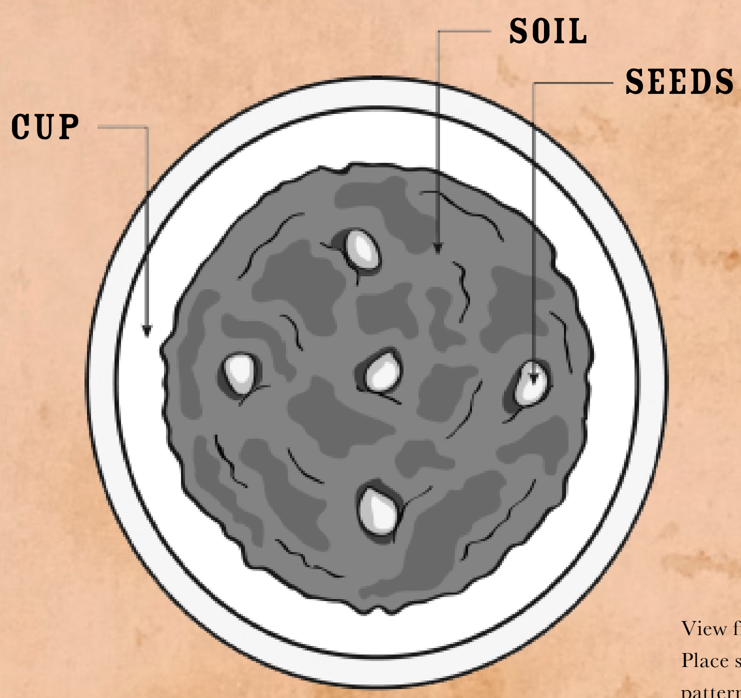
4. Give each student a copy of Master 1.1, *My Gardening Record.* Give each student a few seeds to examine (see *Preparation*). Ask students to draw a picture of their seed in the appropriate space and to write a few words to describe the appearance of the seeds.

Students will continue to work with this master over the course of their gardening activity. Point out to students that there is a place on the handout for them to write the date. Explain that part of the activity involves learning how to keep good records of their investigation. Whenever they make another observation or record data, they will also record the date of that entry onto their handout.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written.

Procedure

5. After students finish drawing their pictures, demonstrate how students will plant their seeds. Point out the cups that students will use and tell them that you have already added some potting soil to each one. You can also point out that the cups have holes in the bottom so extra water can drain out. Explain to students that they will place five seeds on top of the soil. Draw the pattern for arranging the seeds on the board or chart paper. After students place the seeds on top of the soil, have them put a thin layer (usually about $\frac{1}{4}$ – $\frac{1}{2}$ inch) of soil on top of the seeds. Students can then use a spray bottle to moisten the top layer of soil.



View from the top looking down into the cup. Place seeds on top of the potting soil in this pattern. Ask students not to plant seeds at the very edge of the cup.

Procedure

You may want students to bring their cups to you to add the top layer of soil. In that way, you can help them add the right amount—enough to cover the seeds well but not too deeply. Also, you may want to explain that they want to be gentle when they water so that the seeds aren't disrupted (and that not all the seeds end up in a single place in the container). The spray bottle works well if you are just moistening the top layer of soil and that the soil beneath the seeds is already fully moistened (see *Preparation*). The spray bottle, however, is not an efficient method for thoroughly watering all the soil in the cup.

Having students plant five seeds in their cups helps ensure that students will have at least one seed germinate. Students will also be able to observe that even for a single type of seed, there is variation in the amount of time it takes for germination. At a later point, the seedlings may need to be thinned out so that there are one or two plants per cup.

Have the students write their names on their containers. Then show students where to put their containers. Make sure students record when the seeds were planted on the gardening record.

6. Over the next several days, allow students to observe their cups to see if their seeds have germinated. Each day, they can count the number of seedlings that have sprouted and record their data in their gardening record.

Consider the day the seeds were planted to be Day 0. The following day would be Day 1. At first, students may not see any visible change in their containers. They can make a brief note on their gardening record of this. After a few days (depending on the seed type), they will start seeing sprouts emerging. They should record the date and the number of seedlings sprouted on their record. They should also draw a picture of what they observe.

NOTE: The soil needs to be kept moist while seeds are germinating. Decide whether you will take that responsibility for watering all the cups or if you want students to be responsible for watering their own cups.

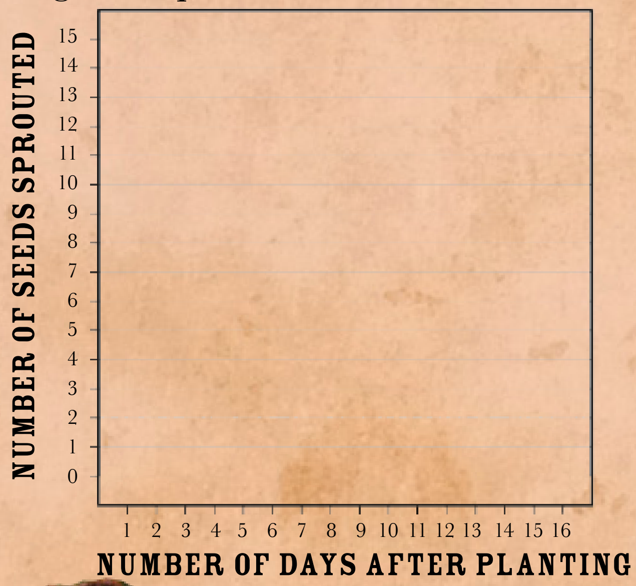
Procedure

7. When students have seedlings that are about one week old (doesn't need to be exact), ask students to draw another picture of their seedlings.

   Some students will have seeds germinate before others. Encourage students to look at the seedlings that other students have and compare the different kinds of seedlings. Ask them if they see differences in leaf shape, leaf size, color of stems or leaves, and so forth.

   NOTE: If you skip Step 8, go directly to Step 9 to conclude this activity.

8. (Optional) If you have employed the strategy of having students plant two cups of seeds with each student planting the same type of seed in one cup, you can pool the data for one kind of seed from the entire class for analysis. Begin by collecting the data from each student on a transparency of Master 1.2. Then use the data to construct a bar graph using a template similar to the one that follows.



You can use an X to represent each seed that has sprouted. Alternatively, you can use a sticky note to represent each sprouted seed. This will form a bar graph of the class' pooled data.

Procedure

Discuss the data with the class to make conclusions about the time needed for seeds to sprout. Guide the discussion using questions such as:

- When did the first seeds sprout?
- On what day did the greatest number of seeds sprout?
- Did all seeds sprout on the same day?
- Did all seeds sprout?
- Why do you think some seeds didn't sprout?
- Why do you think that seeds sprouted at different times?

The data should reveal that the seeds generated over a range of days. Even though they were all the same type of seed, there were differences in the time it took for the seeds to sprout. It is also likely that some seeds didn't sprout at all; perhaps those seeds got damaged in some way or they weren't healthy seeds. Just as in humans and all other species, there are differences between individuals.

If time permits, students could also measure the height of seedlings over time and communicate that information graphically.

Procedure

9. Ask students to draw some conclusions based on what they have learned from the seed growing activity.

You may want students to think about this individually or in small teams before sharing their responses with the class. Some possible conclusions are:

- Some kinds of seeds sprout more quickly than others.
- Some seeds may not sprout at all.
- Different seedlings look different than others in their size, shape of leaves, color, and so forth.
- If you have more than one seed of the same kind, you can see differences between individuals (e.g., time to germinate or size may be different among individuals).

***NOTE TO TEACHERS:* You can decide how long students will keep their plants growing. Depending on the type of plant, the size of the container, and the type of soil, some seedlings may do very well at first and then become less healthy over time. This is an opportunity to help students understand that there is probably something about the plant's environment that isn't exactly right. Maybe that plant needs something else to be healthy that can't be provided in this setup.**

Procedure

LESSON 1: ORGANIZER

Activity 1: *Thinking about Plants*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Display a variety of plant materials and ask students to share comments about what they see.	Step 1 **PAGE 044**
Ask students to sort the plant materials into categories.	Step 2 **PAGE 044**
Have students share their categorization schemes with the class. Ask them to provide examples of things that fit into their categories and describe any problems they had trying to fit certain materials into a category.	Step 3 **PAGE 045**
Focus the class on the categories of growing vs. not growing. Ask "What parts of a plant are necessary for a plant to grow?"	Step 4 **PAGE 046**
Ask students to name other things that a plant needs in order to grow.	Step 5 **PAGE 046**
Write the word "environment" on chart paper. Explain that the environment is all of the living and non-living things surrounding an organism. For plants, the environment includes soil, air, light, water, other plants, and animals living around or on the plant.	Step 6 **PAGE 047**
Continue the discussion by asking, "What happens if plants don't have the things they need to grow or if they don't have the right amounts of those things?"	Step 7 **PAGE 048**

Procedure

LESSON 1: ORGANIZER

Activity 2: *Growing a Garden*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Ask students where the food they eat comes from.	Step 1 **PAGE 049**
Ask if students would like to grow some vegetables to learn more about how plants grow. Explain that they will plant some seeds now and watch them over the next several days and weeks.	Step 2 **PAGE 049** Step 3 **PAGE 050**
Give each student a copy of Master 1.1, My Gardening Record, and several seeds. Ask students to draw a picture of their seeds and write a few words to describe their appearance.	Step 4 **PAGE 050**
Demonstrate how students will plant their seeds in prepared cups.	Step 5 **PAGE 051**
Over several days, ask students to observe their cups and look for germination. Have students record their observations on Master 1.1.	Step 6 **PAGE 052**
When the seedlings are about 1 week old, have students draw another picture of their young plants.	Step 7 **PAGE 053**
Pool all of the data from the class (using Master 1.2). Construct a bar graph showing the number of seeds sprouted each day after planting. Help students draw conclusions from the experiment by asking questions such as • When did the first seeds sprout? • On what day did the greatest number of seeds sprout? • Did all the seeds sprout on the same day? • Did all seeds sprout? • Why do you think some seeds didn't sprout? • Why do you think seeds sprouted at different times?	Step 8 **PAGE 053**
Ask students to state some conclusions about what they have learned so far from the seed-growing activity.	Step 9 **PAGE 055**

Name ____________________

MASTER 1.1,

MY GARDENING RECORD

Part 1: The Seeds

Write the name of the seed: ____________________

Draw a picture of your seed.

Write two or three words to describe what your seed looks like.

____

____

Name ______________________________

Part 2: Planting Seeds

I planted my seed on this date: ____.

How many seeds did you plant in your cup? ________

Draw a picture to show how you planted your seeds. Label each part on your picture.

Name ________________________________

Part 3: Watching Seeds Sprout

Look at your pots each day. For each day that you observe your pots, write or draw the following information.

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Date ___________________
Number of days after planting: _______ Number of sprouts _______

Name ______________________________

When you first see your young plants, draw a picture of what you see.

About one week after you first see your young plants, draw a picture of what you see.

Date ______________________

Name ______________________________

MASTER 1.2,

TIME FOR SEED SPROUTING

Total Number of Seeds Planted by the Class: ________

NUMBER OF DAYS AFTER PLANTING	NUMBER OF SEEDS SPROUTED
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
Never Sprouted	

Lesson 2 **EXPLORE**

PROPERTIES OF SOILS

Nourishing the Planet in the 21st Century

At a Glance

OVERVIEW

To learn that different soils have different characteristics, students examine different types of soil that have been mixed with water and allowed to settle. Next, they investigate soil components and how air space allows soils to hold and transmit water.

MAJOR CONCEPTS

- Soils vary in their compositions.
- Soils contain materials from both nonliving and living sources.
- Soils contain differing amounts of air space.
- Soils differ in their abilities to hold and transmit water.

OBJECTIVES

After completing this lesson, students will be able to:

- list aspects of soil composition,
- recognize that soils vary in composition, and
- provide examples of ways that soils differ in their ability to absorb water

In Advance

PHOTOCOPIES

ACTIVITY 1: ***Properties of Soils***	**Master 2.1,** ***Looking at Soil Samples*** (2 copies per group of 4 students). **Master 2.2,** ***Investigation 1: Dry Soil*** Soil (Make 4 copies per group of 4 students). **Master 2.3,** ***Investigation 2: Soil and Air Space*** Soil (Make 4 copies per group of 4 students).
OPTIONAL ACTIVITY: ***Growing a Garden***	**Master 2.4,** ***Does Soil Matter?*** (Make 1 copy per student. Make additional copies of Master 2.4b as needed).

In Advance

MATERIALS

ACTIVITY 1: ***Properties of Soils.*** **Soil Separation**	**FOR THE CLASS:** • 3 clear, 12-oz plastic bottles • 10 oz each of potting soil, local soil, and sand • Water • Funnel (optional)
INVESTIGATION 1: ***Looking at Soil***	**FOR A GROUP OF 4 STUDENTS:** • 2 hand lenses • 1 teaspoon each of potting soil (labeled Soil A) and local soil (labeled Soil B) (students can use plastic spoons for measuring soil) • 2 pencils
INVESTIGATION 2: ***Soil and Air Space***	**FOR A GROUP OF 4 STUDENTS:** • 3 clear, plastic cups (9 fluid ounce (266 mL); approximately 3 inches tall and 3.75 inches across at the top) • 1 permanent marker • 1/2 cup each of potting soil, local soil, and sand • 3 small paper cups each containing ½ cup of water • 1 ruler
OPTIONAL ACTIVITY: * ***(see Preparation)***	**FOR A GROUP OF 4 STUDENTS:** • 3 clear plastic cups with holes in bottom prepared for planting • Potting soil • Local soil • Sand • Seeds (choose seeds that germinate fairly quickly, such as peas or radishes) • Permanent marker • 1 ruler • Spray bottle (1-2 per class)

Preparation

Try to obtain coarse sand such as that used for home improvement projects. Clean, fine sand may not allow water to pass as readily as most sands found in soils.

SOIL SEPARATION. In Step 3, students are asked to observe three different soil types (potting soil, local soil and sand) that have been mixed with water and allowed to settle. For this demonstration, clear plastic, 12-oz bottles work well. Fill each bottle about two-thirds full of soil. Place potting soil, local soil and sand in separate bottles. (A funnel or a paper cone may make it easier to get the soil in the bottles). Add water to near the top of each bottle. Place caps on the bottles, shake the contents well, and place the bottles in a location where they will not be disturbed. Prepare at least one day before making observations.

a. Soil separation after the surface of the water

b. Organic material floating on the surface of the water

When teams conduct the investigations described beginning in Step 10, prepare the following materials (exact numbers of sets will depend on the number of students and teams in your class). Identify a place in the classroom where students can pick up their materials needed for their assigned investigation.

Preparation

INVESTIGATION 1:
LOOKING AT SOIL SAMPLES

Make available enough potting soil (labeled Soil A) and local soil (labeled Soil B) to be contained in the center circles on Master 2.1a and b, *Looking at Soil Samples* (about 1 teaspoon for each group of 4 students). Also have hand lenses available.

Preparation

INVESTIGATION 2:
SOIL AND AIR SPACE

Each team will need three clear plastic cups containing soil samples. Use cups that hold about 1 cup of liquid. Label the cups 1, 2 and 3. Add soil to each cup as follows.

CUP 1: 1/2 cup of potting soil
CUP 2: 1/2 cup of local soil
CUP 3: 1/2 cup of sand

Each team will also need 3 cups that each contain 1/2 cup of water. Also have a ruler available for each team.

Preparation

OPTIONAL ACTIVITY:
DOES SOIL MATTER?

The cups for this activity and the planting of seeds will be similar to the procedure in Lesson 1. You can prepare cups and fill them with potting soil, local soil, and sand in advance to save class time before students plant the seeds. Another option is for you to prepare and plant the seeds for students to observe. If you choose this option, you may want to prepare 2–3 cups with each type of soil to allow teams of students to observe a set of cups. This would also allow for comparisons among different sets of cups (to demonstrate that the results of a single cup are not simply a fluke).

Procedure

ACTIVITY 1:
PROPERTIES OF SOILS

CAUTION: Be careful when moving the three bottles with the soils settled in water (Step 3). Excessive movement will cause the soil layers to mix together. Try to keep the bottles undisturbed.

1. Remind students that in Lesson 1, they listed soil as one of the things that plants need to grow. Ask students, “What is soil?” and “What things are in soils?” Write students’ responses on the board or chart paper.

   At this time, accept all reasonable answers. Students may suggest that soil is dirt or that it is what plants grow in. When thinking about the components of soil, student responses may include rocks, sand, clay, insects, worms, bacteria, bits of wood and water.

2. Continue the discussion by asking students, “Can you group the things in soils into different categories?” Ask students what they would put in the different categories. Record their responses on the board or chart paper.

   Student responses will vary. Guide the discussion to bring out the fact that soil consists of nonliving material, such as clay, silt and sand, as well as living material, such as bacteria, insects, worms, and material from previously living organisms (e.g., dead plant material or even the bodies of decomposed dead animals such as insects). (Materials from living or once-living organisms can be called organic, and nonliving materials such as clay, rocks or sand are inorganic materials. Students do not need to learn these terms).

Procedure

3. Inform the students that they will be making observations of different kinds of soil to learn more about what is in them. Show the class the bottles of potting soil, local soil, and sand that were previously mixed with water and allowed to settle. Explain how they were prepared. Ask students to gather around the bottles and make observations about the different soils.

   Caution students not to pick up or move the bottles.

   Students will observe that the different soils separate differently. At this point, students will not know what is found in each layer. They should record their observations and refer back to them later in the lesson.

   - The potting soil will show a thick layer of dark material on the bottom, a thick layer of cloudy water, and a thinner layer of material on the top.
   - Local soils may differ, but a typical soil will show layering similar to potting soil, though there may be less material floating on the surface.
   - Most of the sand will form a very thick layer on the bottom of the container. There will be a thick layer of clear water and a very thin layer of material on the surface.

4. Remind students of the categories that they created earlier (Step 2). Ask students if they can tell which categories match up with the different layers in the bottles.

   Have students refer back to the lists from Step 2. Student responses will vary. Many students will indicate that things like rocks and sand will sink to the bottom. They may have more difficulty predicting what makes up the upper layers in the bottles. For example, they may be uncertain about what happens to the material from decomposed plants. (Some students may think that dead plant or animal material "just goes away" so it isn't in any layer). Listen to their answers to assess what students' current thoughts and ideas are.

Procedure

5. Point out the thin layer that floats on the surface. Inform students that this material is made up mostly of the materials in soil that came from organisms that were alive once but are dead now and have been decomposed by other organisms in the soil.

   If students are not sure how a once living organism would now be in the soil, you can ask if they have ever seen a tree that has fallen and has started to rot and break down. They may also have seen insects that have died and are in early stages of decomposition.

   If students have learned about density, you can reinforce their understanding of that concept by explaining that some materials in the soil are more dense (e.g., sand and rock) while other materials are less dense (e.g., clay, the organic material floating on top). However, students do not need to incorporate these terms for this lesson.

6. Explain to students that the cloudiness in the water comes from small particles called clay. Clay particles are like rock or sand in that they are nonliving. They are very small—so small that they can remain suspended in the water.

   Students are likely to think that sand particles are small and they sink. They may have trouble understanding that clay particles are even smaller (smaller than they can see as individual particles) and are able to stay suspended in water.

   CONTENT STANDARD D, EARTH AND SPACE SCIENCE: Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.

Procedure

7. Ask students, "How do soils help plants grow?" Write student responses on the board.

Another way to phrase the question is "Why do plants need soil?" Accept reasonable answers at this time—students will continue thinking about the relationship between plants and soil throughout this lesson and continue to deepen their understanding through subsequent lessons. Student responses to the question will vary. Some of the ideas that students may suggest include:

- Soils provide support for plants' root systems.
- Soils provide things that plants need so they can grow.
- Soils hold water and make it accessible to plants.

You may find it helpful to write student responses on chart paper or the board to refer to after students have participated in the investigations.

8. Ask students, "Do plants grow just as well in any kind of soil?"

Students are likely to say that plants grow better in some soils than others, but they may not be able to explain why they think that. Ask students if they can give examples that they have seen that would support their answers.

9. Inform students they are now going to investigate some other properties of soils that affect plant growth. Divide the class into groups of four students and direct them to their work areas.

Student groups will explore two different aspects of soil. Because students will work in groups of 4 for these investigations, you will need to set up multiple lab stations:

- Investigation 1: Dry Soil
- Investigation 2: Soil and Air Space

Procedure

10. Pass out the appropriate masters to the groups as follows:
    - **Investigation 1:**
      Master 2.1, *Looking at Soil Samples* (2 copies per group)
      Master 2.2, *Investigation 1: Dry Soil* (1 copy per student in group)
    - **Investigation 2:**
      Master 2.3, *Investigation 2: Soil and Air Space* (1 copy per student in group)

11. Instruct students to follow the directions on their handouts, record their observations and answer any questions.

    Give students approximately 15 minutes to complete their investigations.

12. After the groups complete their investigations, reconvene the class and ask each group to take turns describing their investigation and reporting their results.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Communicate investigations and Explanations: Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written.

Procedure

Student reports will vary. For each type of investigation, summarize the results on the board or an overhead transparency. As necessary, ask guided questions to bring out the following:

Investigation 1: Looking at Soil Samples

- Soils differ in their composition.
- Soils contain nonliving and living (or once-living) things.
- Visual inspection cannot fully evaluate everything about soils.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Employ simple equipment and tools to gather data and extend the senses.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.

Procedure

Answers to questions on Master 2.2:

INVESTIGATION 1:

LOOKING AT SOIL SAMPLES

1. How is the soil sample A like soil sample B?

Potting soil (sample A) and local soil (Sample B) are similar in that they both contain nonliving (inorganic) materials and materials from living sources (either currently alive or formerly living; organic). Organic materials come from plant and animal sources. For example, students might see pieces of leaves or even parts of dead insects in the soil. Organic materials also come from bacteria and other microorganisms too small to be seen without a microscope. Both types of soil also contain particles from nonliving sources that vary in size, such as sand or small stones. The two soils differ in the relative amounts of the different kinds of materials. Often, the potting soil will have more organic material than the local soil. The local soil often contains small pebbles and rocks not found in the potting soil. You may need to help students distinguish between soil components that are nonliving versus those that were at one point part of a living organism but are no longer alive. For example, students may categorize a small piece of wood as nonliving because they don't recognize that it was once part of a living organism.

2. How is sample A different from sample B?

See answer to question 1.

3. Do you think that plants will grow better in sample A or sample B? Why?

Generally, we cannot tell how well a soil will support plant growth by visual inspection alone. Although we may be able to see some differences in the kinds of particles in a soil sample, it is not possible to see many of the different things (nutrients) that plants need.

Procedure

INVESTIGATION 2:
SOIL AND AIR SPACE

As water was slowly added to the soil samples, students should have noted that both the potting soil and the local soil produced air bubbles that rose to the surface. Few or no air bubbles would be seen when water was added to sand. After the water was allowed to percolate into the potting soil, students should have observed that the final water level was approximately halfway between the surface of the soil and the line drawn on the cup. This means that the potting soil contained about 50 percent air space. The local soil also would contain a significant amount of air space, though it may be less than the potting soil. The sand would display only a small amount of air space, depending on the grain size. Make sure to bring out the following points:

o Soils differ in the amounts of air space that they contain.

o Average soils that support crops consist of nearly 50 percent air space.

o Soils need both air space and water to support a plant's root system.

o Water moves through some soils more quickly than others.

As a follow up question, you might want to ask students how the air spaces in soil can help plants. The air space provides room for the soil to hold water and substances (nutrients) needed by the plant. The air also provides oxygen, which is needed by the roots of all plants and most (but not all!) microorganisms that live in the soil.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Employ simple equipment and tools to gather data and extend the senses.

Procedure

Answers to questions on Master 2.3:

INVESTIGATION 2:
SOIL AND AIR SPACE

1. Did it take longer for water to get to the bottom of some cups than others? What did you observe?

Students will probably notice that it takes different amounts of time for the water to move through the different types of soil. Depending on the soils you use, water may move through some much faster than it does through others.

2. What did you notice about the water level of the three cups?

After adding the water to the cups and letting it move through the soils, students will likely see that there is either a very thin layer of water on top of the soil or that all the water was absorbed into the soil. For the cup with sand, students will see a thicker layer of water on top of the sand. The different soil types contained different amounts of air space within them. The potting soil has about 50 percent air space, while the sand has much less. The local soil most likely has less air space than the potting soil, but more than the sand.

3. Why do you think the water levels are different?

As water enters the soil, it occupies the spaces previously taken up by air. This means that the more air space in the soil, the more water is taken up, and the lower the observed water level. If students have difficulty with this, ask them to imagine a container containing balls, such as tennis balls. Can the tennis balls occupy all of the space in the container? What is between the balls? Can you think of the tennis ball scenario as a very large model of soil particles?

Procedure

13. Help students summarize what they have learned in these investigations by asking students to list things that they learned about soils.

Write the list on the board or on chart paper. Students should mention the following:

- Soils contain different kinds of materials in them.
- Different soils contain different amount of air spaces between the particles.
- Different types of soil allow water to pass at different rates.

CONTENT STANDARD D, EARTH AND SPACE SCIENCE: Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.

14. Explain to students that farmers and gardeners sometimes dig up or till the soil in the spring to loosen it up (make it less compacted) and they may even add decomposed plant and animal materials to the soil. Why do you think they go through these steps to prepare the soil? Can you think of any reason these steps may not be good for the soil?

Breaking up or loosening the soil allows air to get into the soil for better root growth, and it may help water penetrate the soil. Adding organic matter to the soil provides plants with things (nutrients) they need. Digging up soil is not always good for plant growth because the soil can wash or blow away more easily, and plants need soil. Many farmers have learned how to grow healthy crops without tilling the soil.

Procedure

OPTIONAL ACTIVITY:
DOES SOIL MATTER?

1. Explain to students that they are going to investigate the importance of the type of soil for plant growth. In the first lesson, students planted their seeds in potting soil. In this experiment, they will plant seeds in potting soil, local dirt, and sand. Give each team a copy of Master 2.4, *Does Soil Matter?* (first page). Review the information on the master with students so they understand the investigation they will be doing.

Students should write their predictions in the space provided. For example, some students may predict that the seeds will grow better in local soil than they do in sand. Other students may predict that seeds will grow equally well in all three cups. Students will revisit their hypotheses after the seeds have had time to germinate and grow.

CONTENT STANDARD A, LIFE SCIENCE: Plan and conduct a scientific investigation.

Procedure

2. Ask students to work in groups of three. Give each group a set of three planting cups. Have students plant seeds in each cup in the same manner they did in Lesson 1.
   CUP 1: Potting Soil
   CUP 2: Local Soil
   CUP 3: Sand

   Make sure students write their names (or otherwise identify) their cups.

3. Have students check on their seeds every few days. Students can check to see how many seeds germinated in each container and how much the seedlings have grown.

   Have students record their data and their observations on Master 2.4, *Does Soil Matter?* You can give out copies of Master 2.4b as needed. Instruct students where to record their data. You can decide how often students should check their cups. Make sure you water the seedlings frequently. The sand, especially, will dry out fairly quickly.

   NOTE TO TEACHERS: ***To document the results of the experiment, you could take digital photographs of the growing plants periodically to record the results. The pictures could be stored on your computer. It is helpful to have the seedlings in the three different growing media in the same photograph for comparison or to include a ruler in the photo to help compare sizes.***

Procedure

4. After allowing the young plants to grow for approximately 2-3 weeks, ask students to summarize what they have observed about their plants.

The length of time needed to continue this investigation will depend on a few factors, such as the seeds chosen for the experiment (and how long they need to germinate), the quality of your local soil. If you are in an area that has very rich soil, students may see few if any differences between seedlings grown in local soil and in potting soil. Some differences may take a while to appear. For example, some seeds may sprout equally well in sand and potting soil, but after a period of time, the seedlings in sand may not grow as well as those in potting soil or local soil. Students won't need to check their plants every day (especially after most seeds have germinated), but they should check them every few days throughout the experiment.

5. Conclude the activity by asking students to share the results of their investigation.

The strategy for how students share their results is your choice. Students can discuss their results or they could create a poster that presents their data. If you choose this option, allow time for students to view the other posters and compare their results to those of other groups.

Carrots

Beets

Fennel

FIGURE: SOIL AFFECTS GROWTH. In each picture, plants are growing in potting soil in the cup on the left and sand in the cup on the right. All seeds were planted at the same time and kept under identical conditions.

Procedure

TIP FROM THE FIELD TEST: Some students were surprised that the seeds in the sand germinated and, at first, seemed to be as healthy as those growing in potting soil or local soil. They observed differences in growth a week or two after germination. The seeds contain nutrients that the young seedling needs, but these nutrients will run out. After that, seeds need to obtain nutrients from the soil.

Procedure

LESSON 2: ORGANIZER

Activity 1:

WHAT THE TEACHERS DOES	PROCEDURE REFERENCE
Remind students that soil is one thing that plants need in order to grow. Ask students, "What is soil" and "What things are in soil?" Record students' responses on chart paper or on the board.	Step 1 **PAGE 071**
Continue the discussion by asking, "Can you group the things in soil into different categories?"	Step 2 **PAGE 071**
Show the bottles filled with different types of soil. Explain how the bottles were prepared. Have students make observations of the different bottles.	Step 3 **PAGE 072**
Remind students of the categories they listed in Step 2. Ask if student can tell which categories match up with the different layers in the bottles.	Step 4 **PAGE 072**
Point out the thin layer floating on the surface. Explain that this material is made up mostly of the materials in the soil from organisms that were once alive but are now dead and decomposed.	Step 5 **PAGE 073**
Explain that the cloudiness in the water comes from very small particles called clay. Clay particles are nonliving but are so small that they can remain suspended in the water.	Step 6 **PAGE 073**
Ask students to consider "How do soils help plants grow?" Write student responses on the board. Continue by asking students, "Do plants grow just as well in any kind of soil?"	Step 7 **PAGE 074** Step 8 **PAGE 074**

Procedure

LESSON 2: ORGANIZER

Activity 1:

WHAT THE TEACHERS DOES	PROCEDURE REFERENCE
Explain that students will now investigate properties of soil. Half the students will work in teams of 4 to complete Investigation 1 and the other students will work in teams of 4 to complete Investigation 2. Give students the appropriate handouts and allow time for them to read the instructions and ask questions.	Step 9 **PAGE 074** Step 10 **PAGE 075**
Allow time for teams to conduct their investigations.	Step 11 **PAGE 075**
Ask groups to describe the results of their investigation to the other students in the class.	Step 12 **PAGE 075**
Conclude the activity by asking students to list things they have learned about soil from the activities in this lesson.	Step 13 **PAGE 080**
Ask students to share ideas about why farmers or gardeners dig up or till the soil, or even add decomposed materials to the soil, before planting.	Step 14 **PAGE 080**

Procedure

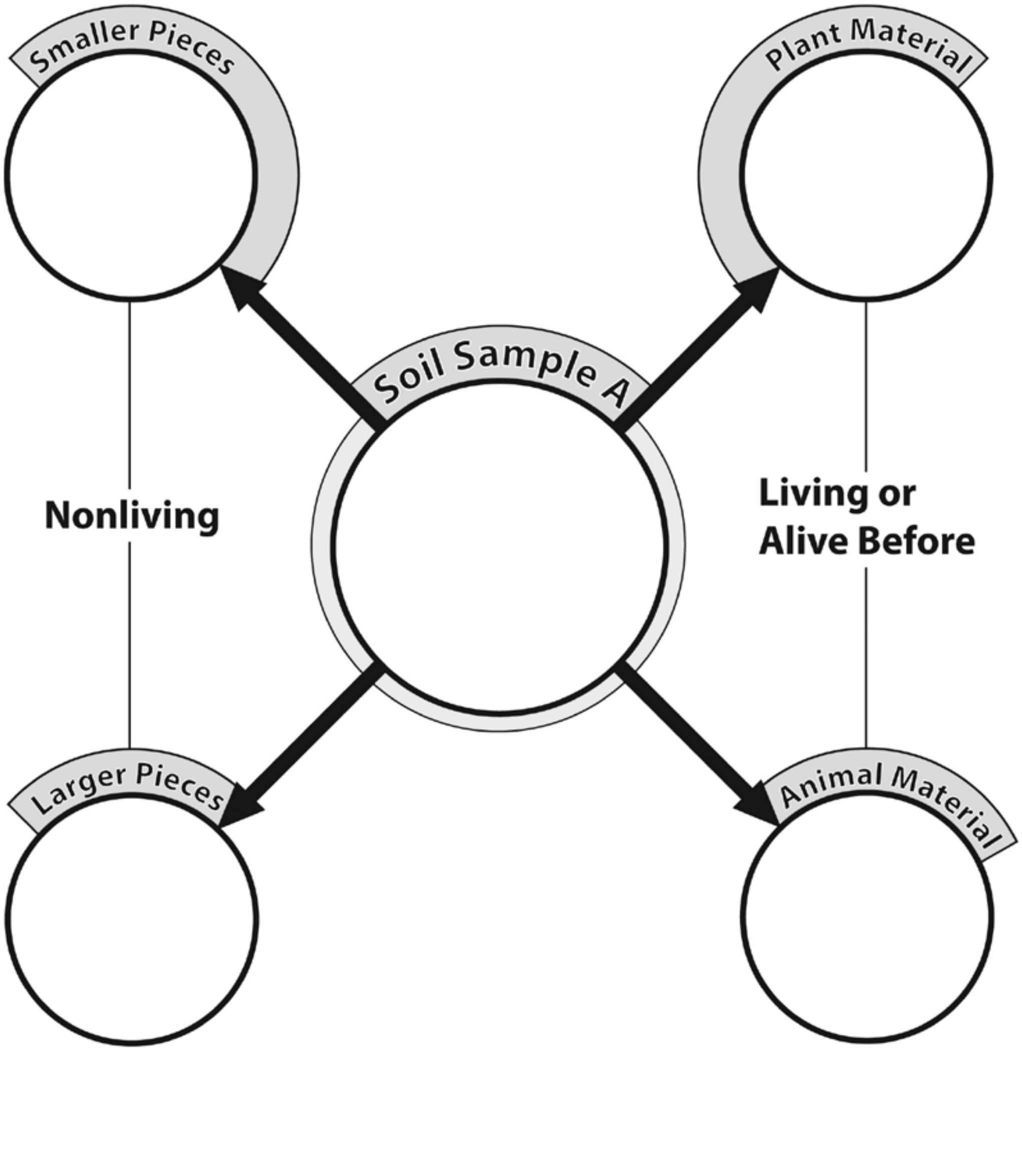
LESSON 2: ORGANIZER

Optional Activity: *Does Soil Matter?*

WHAT THE TEACHERS DOES	PROCEDURE REFERENCE
Explain that students will investigate how the type of soil affects plant growth. Students will plant seeds in potting soil, local dirt, and sand. Give each team of students a copy of Master 2.4, Does Soil Matter? (first page). Review material on handout with students before proceeding.	Step 1 **PAGE 081**
Have students work in teams of three to plant seeds in the different kinds of soil.	Step 2 **PAGE 082**
Allow students to check their seeds every few days. Ask students to record their data and observations on Master 2.4b	Step 3 **PAGE 082**
After plants grow for approximately 2-3 weeks, ask students to write some conclusions about what they have observed about how soil type affects plant growth. Ask students to share their experimental results and conclusions with the class.	Step 4 **PAGE 083**

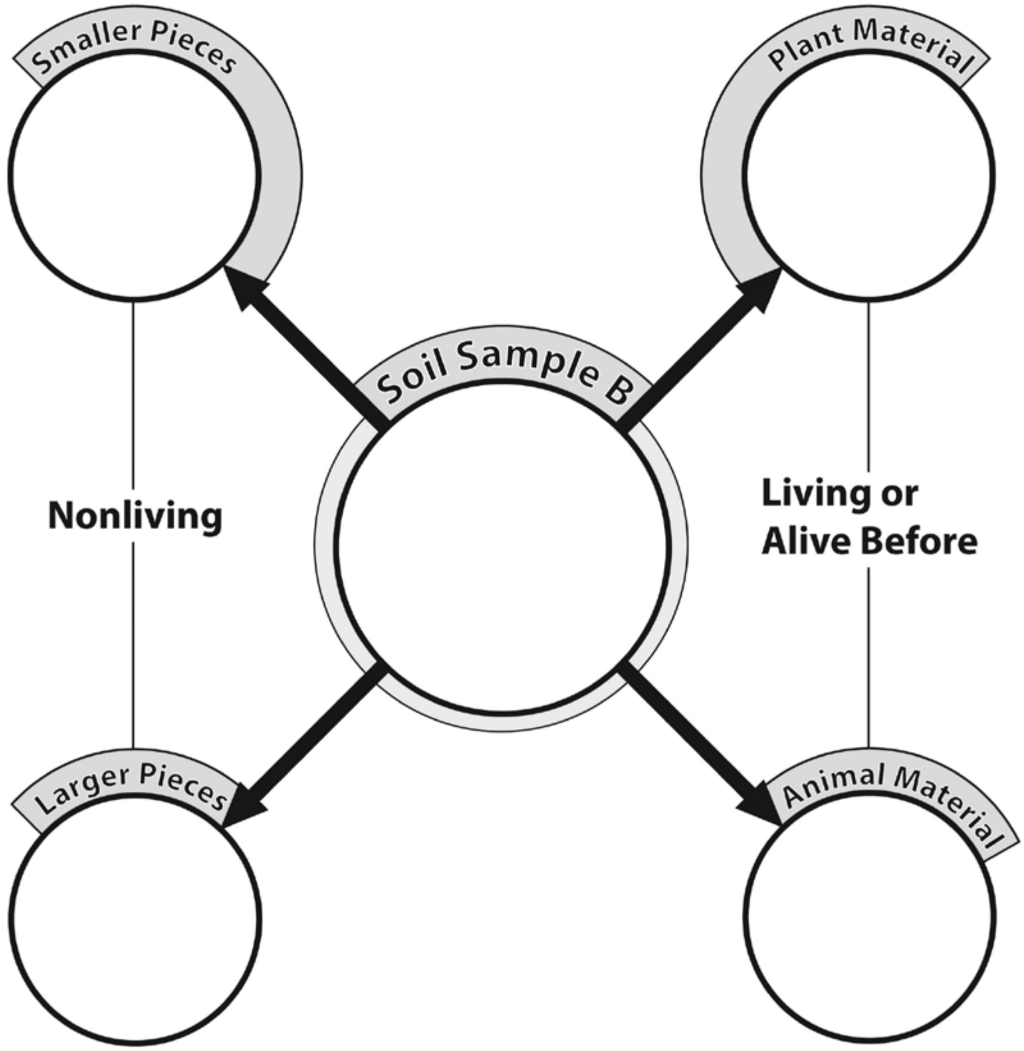
MASTER 2.1A, INVESTIGATION 1:
LOOKING AT SOIL SAMPLES

1. Put one spoonful of soil A the middle circle.
2. Use a hand lens and a pencil to sort the parts of the soil into different piles.



MASTER 2.1B, INVESTIGATION 1:
LOOKING AT SOIL SAMPLES

1. Put one spoonful of soil B the middle circle.
2. Use a hand lens and a pencil to sort the parts of the soil into different piles.



Name ________________________________

MASTER 2.2, INVESTIGATION 1:
DRY SOIL

After you look at Soil A and Soil B, answer these questions.

1. How is the soil sample A like soil sample B?

2. How is sample A different from sample B?

3. Do you think that plants will grow better in sample A or sample B? Why?

Name ____________________

MASTER 2.3, INVESTIGATION 2:
SOIL AND SPACE

1. Get a set of three clear plastic cups containing soil from your teacher.

2. Measure the height of the soil in each cup. Write your measurements (dry soil height) in the chart below. Draw a line on your cup to mark the level of the soil or sand.

3. Slowly pour one small cup of water into each cup of soil. Measure the height of the water level in your chart.

Name ______________________________

MASTER 2.3, INVESTIGATION 2:

SOIL AND SPACE

CUP	SOIL TYPE	SOIL HEIGHT BEFORE ADDING WATER	SOIL HEIGHT AFTER ADDING WATER	WATER LEVEL HEIGHT
1	Plotting soil			
2	Local soil			
3	Sand			

QUESTIONS

1. What did you notice about the water level of the three cups?

2. Why do you think the water levels are different?

Name ______________________________

MASTER 2.4, A

DOES SOIL MATTER?

RESULTS

We planted our seeds on ______________________________.
(Write date here).

We planted ___________________________ seeds.
(Write the type of seeds you planted).

We planted ________ seeds in each cup.
(Write the number of seeds you planted).

Name ______________________________

MASTER 2.4, B

DOES SOIL MATTER?

In which soil will the plants sprout or grow best? In which soil will the plants grow poorly? Write your predictions for how the type of soil will affect the growth of the plants.

DATE:

CUP	SOIL TYPE	NUMBER OF SEEDS SPROUTED	HEIGHT OF PLANTS
1	Plotting soil		
2	Local soil		
3	Sand		

OBSERVATIONS:

Name ____________________

MASTER 2.4,C

DOES SOIL MATTER?

DATE:

CUP NUMBER	NUMBER OF SEEDS SPROUTED	HEIGHT OF PLANTS
1 Plotting soil		
2 Local soil		
3 Sand		

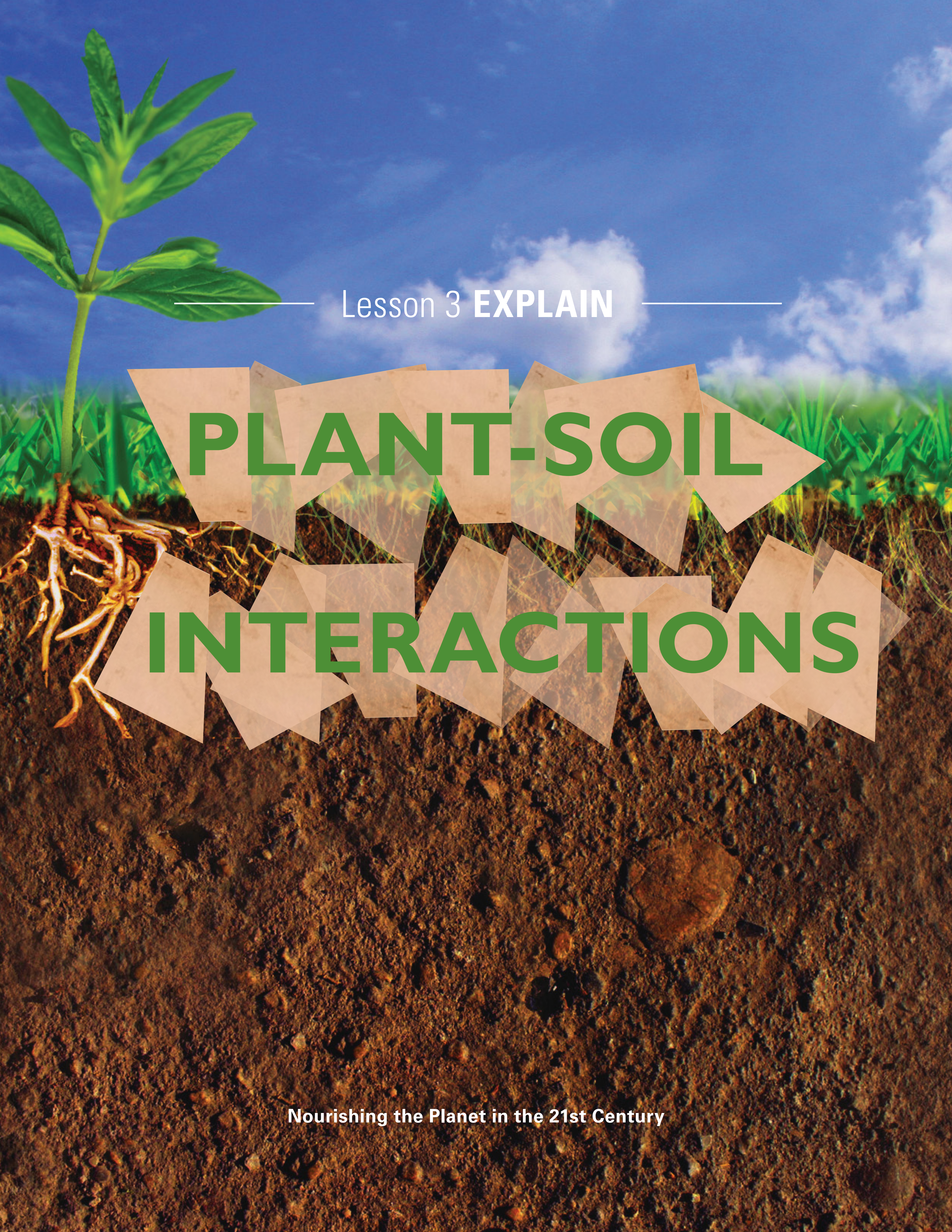
OBSERVATIONS:

DATE:

CUP NUMBER	NUMBER OF SEEDS SPROUTED	HEIGHT OF PLANTS
1 Plotting soil		
2 Local soil		
3 Sand		

OBSERVATIONS:

CONCLUSIONS OF INVESTIGATION:



Lesson 3 **EXPLAIN**

PLANT-SOIL INTERACTIONS

Nourishing the Planet in the 21st Century

At a Glance

OVERVIEW

Students begin the lesson by observing root growth. They then use a hand lens to examine roots of young seedlings. Students consider the function of a plant's roots. A model demonstrates the movement of water into the roots. Finally, students investigate movement of water and nutrients throughout the plant using pieces of celery stalks and food coloring.

MAJOR CONCEPTS

- Plants take in water and nutrients from the soil through the plant's root system.
- Plants transport water from the roots to the rest of the plant.
- The systems in plants that transport water and nutrients throughout the plant have similarities to the human circulatory system.

OBJECTIVES

After completing this lesson, students will be able to:

- Define "nutrient,"
- recognize that plants remove water and nutrients from the soil through their roots, and
- explain how the models in this lesson reflect how a plant's roots and vascular system function.

In Advance

PHOTOCOPIES

ACTIVITY 1: ***How Does a Plant Grow?***	**No photocopies or transparencies**
ACTIVITY 2: ***From Soil to Roots***	**No photocopies or transparencies**
ACTIVITY 3: ***From Roots to the Plant***	**Master 3.1** ***Getting Water and Nutrients to the Plant*** (Make 1 copy for each student.)

In Advance

MATERIALS

ACTIVITY 1: ***How Does a Plant Grow?*** ***(Optional Activity)*** ***(5-7 days before students do Activity 2***	**FOR EACH STUDENT:** • 1 clear plastic cup or glass (approximately 4 inches tall) • 1 paper towel • 2-3 pea seeds **FOR THE CLASS:** • 3-4 permanent markers
ACTIVITY 2: ***From Soil to Roots*** **(Seedling Preparation:** **5 to 6 days in advance**	**FOR A GROUP OF 4 STUDENTS:** • 1 drinking glass • 1 hand lens • 6 pea or pinto bean (or other type) seeds • 1 cup of water • 1 paper towel
ACTIVITY 2: ***From Soil to Roots*** **Demonstration** **(Moving Water and Nutrients into Roots)**	**FOR THE CLASS:** • 1 paper or Styrofoam cup • 1 large container • 1 bottle of food coloring • water (enough to fill the large container) • 1 sharp pencil
ACTIVITY 3: ***From Roots to the Plant*** **(Celery investigation)**	**FOR THE TEACHER:** • Sharp knife **FOR EACH GROUP OF 4 STUDENTS:** • 1 paper or Styrofoam cup • 1 piece of celery stalk (approximately 2 inches) • 1 bottle of food coloring

Preparation

ACTIVITY 1:
PEA SEED GROWTH PREPARATION

In Activity 1, students will "plant" pea seeds in a system where they can observe seed germination and the growth of the seedlings. This setup enables students to observe the growth of the young seedling in a way that is not possible for seeds planted in soil. For example, students can see that the root emerges from the seed first and grows downward, and that the stem emerges later, grows upward and is green. In Activity 2, students have the opportunity to make close observations of the roots of a seedling using a hand lens. However, handling the seedlings damages them and they will not continue growing. The two activities compliment each other—in Activity 1, students can easily see continuing growth and in Activity 2, students can observe in close-up detail.

Preparation

EACH STUDENT WILL PREPARE A CUP WITH 2–3 PEA SEEDS. FAMILIARIZE YOURSELF WITH THE FOLLOWING PROCEDURE BEFORE BEGINNING THIS ACTIVITY. TO GROW THE SEEDS,

1. Roll up a paper towel and insert into a clear plastic cup (or glass). A cup that has fairly straight sides (not too much flare at the top) is best. Tri-fold paper towels (the kind in many dispensers) work well for this, but any paper towel can be used. If using paper towels off a roll, fold them in half so they are a bit thicker and stiffer than a single layer and so they don't extend too far up above the rim of the cup.
2. After inserting the rolled-up paper towel into the cup, let it expand so that it lies against the walls of the cup. Use a spray bottle to moisten the paper towel.
3. Students can insert 2 or 3 pea seeds between the paper towel and wall of the cup. The seeds should be placed evenly around the cup. The seeds should be about 1/3 of the way from the bottom of the cup. It may be helpful to use the eraser end of a pencil to push the seeds down to the correct position. The moistened paper towel will hold the seeds in place.
4. After the seeds are in place, add water to the cup. The seeds should not be submerged in water—the paper towel will wick water to keep the seeds moist.
5. You will need to add water periodically so that the paper towel and seeds do not dry out.

Pea seed in cup with wet paper towel

Use your judgment as to the most appropriate way to involve your students in this setup. If you feel that it would take an excessive amount of class time for each student to do all of the set up, you can put the paper towels in the cups and moisten the paper towels ahead of time. Then students can add the seeds themselves.

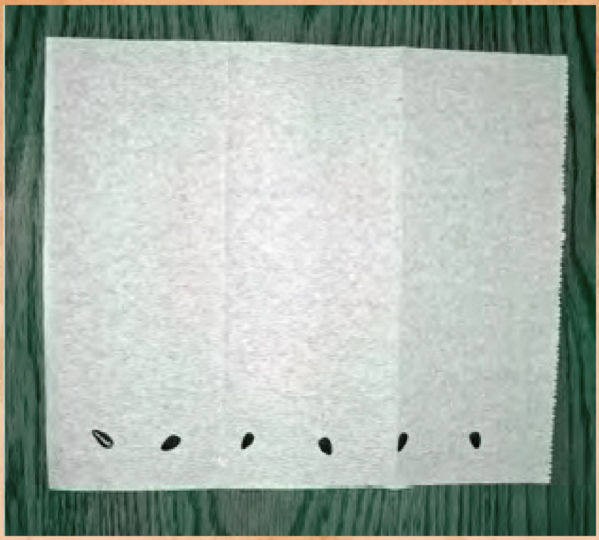
Preparation

ACTIVITY 2:

SEEDLING PREPARATION

In Step 4, students are asked to observe the root systems of young seedlings. For this activity, any type of seeds may be used so long as the roots have grown about 1 or 2 cm. Peas are easy to obtain and work well. Pinto beans are also a good choice. To germinate the seeds, place several seeds in a row along one side of a paper towel as shown in the photos that follow. Carefully roll up the paper towel from the bottom to top. Place the rolled paper towel into a glass of water so that the seeds are at the top and out of the water glass. Water will wick up through the paper towel and keep the seeds moist. Prepare enough seedlings so that each group of four students will have a seed to observe. Assume that just half of the seeds you prepare will germinate. Set the glasses of seedlings in a location where they will not be disturbed. The seeds will need approximately four to six days for the roots to grow enough for observation. During the germination period, be careful to replace any water that is lost through evaporation.

Preparation



a. Seeds are rolled up in a paper towel.

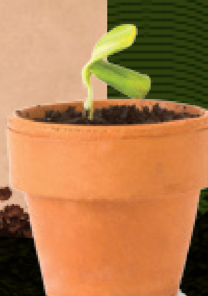
b. Seeds are placed into a glass of water.

Preparation

ACTIVITY 3:
CELERY INVESTIGATION

Use a sharp knife to cut celery stalks into pieces approximately two inches long. Make sure that the cut surfaces are flat and will allow the celery to rest upright when placed into the paper cups. Pour food coloring into the cups to minimize the amount of food coloring that students have to handle.

***NOTE TO TEACHERS:** The celery demonstration described in this section is designed to show how water is transported quickly. For a more impressive demonstration, you can have carnations take up colored water and see the edges of the petals take on the color of the dye. While more dramatic than the celery demonstration, it takes much longer to see the effect; about two to three hours, as compared with 15 to 20 minutes for the celery demonstration.*

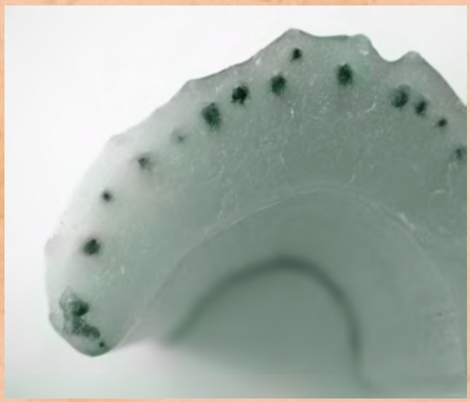


Preparation

OPTIONAL EXTENSION ACTIVITY:

CARNATION DEMONSTRATION

1. Obtain a white carnation and cut the stem diagonally so that the stem is about 6 inches long.
2. Add about 2 inches of water to a paper cup.
3. Add 6 drops of food coloring (blue works well) to the water and mix.
4. Place the carnation into the colored water.
5. Within 2 hours, small colored areas will appear at the edges of the petals.



a. Demonstration with celery

b. Demonstration with carnation

Procedure

ACTIVITY 1:
HOW DOES A PLANT GROW?

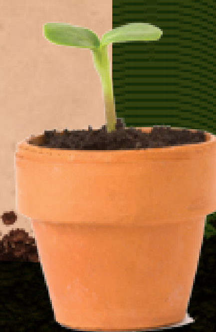
1. Inform students that they will be looking at the growth of pea seeds over the next few days and that their task for the day is to begin this investigation. Explain that they will be letting pea seeds germinate in a way that they will be able to see the growth of the plants. Demonstrate how the students will set up their pea seeds in a cup with a paper towel and water.

   See preparation for details about setting this up. This step will need to be done several days before students do Activity 2. Make sure students write their names near the top of the cup using a permanent marker.

2. For the next few days, allow a few minutes for students to observe their pea seeds.

   Although students cannot handle the roots of their pea plants growing in the cups with water, this method will enable them to visualize the early growth of the root, stem, and then leaves from the pea seed. (If students try to remove the young pea plants from the cup/paper towel setup, the plants will be damaged and they won't be able to see further growth of the plant.)

   Students will be able to compare their observations from this activity to their observations in Activity 2.



Procedure

3. After students begin to observe changes or growth in their seeds, ask students to share their observations. Record observations on the board or chart paper. Continue to add to this list for a few days.

Students can make a variety of observations over time. They may notice that the seed seems to swell or get larger after being in the cup. Then they may observe something sprouting from the seed. The first thing they see will be the root, which grows downward. After a few days, they will see branching of the root system. The stem grows from the seed next. Unlike the root, students will see green color and observe that the stem grows upward. Students will also see small leaves as the stem continues to grow.

3 days

5 days

7 days

Watching peas germinate and grow in a cup with water.

Procedure

ACTIVITY 2:
FROM SOIL TO ROOTS

1. Remind students that in the previous lesson they learned that air spaces in soil become filled with water. Ask, "Why do the plants need water in the soil?" Follow this with the question, "Are there any other things in the water that the plant can take in too?"

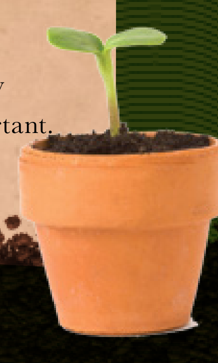
   Students' responses will vary. It is likely that students will suggest that plants need the water to grow. If necessary, guide the discussion to mention the plant's root system. The second question may be more challenging for students.

2. Introduce the word "nutrients" to students. Nutrients are substances that plants and animals need to be healthy.

   Nutrients are not things that can be seen, but are important for health. Students may be familiar with nutrients such as vitamins and minerals in the food they eat or drink. Students cannot see the nutrients in their food or drink but are likely to acknowledge that these substances are important for keeping them healthy. Plants need nutrients as well. The nutrients that plants need are released from soil particles into soil water. Plants need many of the same nutrients that animals do, but some of the needs of plants are different than the needs of animals. Also, the amount of different nutrients that plants need is different than the amounts that animals need.

3. Continue the discussion by asking students how plants get their nutrients. What parts of the plant are important for getting nutrients from the soil?

   This discussion is intended to help students begin thinking about how nutrients in soil actually get into plants. At this point, don't go into detail, but simply acknowledge that roots are important. The remainder of this lesson will help students learn more about how this happens.

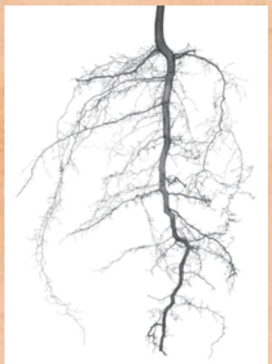


Procedure

4. Explain that students will examine the roots of a plant. Divide the students into groups of four. Pass out to each group a young seedling (taken from the paper towel germination) and a hand lens. Tell students that they should look at the roots of the seedling first using just their eyes and then using the hand lens. Ask students to draw a picture of the roots of their seedling.

Allow time for students to observe the roots of the seedling. As students work, encourage students to take turns using the hand lens and to share what they observe with their team members.

When students look at the roots with just their eyes, they may see just a basic root structure. When they use the hand lens, they are likely to notice small, fine projections coming off the roots. These are the root hairs. The root hairs are white and very fine. It may be easier to see the root hairs if students put a dark background behind the roots.



The use of the hand lens is a way for students to observe things that they cannot see with their eyes alone. If students have difficulty observing root hairs on the roots, don't spend a great deal of time on this. They will notice other important things about roots, including the fairly large number of branches to the roots.

CONTENT STANDARD A, LIFE SCIENCE: Employ simple equipment and tools to gather data and extend the senses.

Procedure

5. After the students have drawn pictures to represent their observations, ask for volunteers to describe what they saw. Students can also compare their observations of these seedlings with the ones they are growing in water in their cups (if they did Activity 1).

   Students will report seeing one large root emerging from the seed. They also will describe fine white hairs growing out from the root. If time permits, post the students' drawings around the room and allow time for students to look at the drawings of other students.

6. Ask students, "Why do you think that plants have so many root branches and root hairs?"

   Student responses will vary. Guide the discussion to bring out that more root hairs mean more area with which to contact water and nutrients in the soil.

   CONTENT STANDARD C, LIFE SCIENCE: Each plant or animal has different structures that serve different functions in growth, survival, and reproduction.

7. Ask students, "How do nutrients in the soil water get into the root hairs?"

   Students' responses will vary. At this time, accept all answers.

Procedure

8. Explain that students will now watch a demonstration to investigate the process by which water enters the roots. As you do the steps listed below, have students gather around so they can see what you are doing and what is happening in the investigation.

STEP 1. Fill the cup about half full of water.

STEP 2. Place the cup of water into the center of the larger container.

STEP 3. Fill the larger container with water until its level is the same as that in the cup.

STEP 4. Add several drops of food coloring to the water in the larger container and gently mix the water until the color is evenly distributed through the water. Do not add food coloring to the water in the cup!

STEP 5. Using a sharp pencil, poke two small holes in the cup opposite each other.

STEP 6. Watch the water in the cup for up to five minutes.

As you lead the demonstration, explain that

- the cup represents the root,
- the water inside the cup represents water inside the root,
- the water in larger container represents the water in the soil, and
- the food coloring represents the nutrients dissolved in the water.

Procedure

9. After students have watched the demonstration, reconvene the class. Ask students to state their observations from the demonstration.

   Students will report that the colored water slowly entered the cup.

10. Ask students to suggest ideas about how what they saw in the demonstration may be like what happens in the roots of plants.

    The demonstration is a model of how water and nutrients move from outside of the root to the inside of the root.

11. Conclude the activity by asking students the following questions. Ask students to indicate by a show of hands whether they agree or disagree with each statement. Ask for volunteers to explain why they think the statements are correct or incorrect.

Procedure

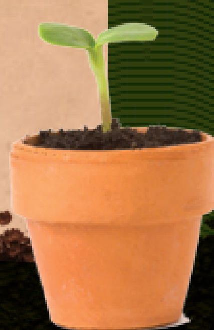
1. PLANTS TAKE IN WATER THROUGH THEIR ROOTS. (TRUE)

Students should use the results of the demonstration to help them answer this question. In the demonstration, students saw water (and food coloring representing the nutrients) move from the larger pan into the cup. Roots and root hairs are important for the uptake of water into the plant. A larger root system contacts and absorbs more water than a smaller one.

2. PLANTS TAKE NUTRIENTS IN THROUGH THEIR ROOTS. (TRUE)

Water enters the root system and takes dissolved nutrients with it. In the demonstration, food coloring representing nutrients was dispersed in the water in the outer pan. After holes were poked into the cup, the food coloring (nutrients) and water moved into the cup (representing movement into the plant).

NOTE TO TEACHERS: ***A common misconception that students may hold is that roots grow specifically in a direction toward water and that they grow until they find water. Roots do not "decide" which direction to grow. Roots can only grow where water is already present. As the surface of the soil dries out, roots near the surface may die while roots further down are in contact with water and can grow still deeper.***



Procedure

ACTIVITY 3:
FROM ROOTS TO THE PLANT

1. Explain that getting nutrients into the plant roots is an important first step. Ask students, “Do other parts of the plant need water and nutrients?” followed by “How do the water and nutrients get from the roots to the rest of the plant?”

   Students are likely to think that the rest of the plants need water and nutrients but may not have any firm ideas about how that might happen.

2. Explain that students are going to investigate how water moves from the roots to the rest of the plant. Ask students to again work in their groups of four.

3. Pass out to each student one copy of Master 3.1, *Getting Water and Nutrients to the Plant.* Read through the instructions for the investigation with the students to ensure that they understand their task.

   Allow time for students to ask questions about the procedure they will follow. After reviewing the instructions, and before having students begin the hands-on part of the experiment, ask students to write their predictions about what will happen with the food coloring, water, and celery.

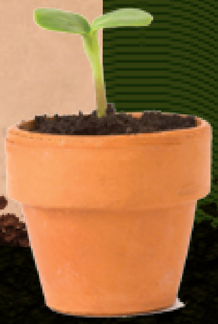
Procedure

4. As teams work on their investigation, circulate among teams to answer questions and help them with timing the investigation.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Plan and conduct a simple investigation.

5. Reconvene the class and ask for volunteers to report their predictions and results about the movement of the food coloring in the celery. Ask them if their predictions were correct or incorrect. Ask them what conclusions they can make about the movement of water and nutrients in plants.

Students' predictions will vary. They should report that the food coloring was transported up the celery stalk and was visible as a series of colored dots along the top of the stalk.



Procedure

6. Conclude the lesson by asking students if they can think of a part of their own bodies that moves nutrients or other substances from one place to another. Can they think of ways that the movement of water and nutrients from the roots to other parts of plants is either similar to or different from what they know about the function of blood in the human body?

Depending on what students have learned about their bodies, they may see some similarities between the movement of water and nutrients in plants and the blood in their own bodies. Students are likely to have some knowledge of blood taking oxygen from the air to their lungs and then other parts of their bodies and also taking carbon dioxide (waste products) away from their cells. Students may also recognize that plants, unlike humans and other animals, do not have pumps (hearts) that pump the blood from one part of the body to another.

If students do not have this background knowledge, you may choose to omit this step. However, if students have some understanding of the circulatory system, this may help them recognize that living systems of various kinds need to have a way to get nutrients and water to all parts of their bodies.

Procedure

LESSON 3: ORGANIZER

Activity 1: *How Does a Plant Grow? (Optional)*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Inform students that they will be looking at the growth of pea seeds over the next few days. Demonstrate how students will set up their seeds in clear containers.	Step 1 **PAGE 106**
Over the next few days, allow a few minutes for students to observe their seeds. Ask students to share their observations with the class.	Step 2 **PAGE 106** Step 3 **PAGE 107**

Procedure

LESSON 3: ORGANIZER

Activity 2: *From Soil to Roots*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Remind students that air spaces in soil become filled with water (Lesson 2). Ask, "Why do the plants need water in the soil?" and then, "Are there other things in the water that plants can take in also?"	Step 1 **PAGE 108**
Introduce the word "nutrients" to students. Explain that nutrients are substances that plants and animals need to be healthy.	Step 2 **PAGE 108**
Continue the discussion by asking students • How do plants get their nutrients? • What parts of the plant are important for getting nutrients from the soil?	Step 3 **PAGE 108**
Explain how students will examine plant roots. Ask students to work in teams of 4. Give each team a young seedling and a hand lens. Have students draw a picture of the roots.	Step 4 **PAGE 109**
Ask for volunteers to share what they saw. Encourage students to compare their observations using the hand lenses to what they could see with just their eyes. (They can also compare with what they saw in the plants in Activity 1).	Step 5 **PAGE 110**

Procedure

LESSON 3: ORGANIZER

Activity 2: *From Soil to Roots*

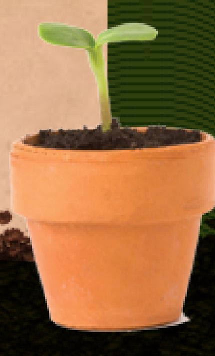
WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Ask students to consider why plants have so many root branches and root hairs. Follow that by asking, "How do nutrients in the soil water get into the roots?"	Step 6 **PAGE 110** Step 7 **PAGE 110**
Conduct the demonstration using the pan of water, a cup, and food coloring. Discuss what the students observed during the demonstration. Then ask students to suggest ideas for how the demonstration may be like what happens in the roots of plants.	Step 8 **PAGE 111** Step 9 **PAGE 112** Step 10 **PAGE 112**
Conclude the activity by reading the following statements • Plants take in water through their roots. • Plants take nutrients in through their roots. For each statement, ask students to indicate by show of hands whether they agree or disagree with the statement. Ask for volunteers to explain why they think the statement is correct or incorrect. Encourage students to refer back to the demonstration for their explanations.	Step 11 **PAGE 112**

Procedure

LESSON 3: ORGANIZER

Activity 3: *From Roots to the Plants*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Inform students that getting nutrients into the plant's roots is an important first step. Ask • Do other parts of the plant need water and nutrients? • How do the water and nutrients get from the roots to the rest of the plant?	Step 1 **PAGE 114**
Explain that students will do an investigation to find out more about how water moves to other parts of the plant. Have students work in groups of 4.	Step 2 **PAGE 114**
Give each student 1 copy of Master 3.1, *Getting Water and Nutrients to the Plant.* Read through the instructions and allow students to ask questions about the procedure.	Step 3 **PAGE 114**
As students work through the investigation, circulate among teams to answer questions and monitor progress.	Step 4 **PAGE 115**
Ask for volunteers to report their predictions and their results for the investigation. Ask students to share their conclusions.	Step 5 **PAGE 115**
Conclude the activity by asking students if they can think of a part of their own body that moves nutrients from one place to another. Can they think of ways that the movement of water and nutrients from the roots to other parts of plants is either similar to or different from what happens with blood in their own bodies?	Step 6 **PAGE 116**



Name ______________________________

MASTER 3.1

GETTING WATER AND NUTRIENTS TO THE PLANT

PROCEDURE

1. Choose one student in the team to get a cup of food coloring and a piece of celery from the supply table.

2. What do you think will happen to the celery and the food coloring when you put the celery in the cup?
   Write your prediction.

3. Put the piece of celery into the cup so that one end of the celery is sitting in the food coloring. Start timing when you put the celery in the cup.

   Write the time that you put the celery in the food coloring.

   ____

Name ___________________________________

MASTER 3.1

GETTING WATER AND NUTRIENTS TO THE PLANT

4. Leave the celery in the cup for 5 to 10 minutes. Do not move the cup or the celery during this time. Write your observations below.

   Write your observations after the celery has been in the food coloring for 5 minutes.

   Write your observations after the celery has been in the food coloring for 10 minutes. Draw a picture of what you see.

Lesson 4 **ELABORATE**

PLANT GROWTH AFFECTS THE SOIL

At a Glance

OVERVIEW

In Lesson 3, students learned that nutrients are things that plants need to be healthy. Now, they investigate how plant growth affects one part of the environment, the soil. Students then consider how plant growth may be affected if there are not enough nutrients in the soil and how nutrients can be added to the soil with the use of fertilizers. Students continue the gardening theme of the unit by analyzing information on seed packets to learn more about the needs that different plants have for growth.

MAJOR CONCEPTS

- Plants remove nutrients from the soil and people remove plants.
- Fertilizers replace nutrients removed from the soil by plants and people.
- Different kinds of plants need different environmental conditions for optimal growth.

OBJECTIVES

After completing this lesson, students will be able to:

- Describe how nutrient levels in the soil change after plants grow in the soil;
- Appreciate how fertilizers can replace nutrients in the soil;
- Predict how plant growth is affected by a lack of nutrients; and
- Analyze information about conditions for best seed germination and plant growth.

In Advance

PHOTOCOPIES

ACTIVITY 1: ***Plants, Soil Nutrients, and Fertilizer***	**Master 4.1** ***How Do Plants Affect the Soil?—An Example*** (Prepare an overhead transparency) **Master 4.2** ***How Do Plants Affect the Soil?*** (See *Preparation*) **Master 4.3** ***Nutrients and Plant Health*** (Prepare an overhead transparency)
ACTIVITY 2: ***What Should I Grow in My Garden?***	**Master 4.4** ***Analyzing Seed Packet Information*** (Prepare 1–2 photocopies; See *Preparation*.)

MATERIALS

ACTIVITY 1: ***Plants, Soil Nutrients, and Fertilizer***	• No materials required other than photocopies and transparency
ACTIVITY 2: ***What Should I Grow in My Garden?***	• No materials required other than photocopies

Preparation

ACTIVITY 1:
PLANTS, SOIL NUTRIENTS, AND FERTILIZER

During Activity 1, students will be analyzing information about how plant growth changes the amount of nutrients in soil. Master 4.2, *How Do Plants Affect the Soil?*, includes data for 14 different crops. Most likely, you will not need all parts of this master. The procedure asks for a pair of students to work together to analyze one crop (vegetable). Partners could choose which vegetable they want to analyze. Another option given in the activity is for teams to analyze more than one example so they can compare different plants. If you choose this option, you may need more than one copy of some of the masters.

Preparation

ACTIVITY 2:

WHAT SHOULD I GROW IN MY GARDEN?

For this activity students will look at the information that is provided on seed packages. Master 4.4, *Analyzing Seed Packet Information,* includes mock-ups of information taken from seed packets for some commonly grown garden vegetables and fruits. Each pair of students will look at information for one kind of seed. Prepare 1–2 photocopies (depending on your class size) and cut them apart at the dotted line.

The information on Master 4.4 is simpler than what appears on many seed packets. In addition, the information for each seed "packet" is standardized so that the same type of information is provided for each plant. If you wish and if you feel that it is appropriate for your students, you could have students analyze information from real seed packets instead of using the master.

Preparation

OPTIONAL EXTENSION ACTIVITY:

FERTILIZER—HOW MUCH?

Check your school's procedures and safety policy before bringing fertilizer into the classroom. Some schools may not allow the use of chemicals. If you do plan to use the fertilizer, develop a plan for safe storage and use of the fertilizer. Make sure it is in a well-marked container and kept out of reach of students. Inform students about safe use and handling of the fertilizer.

Procedure

ACTIVITY 1:
PLANTS, SOIL NUTRIENTS, AND FERTILIZER

1. Remind students of the word nutrients (introduced briefly in Lesson 3). Ask students if they remember what it means. If necessary, explain that nutrients are things that organisms need to be healthy.

2. Write the terms “Vitamin C” and “Calcium” on the board. Ask students what they know about these things. After students express their ideas, summarize the idea that vitamin C and calcium are types of nutrients that people need to be healthy and we get these nutrients in the food and drink that we consume.

This comparison with humans should help students recognize that there are things (nutrients) in the food we eat that we can’t see but are needed for health. Students may be able to give examples of the foods that contain these nutrients. For example, they may be familiar with oranges being a good source of vitamin C and milk being a good source for calcium and vitamin D. (If this is confusing to students, you might want to help them understand that the food contains the nutrients, but nutrients are not the same thing as food (food is important for providing energy). In later steps, students will be learning about nutrients in soil that they can’t see but are needed for plant health.

Procedure

***NOTE TO TEACHERS:** In Step 2, you have an opportunity to gauge students' understanding that there are important things that are too small to see with our eyes alone and that organisms need certain things in order to live and be healthy. The difficulty with this analogy is that a common misconception is that plants "feed" (gain energy) off of nutrients in the soil. Plants use photosynthesis to create the sugars (energy) they need for plant growth and cell function. They take in nutrients from the soil to fulfill other functions. This is not completely analogous to how humans and animals eat food to get energy and to obtain nutrients.*

3. Write the following words on the board or chart paper: nitrogen, phosphorus, and potassium. Help students pronounce the words. Explain that students will be investigating these nutrients as they work through the rest of this activity.

It isn't necessary at this point for students to have a deep understanding of these specific nutrients. Mainly, they need an introduction to substances as necessary nutrients for plants in preparation for the following steps of the activity. Remind students that they can't see these nutrients in the soil, just like they can't see vitamins in the food they eat.

Procedure

4. Display a transparency of Master 4.1, *How Do Plants Affect the Soil?*—An Example. Read through the information on the master with the class and use this as an example to teach students how to analyze this data.

After working through this example, teams of students will analyze similar information on other plants. The horizontal line marked "starting amount" represents the level of the nutrient **before** plants were grown in the soil. The bars indicate whether the amount of a nutrient in the soil either increased (more in the soil) or decreased (less in the soil) after the plants grew. If there isn't a bar visible on the graph for a particular nutrient, the level in the soil didn't change. (These numbers represent 50 pounds of crop harvest from an acre of soil.) Remember, the graph shows the change in the amount of these three nutrients after plants have grown in the soil compared with the amount before the plants grew. The graph does not show the specific amount of the nutrients in the soil.

Sample answers for the asparagus example on Master 4.1

There was ____**LESS**____ nitrogen in the soil after the plants grew.

There was ____**LESS**____ phosphorus in the soil after the plants grew.

There was ____**THE SAME AMOUNT OF**___ potassium in the soil after the plants grew.

Make sure students recognize that the example is from a specific type of plant or vegetable crop. Students do not need to be concerned with the specific numbers. Rather, the important thing for them to see is that there was less of a nutrient in the soil after the crop grew than there was before. Students also will observe that the amount of each nutrient removed from the soil was different.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Use data to construct a reasonable explanation.

Procedure

NOTE TO TEACHERS: ***Constructing and interpreting information from graphs is a skill that students need to practice. The graphs in this activity are likely to challenge your students. During the field test, working through the example (Master 4.1) helped students understand the big idea from the graph (and the subsequent graphs that they will look at). However, if you think your students would benefit from a visual example to learn how to interpret a graph such as this, you can use the following model with your students before working with the graph on Master 4.1.***

a. Draw a template for a bar graph on the board that is similar to the one below with the starting number of paper clips in the middle of the y-axis.

b. Hold up a cup containing approximately 25 paper clips (the exact number is not important and this model is more similar to the data analysis of the crop plants if they do not how many clips are in the cup).

c. Point out to students that the line labeled "starting amount" represents the amount of paper clips currently in the cup.

d. While students are watching, add 3 more paper clips to the cup. Ask students how the number of paper clips in the cup changed. Students should respond that the number of paper clips increased (changed) by 3. You can explain that you are not asking for the total number of paper clips in the cup—just the number that it changed by.

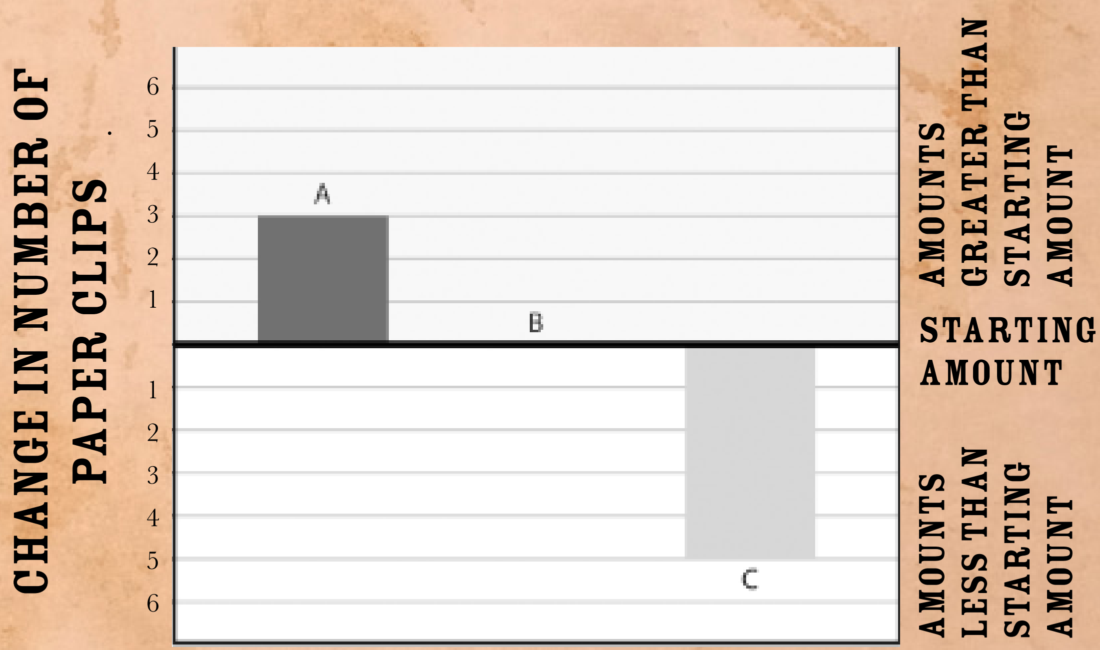
e. Draw a bar on the graph to represent the change (see A on the graph below).

f. Remove the 3 paper clips that you added out of the cup. Help students recognize that the number of paper clips in the cup is the same as when you started. There would not be a bar visible on the graph (B on graph) at this point because the number in the cup matches the starting number.

Procedure

g. Now remove 5 paper clips from the cup and ask students how the number of paper clips in the cup has changed. Students should recognize that the number of paper clips has changed by 5 and there are now five fewer paper clips in the cup compared with the starting number. You can draw a bar on the graph to represent this change. (See C on the graph.)

h. Continue the demonstration and adding bars to the graph if helpful for your students.



Procedure

5. Ask students to work with a partner. Give each pair of students one of the data sets on Master 4.2, *How Do Plants Affect the Soil?* Explain that they will look at data to see if there are differences in soil after plants grow.

As students work, circulate among teams to assess their progress, answer questions, or help teams that are struggling.

The basic format for each graph in Master 4.2 is similar. However, some of the y-axes have a different scale because of the data for the particular vegetable (an extreme example is the y-axis for the graph for peanuts). You might want to point out the scale as students are reporting their results. Including the larger values may make comparing the graphs slightly more challenging for students, but it is also an opportunity to point out things they should look at on graphs and to see how there are differences in plants and their effects on soil.

NOTE TO TEACHERS: ***If you feel that your students are ready for this, ask each student to analyze one graph and then share their findings with their partner. In that way, each pair of students can compare results for two different vegetables.***

Procedure

6. After students have had a chance to analyze their data, hold a class discussion to summarize the data. Ask teams to report which vegetable they analyzed and what conclusions they made from the data.

The main conclusion for students to draw from the data is that nutrients (nitrogen, phosphorus, and potassium) are removed from the soil when plants are grown. There is less of the nutrient in the soil after plants have grown than there was before (or no change for some nutrients). There are no examples given in which the nutrient level is higher after plants grow. There are differences among the plants in the amounts of the different nutrients removed, but this is less important for students to know than simply that nutrients are removed from the soil.

CONTENT STANDARD A, SCIENCE AS INQUIRY: Communicate investigations and explanations.

Procedure

7. After students conclude that the soil has fewer nutrients in it after plants grow, ask them to consider the following questions:
   - o What happened to the nutrients that were removed from the soil?
   - o Where do these nutrients go when the plants are harvested and taken away from the soil?
   - o If there are fewer nutrients in the soil after plants grow, and the nutrients are taken away with the harvest, what do you predict will happen the next year when someone plants a new crop in that soil. Remember that plants need nutrients to grow and be healthy.

It is important that students understand that the soil contains less nutrients after plants grow because the plants took them up through their roots. (This is an opportunity to remind students of the demonstration with the cup, water, and food coloring in Lesson 3 in which students learned that water and nutrients enter plants through the roots.)

Taking nutrients out of the soil would lead to lower levels of nutrients in the soil. If the plants were allowed to decay in the same place, the nutrients they removed would be returned to the soil. However, when crop plants are taken away, the nutrients they removed from the soil are also taken away and the nutrients do not return to the soil. If the soil doesn't have enough of the required nutrients, then plants would not grow as well and would not be very healthy. Even though the amount of nutrients removed from the soil seems very small, if plants are grown year after year, the soil can become depleted.

CONTENT STANDARD C, LIFE SCIENCE: All organisms cause changes in the environment where they live.

Procedure

8. Display a transparency of Master 4.3, *Nutrients and Plant Health.* Ask for volunteers to read information in the chart aloud to the class. Ask students if they can draw a conclusion about what happens to plants when they don't get enough of a specific nutrient. Ask students if this supports their answers to the question in Step 7.

   The main conclusion for students is that crop plants don't grow well and aren't healthy when they are missing nutrients. Students don't need to know all the specific changes that occur in plants when nutrient levels are low.

9. Continue the discussion by asking students if they think there is anything that can be done to put nutrients back into the soil.

   Accept reasonable answers at this point.

Procedure

10. Explain to students that one of the things that can be done to replace the nutrients that come out of the soils is to use fertilizers. Fertilizers add nutrients back to the soil.

You may want to point out that the main nutrients in most fertilizers are nitrogen, phosphorus, and potassium—the same nutrients that students determined were removed from soil when plants grow. If students are interested, you can even point out that different kinds of fertilizers have different amounts of these different nutrients. For example, someone may choose a fertilizer that is higher in nitrogen and lower in phosphorus compared with a different fertilizer. In addition, fertilizers can either be organic (derived from decomposed, once-living things) or synthetic. In either case, the fertilizers contain similar fundamental elements.

Many students may think that fertilizer is plant "food." This is not a scientifically accurate analogy, even though the term gets used this way in some popular media. A more appropriate analogy would be vitamins that humans take. People may take vitamins to replace nutrients that we don't always get in our food.

TIP FROM THE FIELD TEST: One of the common misconceptions that students had was that fertilizers help keep soil moist. Be aware that your students may hold this misconception. If, upon probing, your students also have this misconception, ask them to explain why they think that this is the function of fertilizer. Help them understand that the purpose of fertilizer is to add nutrients back to the soil. It wasn't clear during the field test what was leading students to this idea, but it could relate to the idea that nutrients are dissolved in water that the plants take up, that some fertilizers are in liquid form, or that the instructions on many fertilizers call for watering the plants after fertilizer is applied.

Procedure

11. Ask students to consider a scenario in which a farmer plants a crop in soil that is low in important nutrients. His plants aren't doing very well so he puts fertilizer on the ground. Ask students to predict what effect this might have on the plants.

    Students should expect that the crop plants would get healthier after the fertilizer is applied to the land. Plants don't distinguish between the nutrients that are natural in the soil and the ones added as fertilizer.

    Soils may be thought of as a "nutrient bank" that holds a limited amount of nutrients. Fertilizers put more "money" in the bank by restoring nutrient balance to farmed soils.

    Students may ask whether you need to worry about using too much fertilizer. In fact, if the amount of a nutrient is too high, plants may not grow too well. For example, if a plant has too much nitrogen, it may not.

12. Explain to students that farmers and gardeners often do soil tests to find out what nutrients are in the soil and what may be lacking. Ask students to think of reasons why a soil test can be helpful.

    A soil test gives the farmer specific information about whether the soil has low levels or high levels of certain nutrients, such as nitrogen, potassium, and phosphorus (and other nutrients). This gives the farmer or gardener information that will help them make decisions about whether they need to use fertilizer, how much fertilizer to use, and even what kind of fertilizer to use. It can also help them make decisions about which crop plants may grow best in their soil.

Procedure

ACTIVITY 2:
WHAT SHOULD I GROW IN MY GARDEN?

1. In Lesson 1, students planted seeds of various types and have been watching them germinate and grow. Ask students to list things that they would need to think about if they wanted to plant a garden outside.

   Accept reasonable answers. If helpful, refer back to the discussion that occurred in Lesson 1 about environment and the things that plants need to be healthy. For plants, the environment would include soil, water, and temperature, among other things.

Procedure

2. Explain that students will now be looking at the information on the packages that seeds come in to find out more about what different plants need to grow well in a garden. Ask students to work with a partner. Give each team one part of Master 4.4, *Analyzing Seed Packet Information.* Hold a class discussion in which students identify categories of information that they can find on the seed packets. Write the categories on the board or chart paper.

Pairs of students will have different information (information about different seeds), but most seed packets have similar types of information. (Depending on the number of students in your class, more than one pair may have the same seed information.) At this point, students don't need to give information specific to their seed type, but rather focus on the type of information you can learn from the packets.

Some categories of information include:

- Name of the seed or plant
- A description of how the vegetable is used (prepared in dishes we eat)
- How deep to plant the seeds
- The type of soil that the plant grows best in
- How far apart to space the seeds when planting
- How far apart the plants should be*
- How long it takes for the seeds to sprout
- How tall the plants get
- How long it takes until the plant is ready for harvest
- The type of weather the plant needs (temperature, sunlight)
- When to plant the seeds

Some seed packets may also give information about whether the plants grow well in containers.

* This may also be referred to as thinning. Usually, seeds are planted closer together than the plants should grow. This accommodates for seeds that do not germinate. On a seed packet, this may be referred to as plant space or thinning space.

Procedure

Much of this information relates to the environment that is optimal for a specific type of seed or plant. This is another opportunity to reinforce understanding of the term environment. If you wrote the word "environment" and its definition on chart paper during Lesson 1, you can point this out to students at this point to reinforce their understanding of the term.

CONTENT STANDARD C, LIFE SCIENCE: Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments and distinct environments support the life of different types of organisms.

3. Now ask teams to find two pieces of information on their handouts that are specific to their seeds. Ask them to share that information with the class in a discussion. Ask students why this information is important if you want to grow these plants in a garden.

For example, students with a lettuce seed packet may say that the seeds sprout in 7 to 14 days and that the plants should be spaced 8 inches apart. Students with a beet seed packet may say that beets grow well in early spring because they like cool soils and that you should plant seeds one inch deep.

Keep this discussion moving and brief. The purpose of this discussion is simply to demonstrate how different seeds and plants have different needs, and knowing this information about the different plants can help make a garden more successful.

Procedure

4. Conclude the activity by asking students if the information on the seed packets makes them think of other things they would need to know if they were going to plant these seeds in a garden. Record their responses on chart paper.

Students will likely give a variety of answers, including, they would need to know how large their garden is (how much space they have), whether it gets full sun, what type of soil is in their garden, what insects live in that area, or when the last frost of the season is in their location.

This is an opportunity to refer back to the list of things in a plant's environment and things that plants need to be healthy that students generated in Lesson 1. Much of the information provided on the seed packets is directly related to the environment in which the plants will grow best.

Save the chart paper with student responses to refer to in Lesson 5.

Procedure

OPTIONAL ACTIVITY:
FERTILIZER—HOW MUCH?

1. Ask students to think about how much fertilizer should be used. Ask students to predict what might happen to plants if a very small amount of fertilizer was used or if a large amount of fertilizer was used.

   Accept reasonable answers. If students understand the idea that fertilizers replace needed nutrients that were removed when a crop is harvested, then they might predict that too little fertilizer would not replace enough nutrients and the plants would still grow poorly. Students may have more difficulty predicting what might result from the use of large amounts of fertilizer.

2. Ask students if they could design an experiment to investigate how the amount of fertilizer used affects plant growth.

   CONTENT STANDARD A, SCIENCE AS INQUIRY: Plan and conduct a simple investigation.

Procedure

The students' ability to design an investigation will rely in part on their previous experiences with this type of task. One basic design is to use different amounts (concentration) of fertilizer. For example, if growing peas, some containers could be treated with fertilizer at the recommended amount (concentration if using a liquid), while other containers would be treated with either a more dilute solution or a more concentrated solution. Another set of containers would not receive any fertilizer as the control for the investigation. The containers that did not receive any fertilizer would serve as the experimental control. Other aspects of the experimental design to consider would be

- Number of containers (plants) to receive each treatment (To be a good experiment, you will need more than one container at each fertilizer concentration.)
- Location for the experiment (The plants/containers need to have the same temperature and amount of light as all of the others in the experiment.)
- Soil and water (The plants should all be growing in the same type of container with the same amount and type of soil, as well as receiving the same amount of water.)

Students will also need to predict the results. An important aspect of experimental design includes having a clear prediction to test (hypothesis). For example, one prediction might be that plants that are fertilized with the recommended amount of fertilizer grow taller than plants that are not fertilized.

NOTE TO TEACHERS: ***If you have fertilizer in your classroom, make sure it is labeled correctly, kept out of students' reach and stored properly. Supervise students' use of the fertilizer. Explain how the fertilizer should be handled.***

3. If time permits, students can work together to conduct this experiment and collect the data.

Procedure

LESSON 4: ORGANIZER

Activity 1: *Plants, Soil Nutrients, and Fertilizer*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Remind students of the word “nutrients” and confirm that they remember the meaning.	Step 1 **PAGE 129**
Write the terms “Vitamin C” and “Calcium” on the board. Ask students what they know about these terms. After students express their ideas, make sure that students recognize that these are the names of two nutrients that humans need and that are found in foods and drinks that we consume.	Step 2 **PAGE 129**
Write the words nitrogen, phosphorus, and potassium on the board or chart paper. Help students pronounce these words. Explain that students will be investigating these nutrients that plants need.	Step 3 **PAGE 130**
Work through the paper clip example and graph if this will help prepare your students for analyzing the graphs in this activity.	**PAGE 130**
Display a transparency of Master 4.1, *How Do Plants Affect the Soil?—An Example*. Read through the information with students and help students understand the information on the graph.	Step 4 **PAGE 131**
Explain that students will work with a partner to analyze information about a different plant. Give each pair one part of Master 4.2, *How Do Plants Affect the Soil?* Allow time for students to complete their analysis.	Step 5 **PAGE 134**

Procedure

LESSON 4: ORGANIZER

Activity 1: *Plants, Soil Nutrients, and Fertilizer*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Ask partners to report their conclusions from the graph analysis. Students should confirm that the amount of nutrients is lower in the soil after plants have grown in the soil.	Step 6 **PAGE 135**
Ask students to consider the following questions: • What happened to the nutrients that were removed from the soil? • Where do these nutrients go when the plants are harvested and taken away from the soil? • If there are fewer nutrients in the soil after plants grow there and these nutrients are needed for plants to grow and be healthy, what do you predict will happen the next year when someone plants a new crop in that soil? Do you think the plants would grow as well? Why?	Step 7 **PAGE 136**
Display a transparency of Master 4.3, *Nutrients and Plant Health.* Ask for volunteers to read information in the chart. Ask students if they draw a conclusion about what happens to plants when they don't get enough of a specific nutrient. Ask students if this conclusion agrees with their answers to the question in Step 7.	Step 8 **PAGE 137**
Ask students if they can think of anything that can be done to put nutrients back into the soil.	Step 9 **PAGE 137**
Explain that people use fertilizers to add nutrients back to the soil.	Step 10 **PAGE 138**
Ask students to consider a scenario in which a farmer plants a crop in soil that is low in important nutrients. His plants aren't doing very well so he puts fertilizer on the ground. Ask students to predict what effect this might have on the plants.	Step 11 **PAGE 139**
Explain that farmers and gardeners often do soil tests to find out if their soil has the right amount of important nutrients. Ask students to think of reasons why a soil test can be helpful.	Step 12 **PAGE 139**

Procedure

LESSON 4: ORGANIZER

Activity 2: *What Should I Grow in My Garden?*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Ask students to list things that they would need to think about if they wanted to plant a garden outside.	Step 1 **PAGE 140**
Explain that students will be looking at information on seed packages to find out more about what different plants need to grow well in a garden. Ask students to work with a partner. Give each team one part of Master 4.4, *Analyzing Seed Packet Information.* After partners have a few minutes to look at the information, hold a class discussion and ask students to identify some categories of information on the seed packets.	Step 2 **PAGE 141**
Now ask teams to find two pieces of information that is specific to their seeds. Why is it important to know this information?	Step 3 **PAGE 142**
Conclude the activity by asking if there are other things that they would also want to know before planting seeds in their garden. Reinforce the idea that the information on the seed packets, as well as any other information they would want to know, relates to providing the best environment for the plants.	Step 4 **PAGE 143**

Procedure

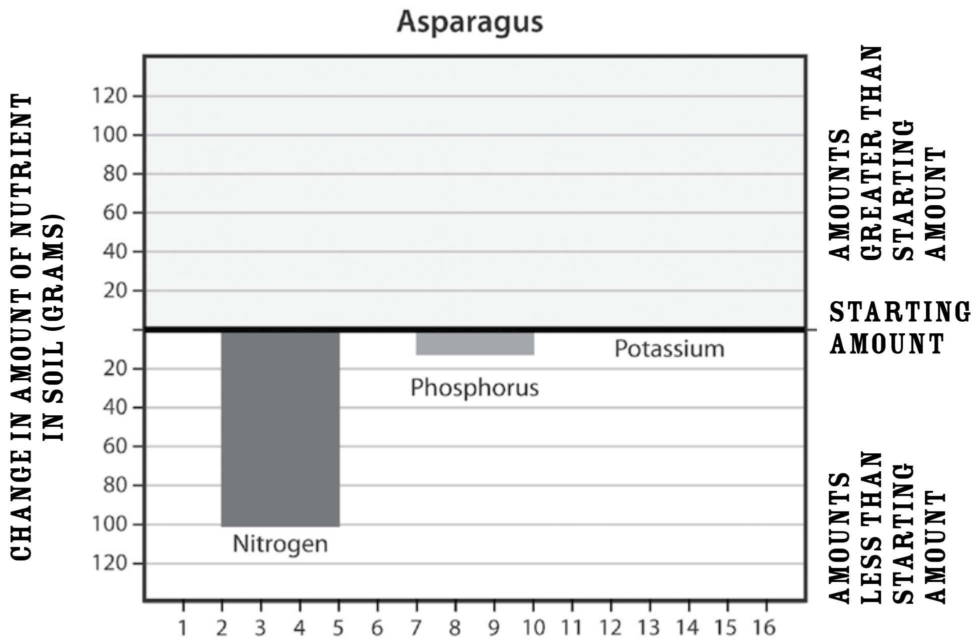
LESSON 4: ORGANIZER

Optional Activity: *Fertilizer—How Much?*

WHAT THE TEACHER DOES	PROCEDURE REFERENCE
Ask students to think about how much fertilizer should be used. Ask students to predict what might happen to plants if a very small amount of fertilizer was used or if a large amount of fertilizer was used.	Step 1 **PAGE 144**
Ask students to design an experiment to investigate how the amount of fertilizer used affects plant growth.	Step 2 **PAGE 144**
If time permits (and if allowable under school safety rules), have students work together to conduct their investigation and collect data.	Step 3 **PAGE 145**

Name ______________________________

MASTER 4.1
HOW DO PLANTS AFFECT THE SOIL?—AN EXAMPLE



The starting amount is the amount of the nutrient in the soil before plants grew there.

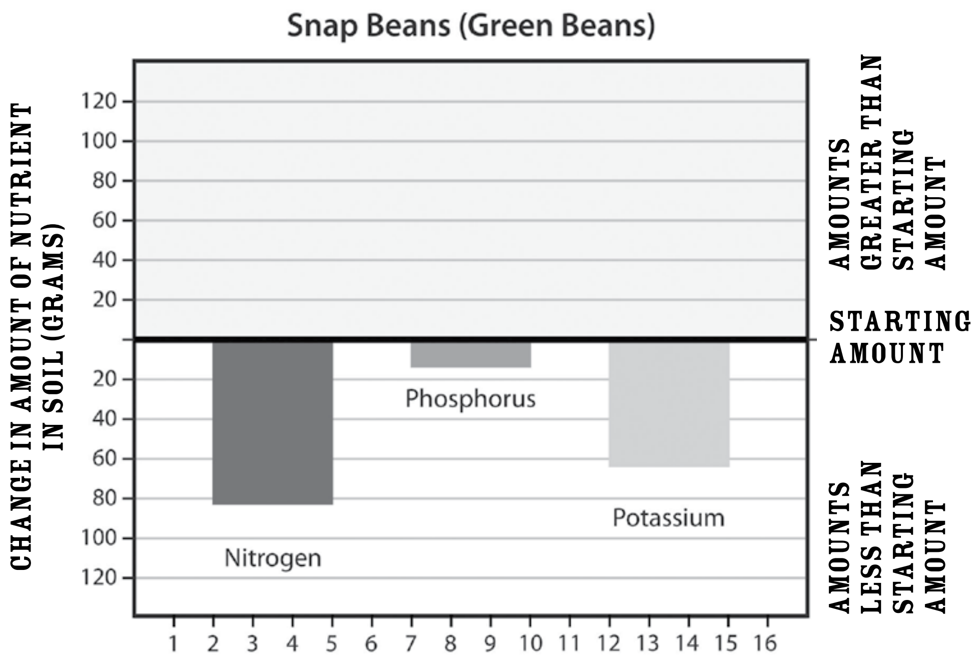
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, A

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

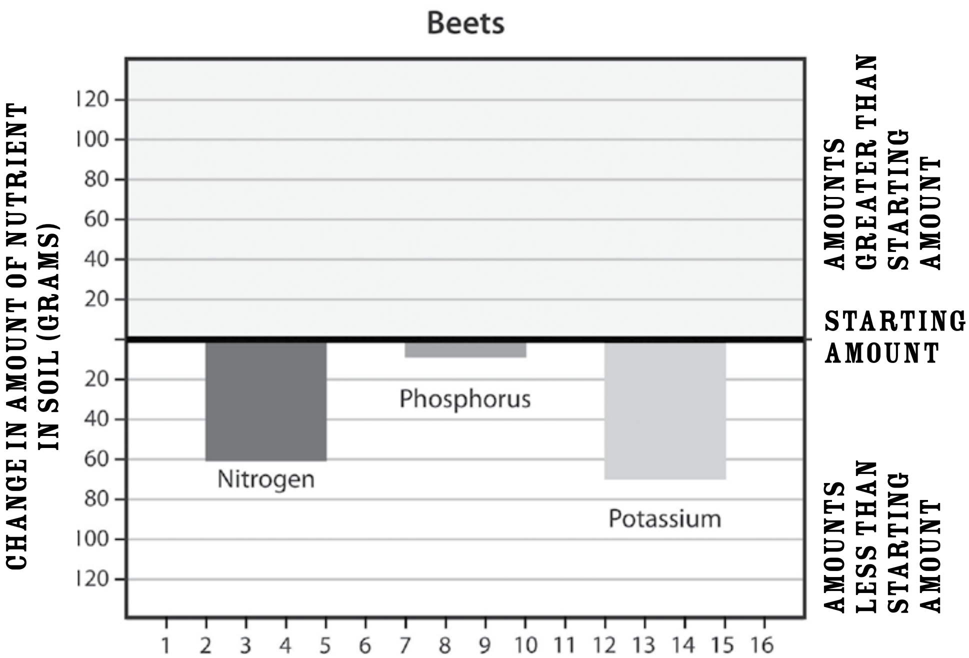
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, B

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

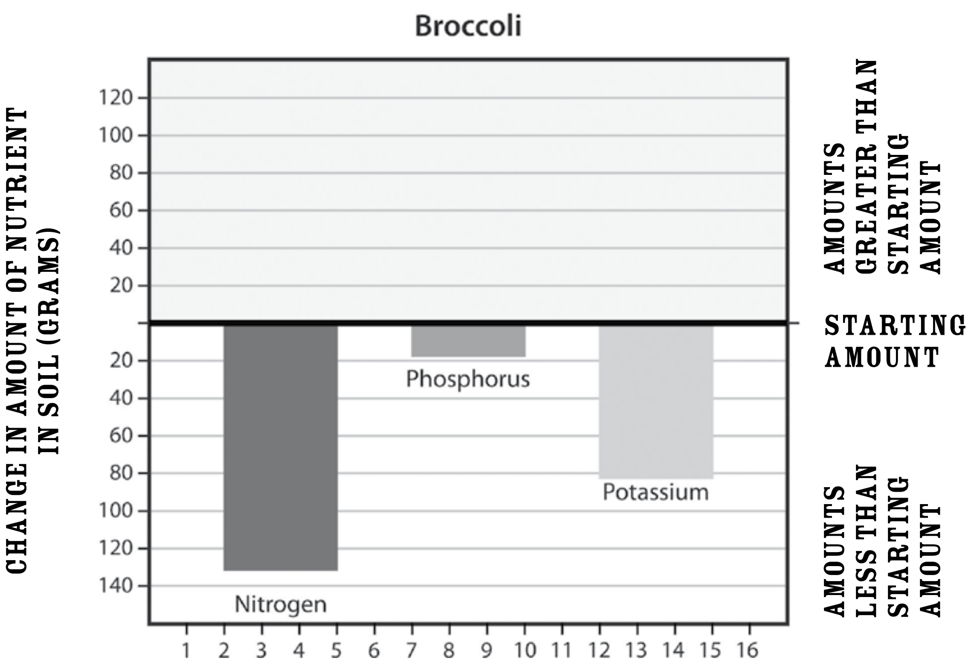
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, C

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

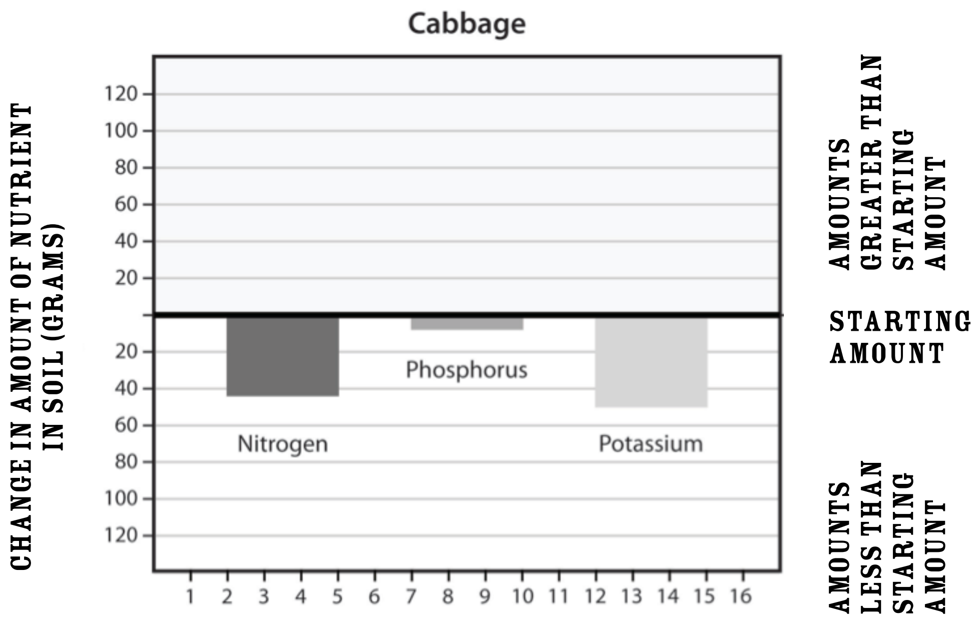
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

{Name ________________________}

MASTER 4.2, D

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

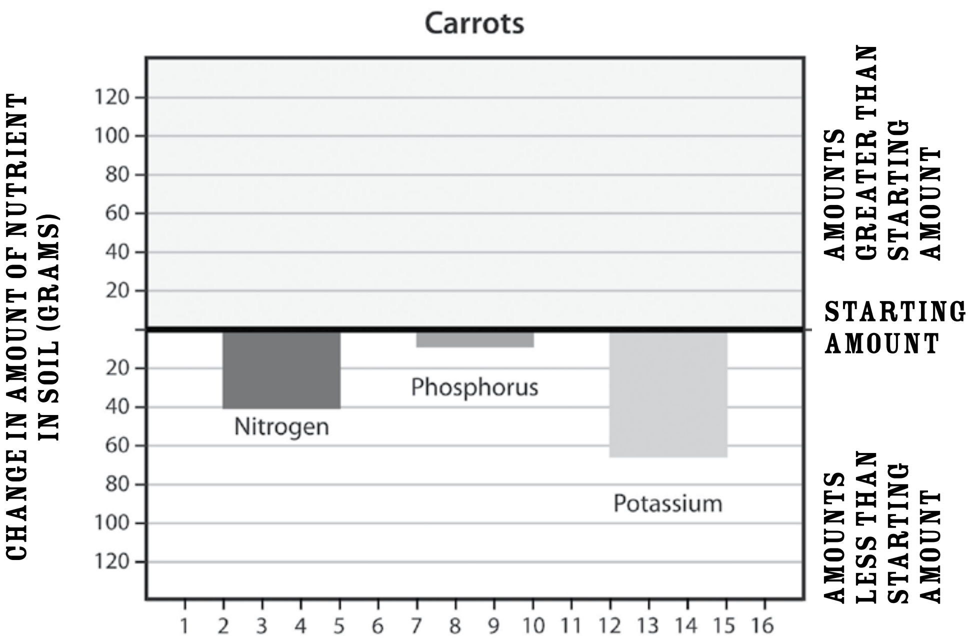
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ____________________

MASTER 4.2, E

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

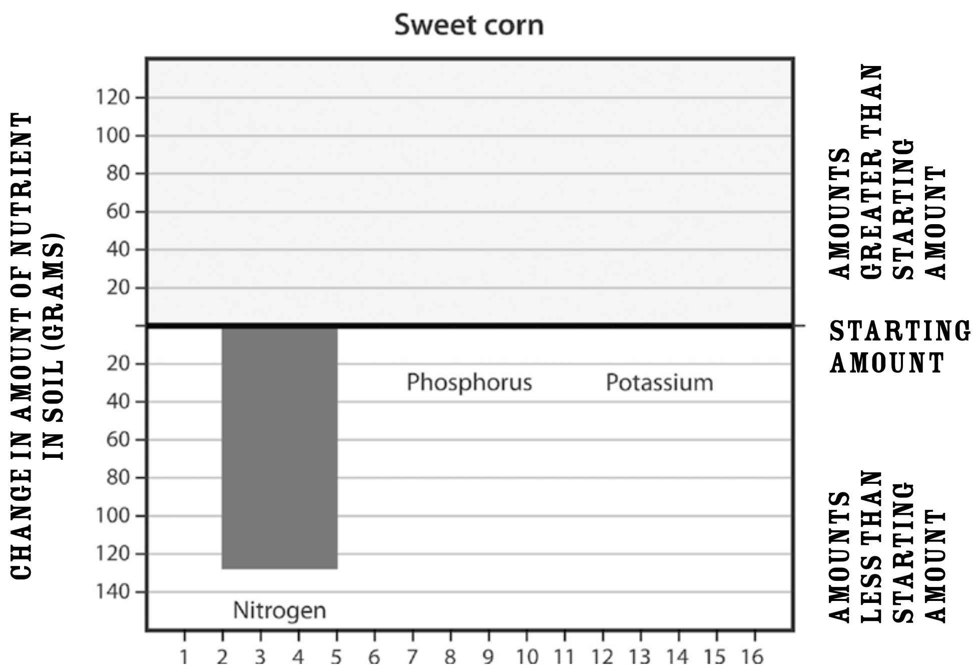
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, F

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

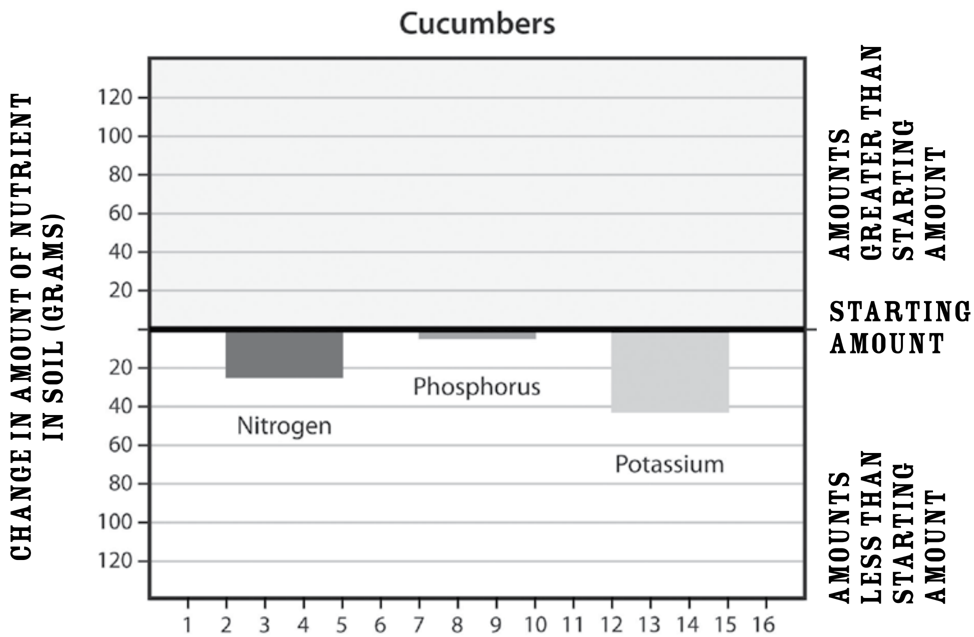
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, G

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

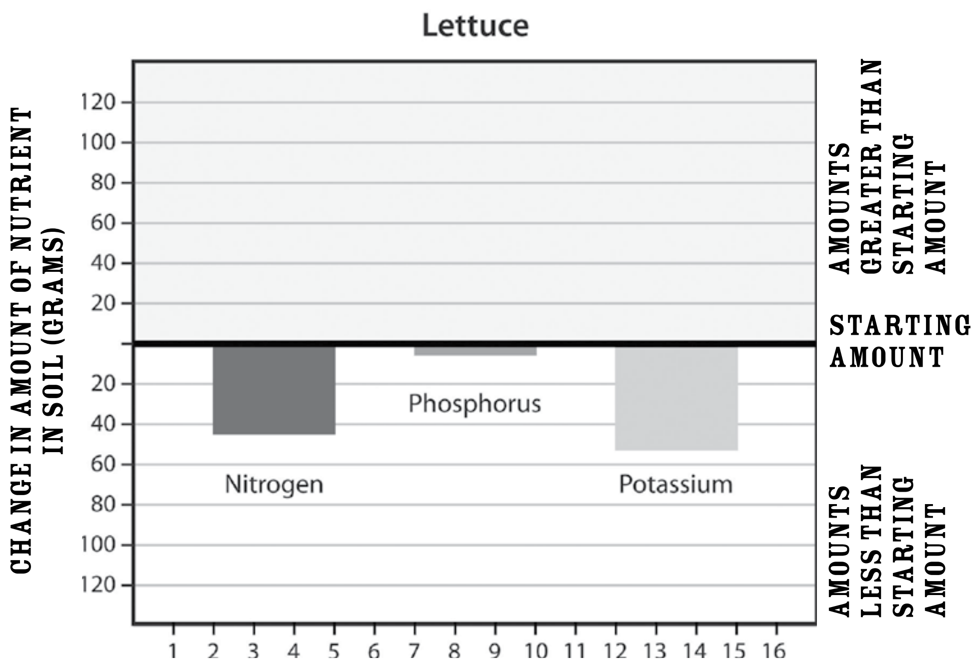
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

{Name ____________________}

MASTER 4.2, H

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

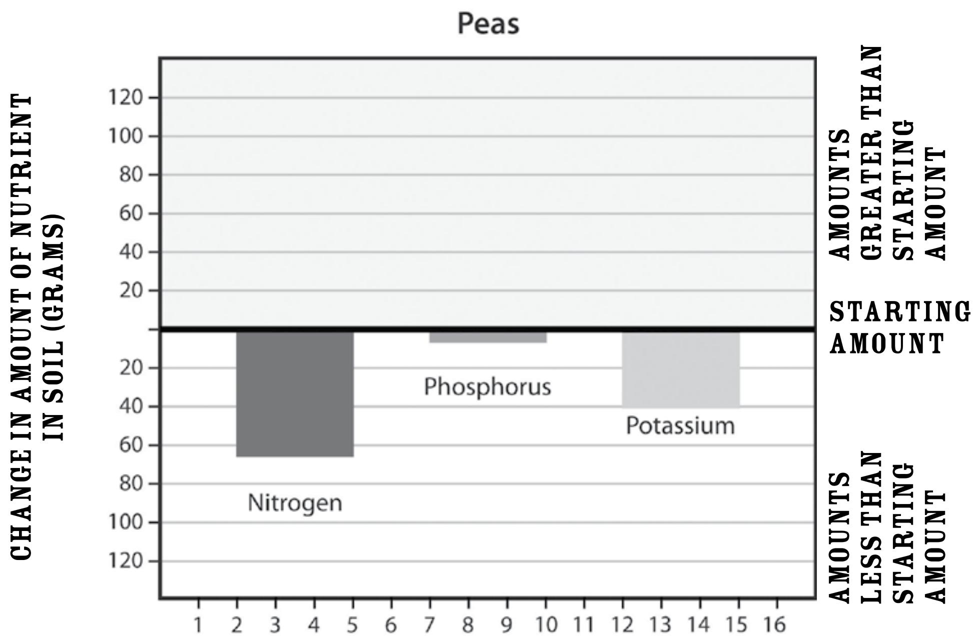
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ____________________

MASTER 4.2, I

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

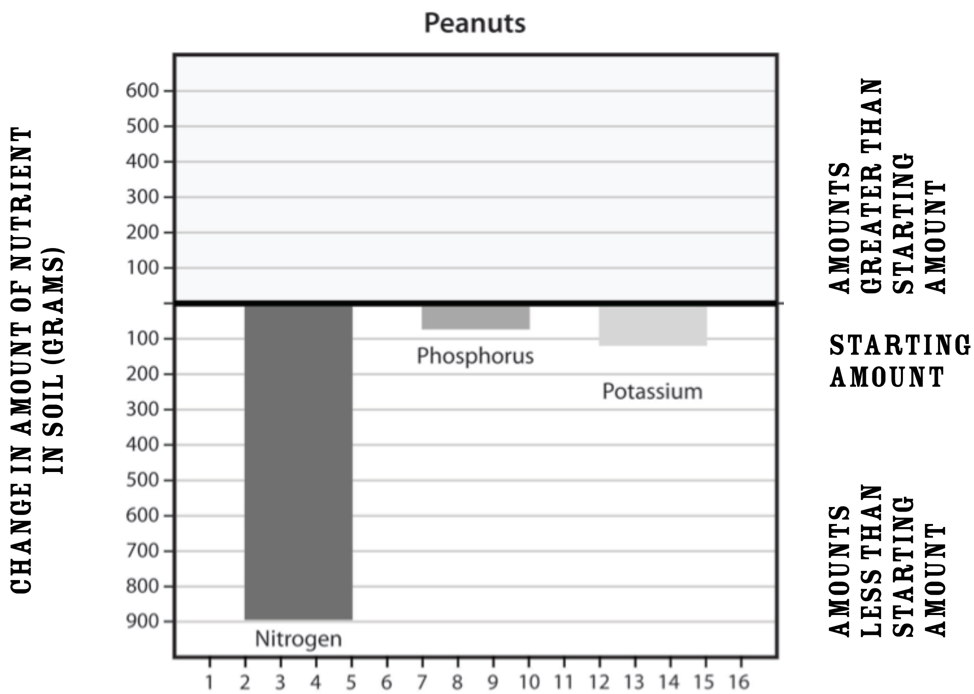
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

{ Name ______________________________ }

MASTER 4.2, J

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

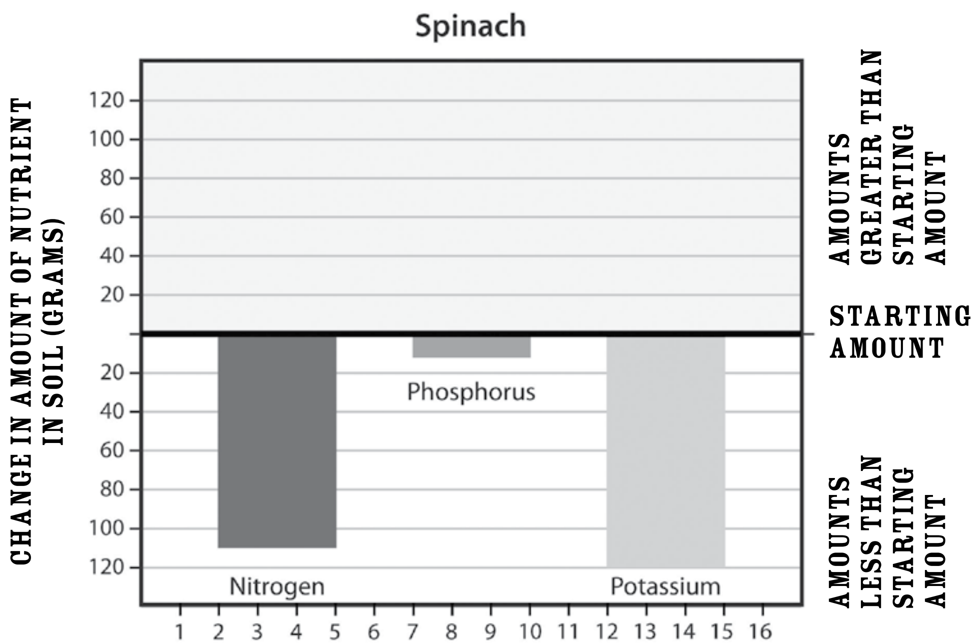
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, K

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

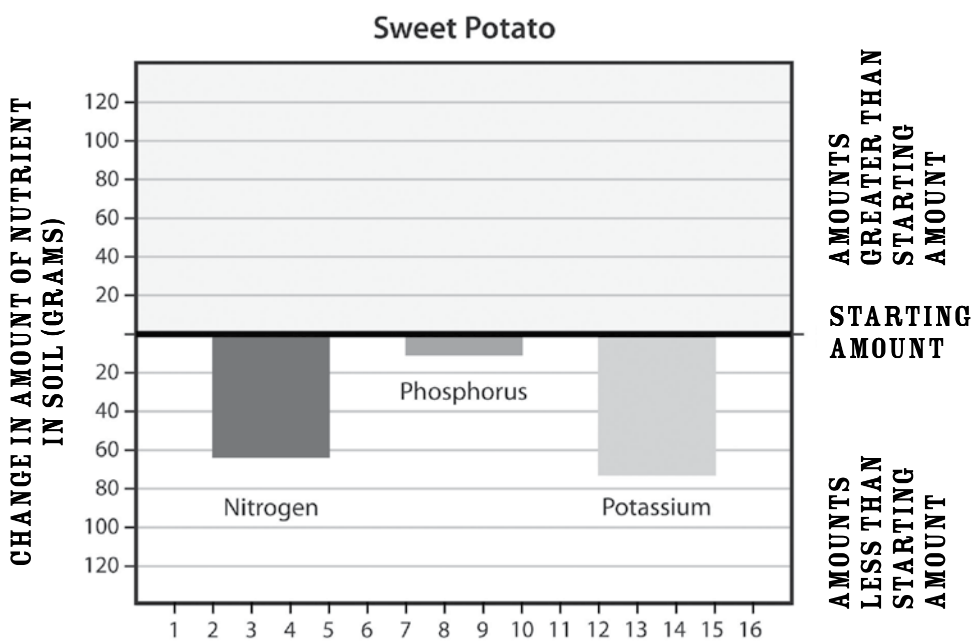
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, L

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

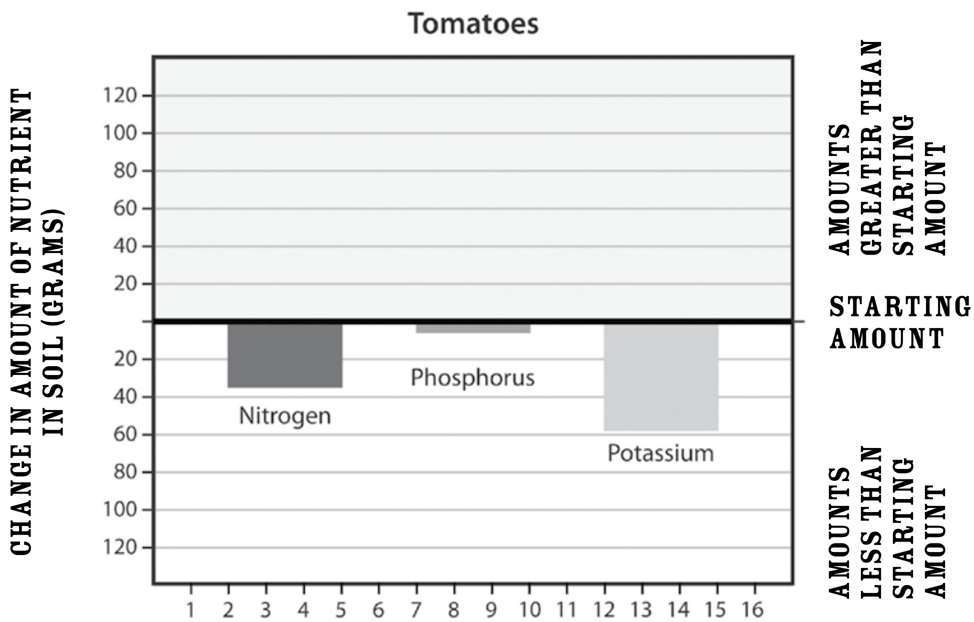
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was __________nitrogen in the soil after the plants grew.
There was __________phosphorus in the soil after the plants grew.
There was __________potassium in the soil after the plants grew.

Name ______________________________

MASTER 4.2, M

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

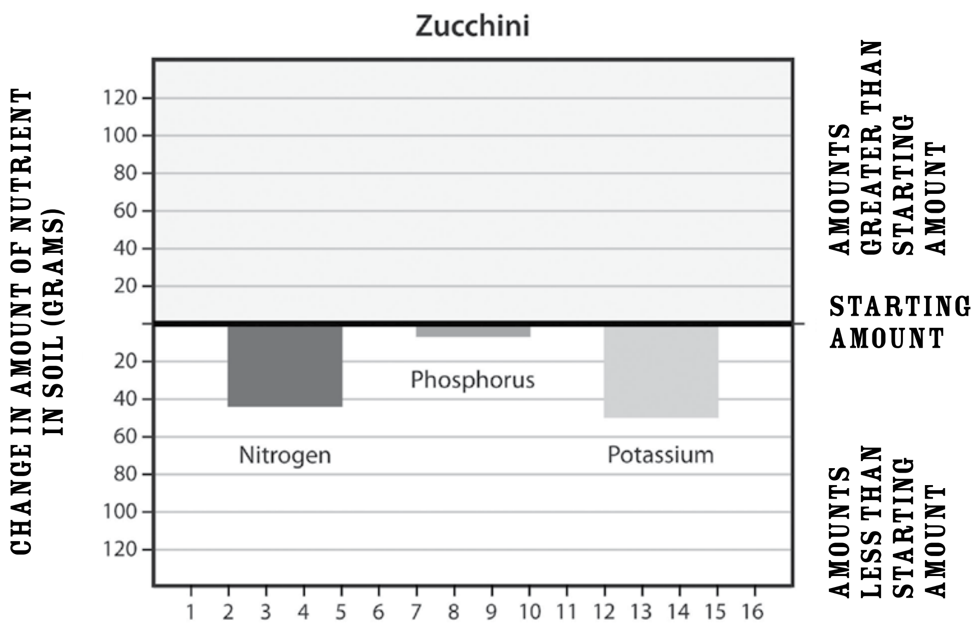
Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

{Name ________________________________}

MASTER 4.2, N

HOW DO PLANTS AFFECT THE SOIL?



The starting amount is the amount of the nutrient in the soil before plants grew there.

Use the information on the graph to fill in the blanks in the following sentences. State whether there was more, less, or the same amount of nutrient in the soil.

There was ___________nitrogen in the soil after the plants grew.
There was ___________phosphorus in the soil after the plants grew.
There was ___________potassium in the soil after the plants grew.

Name ___________________________

MASTER 4.3

NUTRIENTS AND PLANT HEALTH

NUTRIENT	WHY DO PLANTS NEED THIS NUTRIENT?	WHAT HAPPENS IF THERE IS NOT ENOUGH OF THE NUTRIENT?
Nitrogen	Plants need nitrogen to grow and for photosynthesis.	When there is not enough nitrogen, the leaves of the plant turn yellow. The plant may be small and spindly.
Phosphorus	Phosphorus is important for seed germination and for use of water by the plant.	When there is not enough phosphorus, plants may grow slowly and are more likely to be affected by disease or water shortage. The leaves and stems may look purple or red.
Potassium	Potassium is important for water use in plants and for strong stalks.	When there is not enough potassium, the edges of leaves may be yellow or brown. The stems are weak and break easily. The roots do not form well.

Name ____________________

MASTER 4.4, A
SEED PACKET INFORMATION

CORN—EXTRA SWEET	
Corn is easy to grow from seed. Ears of this corn are 9 inches long and very sweet.	**SEED DEPTH** 2 inches (5 centimeters)
PLANTING Plant seeds after last frost and when soil is warm. Plants need a sunny location. Plants will grow about 5 feet tall. Not recommended to start seeds indoors.	**SEED SPACE** 6 inches (15 centimeters) **SPROUTS IN** 7-14 days **PLANT SPACE** 12 inches (30 centimeters)
HARVEST Ears are ready to pick about 18 days after silks appear. Snap the ears off the stalk with a quick twist.	**ROW SPACE** 36 inches (91 centimeters) **READY TO HARVEST IN** 70 days

Name ______________________________

MASTER 4.4, B

SEED PACKET INFORMATION

WATERMELON—CRIMSON SWEET	
These sweet watermelons can weigh up to 25 pounds. They have a light green rind with dark green stripes. The fruit inside is dark red and very sweet. Watermelons make a great low-calorie snack or dessert.	**SEED DEPTH** ½ -1 inch (1-3 centimeters)
PLANTING Plant seeds in deep, well-worked soil in a sunny place after all chance of frost is over. The seeds may be planted indoors 3-4 weeks before planting outside. The seedlings need to be spaced well because the vines can be up to 8 feet long. Watermelon plants do not grow well in containers.	**SEED SPACE** 2-3 inches (5-8 centimeters) **SPROUTS IN** 4-8 days **PLANT SPACE** 6-8 feet (2-2.5 meters)
HARVEST Watermelons are ready when they twist easily off the stem and the spot where they rest on the ground is yellow.	**ROW SPACE** 48 inches (1.2 meters) **READY TO HARVEST IN** 80 days

Name ______________________________

MASTER 4.4, C

SEED PACKET INFORMATION

CARROTS—LITTLE FINGER	
This variety of extra-sweet carrot grows about 3 inches long. Great for serving whole.	**SEED DEPTH** ½ inch (1 centimeter)
PLANTING Plant seeds in well-worked soil after last frost in the spring. Keep seeds evenly moist. Starting seeds inside is not recommended.	**SEED SPACE** ½ inch (1 centimeter) **SPROUTS IN** 14-21 days **PLANT SPACE** 1 inch (3 centimeters)
HARVEST To make harvesting easier, water the soil before pulling carrots. Twist the tops while pulling up the roots.	**ROW SPACE** 12 inches (30 centimeters) **READY TO HARVEST IN** 65 days

Name ______________________________

MASTER 4.4, D

SEED PACKET INFORMATION

TOMATO	
Tomatoes can be used in many recipes, including soups, sauces, stews, and ketchup.	**SEED DEPTH** ¼ inch (6 millimeters)
PLANTING Tomato seeds usually are planted indoors and transplanted to the garden after the last spring frost and when the soil temperature is at least 60 degrees. Do not plant tomatoes in the same spot two years in a row.	**SEED SPACE** 1 per pot **SPROUTS IN** 7-10 days **PLANT SPACE** 18 inches (46 centimeters)
HARVEST Pick tomatoes when they are as ripe as possible. They should be bright red and firm. The leaves of the tomato plant are poisonous and should not be eaten.	**ROW SPACE** 36 inches (91 centimeters) **READY TO HARVEST IN** 72 days

Name ______________________________

MASTER 4.4, E

SEED PACKET INFORMATION

BEET—DARK RED	
The roots are sweet and nutritious. The leafy greens can be used in salads or steamed.	**SEED DEPTH** ½ inch (1 centimeter)
PLANTING Plant seeds in well-worked soil after last frost in the spring. Plants grow best in full sun. Beet seeds are actually a fruit with 1-5 seeds inside. Thinning the seedlings is very important. Plant beets in early spring and in the fall. Beets do not do as well in the hottest part of the summer.	**SEED SPACE** 1 inch (3 centimeters) **SPROUTS IN** 14-21 days **PLANT SPACE** 12 inches (30 centimeters)
HARVEST Pick the greens when they are 4-6 inches tall and the roots are less than 2 inches in diameter.	**ROW SPACE** 12 inches (30 centimeters) **READY TO HARVEST IN** 59 days

Name ______________________________

MASTER 4.4, F

SEED PACKET INFORMATION

CILANTRO (CORIANDER)	
The plant is called cilantro but the seeds are called coriander. The leaves are used in many dishes, especially Asian and Latin American recipes. The leaves are best when fresh. The seeds can be used in many recipes and can even be sugar-coated and eaten as candy.	**SEED DEPTH** ¼ inch(6 millimeters)
PLANTING Plant seeds outdoors in full sun after last chance of frost. Keep soil evenly moist. Starting seeds indoors is not recommended because plants do not transplant well. Seeds need darkness to sprout.	**SEED SPACE** 1 inch (3 centimeters) **SPROUTS IN** 10-20 days **PLANT SPACE** 9 inches (23 centimeters)
HARVEST The leaves of cilantro can be harvested anytime. The seeds should be harvested after they begin to turn brown.	**ROW SPACE** 24 inches (61 centimeters) **READY TO HARVEST IN** 60-90

Name ______

MASTER 4.4, G

SEED PACKET INFORMATION

SPINACH	
The dark green leaves of spinach are tender. Spinach is high in iron and vitamins A and C.	**SEED DEPTH** ½ inch (13 millimeters)
PLANTING Spinach grows best in the spring or fall when the weather is cooler. Choose a location with rich moist soil. To have spinach ready for harvest all the time, plant more seeds every 10 days.	**SEED SPACE** 1 inch (3 centimeters) **SPROUTS IN** 5-10 days **PLANT SPACE** 5 inches (13 millimeters)
HARVEST Harvest by pulling the entire plant or by cutting individual leaves as needed.	**ROW SPACE** 12 inches (30 centimeters) **READY TO HARVEST IN** 42 days

Name ______________________________

MASTER 4.4, H
SEED PACKET INFORMATION

BROCCOLI	
These plants produce lots of broccoli throughout the season. Broccoli can be eaten raw or cooked.	**SEED DEPTH** ¼ inch (6 millimeters)
PLANTING Start seeds indoors. After the last frost and when seedlings are about 2 inches tall, transplant outdoors. Plant seedlings at least 12 inches apart. Plants grow best in full sun.	**SEED SPACE** 1 inch (3 centimeters) **SPROUTS IN** 10-21 days **PLANT SPACE** 12 inches (30 centimeters)
HARVEST Pick broccoli heads that have tight, firm buds. Cut the center head with 6 inches of stalk. Other smaller heads can also be harvested.	**ROW SPACE** 24 inches (61 centimeters) **READY TO HARVEST IN** 60-90 days

Name ___________________________________

MASTER 4.4, I

SEED PACKET INFORMATION

GREEN BEANS—BLUE LAKE	
These plants produce lots of beans over al long season. Beans have excellent flavor either fresh or frozen.	**SEED DEPTH** 2 inches (5 centimeters)
PLANTING Plant seeds outside after last frost and when temperatures are warm. Plant seeds in an area that gets full sun. Plants will grow about 20 inches tall.	**SEED SPACE** 3 inches (8 centimeters) **SPROUTS IN** 7-14 days **PLANT SPACE** 6 inches (15 centimeters)
HARVEST Beans are ready to pick when the pod breaks in half cleanly. This is when seeds have just begun to form and the pods are 4 to 8 inches long. Hold the stem with one hand and pull the pod off with the other hand to avoid breaking the plant's branches.	**ROW SPACE** 36 inches (91 centimeters) **READY TO HARVEST IN** 58 days

Name ______________________________

MASTER 4.4, J

SEED PACKET INFORMATION

CABBAGE	
Cabbage heads can grow very large—up to 20 pounds. Cabbage can be eaten raw or cooked. After harvesting, cabbage can be stored for several months.	**SEED DEPTH** ¼ inch (6 millimeters)
PLANTING Plant outside in early spring or in late summer. If starting seeds indoors, plant seeds 4-6 weeks before transplanting outside. Plants grow best in full sun.	**SEED SPACE** 8 inches (20 centimeters) **SPROUTS IN** 10-21 days **PLANT SPACE** 16 inches (41 centimeters)
HARVEST Harvest cabbage when heads become firm. Cut stems at soil level and remove outer leaves. Smaller heads will grow after the first head is picked.	**ROW SPACE** 24 inches (61 centimeters) **READY TO HARVEST IN** 105 days

Lesson 5 **EVALUATE**

HOW DOES YOUR GARDEN GROW

At a Glance

OVERVIEW

Students synthesize what they have learned about soils, plants, and the environment to plan their garden. They will present their plans and explain why they made the decisions that they did.

MAJOR CONCEPTS

Growing a successful garden requires knowledge of plants and their environment, including the soil. Gardeners make decisions based on their location, their soil, and other environmental factors.

OBJECTIVES

After completing this lesson, students will be able to:

- Plan a garden that is appropriate for their area;
- Explain how understanding a plant's needs is important for a successful garden;
- Explain how plants require nutrients they obtain from the soil and how fertilizers can replace lost nutrients.

In Advance

PHOTOCOPIES

ACTIVITY 1:
What Should I Grow?

Master 5.1
Planning Our Garden
(Make 1 copy per team of 3-4 students)

Master 5.2
Plant Cut-Outs
(Make 2-4 copies per class)

Master 5.3
Thinking about My Garden (Make 1 copy per student)

MATERIALS

ACTIVITY 1:
Thinking about Plants

- Glue sticks
- Optional materials: chart paper, colored pencils, crayons, rulers

Preparation

Find out the last expected frost date in the spring and the first expected frost date in the fall for your area. A local garden center may be able to give you this information easily. Alternatively, you can find this information online.

Cut the pieces on Master 5.2, *Plant Cut-Outs,* apart. Create sets containing parts representing the various plants for each team of students. The height of each cut-out piece is scaled to represent the amount of row space that a plant requires. For example, cabbage plants should be spaced 16 inches apart. The height of the cut-out is scaled so that it represents 16 inches of row on Master 5.1. (The pieces are not scaled in the horizontal direction.) Students will place the cut-outs on the rows on Master 5.1 to show what they would plant in their gardens. Students can line up the shaded line on each cut-out piece with the line representing the row on Master 5.1. They can then glue these pieces down after they have made their decisions.

Procedure

ACTIVITY 1:
PLANNING A GARDEN

1. Remind students of the discussion they had at the end of Lesson 4 (Activity 2). On chart paper, students listed other things that they would need to know to help them plan a garden. Point out that one of the things they will need to know is the last date that frost occurs in the spring in their area. Ask students why this is important.

   The last expected frost data in an area is important because most plants won't tolerate cold temperatures or frost well. The young plants are likely to die if they are hit by frost. Also, it gives them an indication of how many days are in their growing season.

2. Explain to students that you have found out the dates for both the last frost in the spring and the likely first frost of the fall. Write those dates on the board. Explain that you have used this information to figure out the number of days for the growing season in your area.

   Students may remember that seed packets often give a number of days that it takes a plant to mature. If that number is greater than the expected growing season in your area, then that plant may not be a good choice for your area.

Procedure

3. Ask students to work in teams of 3 or 4. Give each group a copy of Master 5.1, *Planning Our Garden.* Explain to students that they are going to plan a garden. They will choose the seeds they want to plant and plan where things will grow in their garden. They can also indicate when they would plant different things. Point out that each student will have three ten-foot rows to plan. Explain that they can place the cut-out pieces for the different plants on their template to plan their garden.

The cut-outs should be a relatively easy way for students to plan what they will put in each row. The cut-out pieces are sized to match the scale of the rows. For example, broccoli plants should be planted 12 inches apart. The cut-out for broccoli represents 12 inches of row space (without needing additional space between cut-outs).

To simplify the lesson, the rows in the student gardens are three feet apart. (Depending on the needs of specific plants, rows could sometimes be spaced closer together, but this makes the math more complicated and isn't necessary for the purpose of this activity.) This could be a discussion point if students mention that rows aren't spaced correctly for the plants that they choose.

Recommend to students that they put all of their cut-out pieces in place before they start gluing them to the template. In that way, they can more easily make changes if they wish.

Procedure

4. Go over the second page of Master 5.1 with students. Explain that they should write the name of the seed/plant they are using, the number of each plant they are growing in their garden, and any extra information they think is helpful to remember about that plant.

   Tell students they will have access to the seed packets they used in Lesson 4 for more information.

5. After teams have had a chance to design their garden, ask them to post their plan in a place where other students can look at it. Allow a few minutes for students to see what other teams have planned.

   Students will likely be interested in what other garden plans look like. Each team will likely design a very different variety and arrangement of plants.

6. Spend a few minutes in class discussion with students about their garden plans. Ask teams to describe why they chose certain plants, how they decided how to plant the seeds, and if there was anything special someone would need to think about when growing some of the plants that they selected.

   Students will have a wide variety of reasons for why they chose certain plants. For some, it may be that they like to eat that plant. For other plants, students may want to grow it because it is really big (a pumpkin, for example). Yet others may choose small plants so they can grow a lot in their garden. They should relate it to the information provided on seed packets.

Procedure

7. Wrap up the activity by giving each student a copy of Master 5.3, *Thinking about My Garden*. Allow a few minutes for students to answer the questions.

Possible answers to questions on Master 5.3

1. LIST AT LEAST 3 WAYS THAT YOU THOUGHT ABOUT THE ENVIRONMENT WHEN PLANNING YOUR GARDEN.

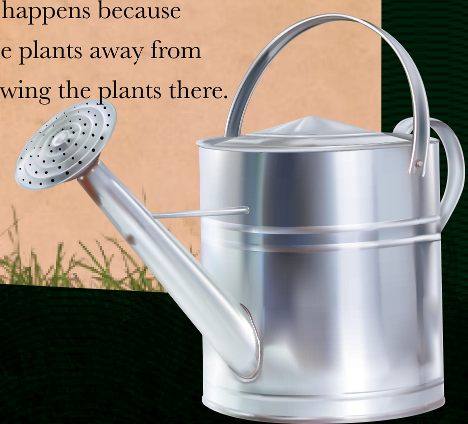
Amount of sunlight the plant needs
Type of soil the plant grows best in
The temperature that the plant needs
Animals and insects living in the area
Amount of water the plant needs

2. WHAT ARE SOME THINGS THAT MIGHT BE WRONG IF YOUR GARDEN WAS NOT GROWING WELL? EXPLAIN.

Some of the things to consider if the garden is not growing well would be the quality of the soil, the amount of water that the plants are getting, the amount of sunlight that the plants are getting, and whether the temperatures are appropriate for the plants. The goal would be to have students relate their answers to this question to the environment.

3. EXPLAIN WHY FERTILIZERS CAN BE ONE WAY TO HELP PLANTS GROW BETTER.

Fertilizers can help plants grow better because they replace nutrients in the soil. When plants grow, they remove nutrients. If you grow the same plant in the same place, and then harvest and remove the plant year after year, you will use up the soil's nutrients. This happens because the plants take nutrients from the soil through their roots, then people take the plants away from the soil to use. Fertilizers make the soil more like it was before you started growing the plants there.



Procedure

Optional Extension Activities

Depending on the time and space available, you and your students may want to continue thinking about plants and gardening. Growing a garden, either indoors or out, can be an exciting way to teach students about the world around us.

OPTIONAL ACTIVITY 1:

AN INDOOR GARDEN

If you have space (or optimally a greenhouse), students could plant an indoor garden. Selecting the appropriate plants for this would be key. Many plants will grow well in containers. Usually, larger containers are much better than small ones. Some of the herbs (such as parsley, chives, or cilantro) and some lettuces may grow well. If the site gets enough sun, pepper plants may grow well in a large container. Students can find out more about container gardening through online research. Have students work together to plan the garden, plant the garden, and maintain the garden.

Procedure

OPTIONAL ACTIVITY 2:

AN OUTDOOR GARDEN

If students are interested and there is an appropriate space, consider planning and planting a school garden. This could be a container garden if it isn't feasible to prepare the soil for a regular garden. Seek volunteer help from parents to prepare the soil. Have students plan the garden, taking into consideration the space available, the local climate, the amount of time available, and so forth.

Procedure

LESSON 5: ORGANIZER

Activity 1: *Planning a Garden*

WHAT THE TEACHERS DOES	PROCEDURE REFERENCE
Inform students that you have found out some information about the area in which they live. You know the last date on which frost is likely to occur in the spring and the date on which frost is likely to first occur in the fall. Ask students why these dates are important to know.	Step 1 **PAGE 180** Step 2 **PAGE 180**
Ask students to work in teams of 3-4 for this activity. Give each group a copy of Master 5.1, *Planning our Garden* and a set of cut-out pieces for a variety of vegetables (from Master 5.2). Explain that students have a garden plot with three 10-foot rows for planting. Groups can decide which plants, and how many, they will plant in their garden. Demonstrate how students can place the cut-outs on their garden plot.	Step 3 **PAGE 181**
Go over the second page of Master 5.1 with students. Ask students to summarize which plants and how many of each kind of plants they will grow in their garden. Also ask students if there is any information that would be helpful to know about each plant that they chose.	Step 4 **PAGE 182**
Ask teams to post their garden plans somewhere in the classroom. Allow a few minutes for students to look at the plans that other teams created.	Step 5 **PAGE 182**
In a class discussion, allow teams to present their garden plans and describe why they chose certain plants for their garden.	Step 6 **PAGE 182**
Wrap up the activity by giving each student a copy of Master 5.3, *Thinking about My Garden*. Allow a few minutes for students to answer the questions.	Step 7 **PAGE 183**

Name ___________________________

MASTER 5.1
PLANNING OUR GARDEN

Each row in your garden is 10 feet long. The rows are three feet apart. Decide what plants and how many of each type you want to grow in your garden.

Name ______________________________

ROW 1			ROW 2			ROW 3	

{ Name ______________________________ }

OUR CROPS	SOIL HEIGHT BEFORE ADDING WATER	NUMBER OF PLANTS WE CAN GROW	EXTRA INFORMATION ABOUT THIS PLANT

Name

1 BEET	1 BEET	1 BEET
1 BEET	1 BEET	1 BEET
1 BEET	1 BEET	1 BEET
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1 BEET	1 BEET	1 BEET
1 BEET	1 BEET	1 BEET

Name ______________________________

1 BROCCOLI	1 BROCCOLI	1 BROCCOLI
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Name ______________________________

1 CABBAGE	1 CABBAGE	1 CABBAGE
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1 CABBAGE	1 CABBAGE	1 CABBAGE

Name ______________________________

6 CARROTS	6 CARROTS	6 CARROTS
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Name ______________________________

1 CILANTRO	1 CILANTRO	1 CILANTRO
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Name ____________________

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Name ____________________

1 GREEN BEAN	1 GREEN BEAN	1 GREEN BEAN
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1 GREEN BEAN	1 GREEN BEAN	1 GREEN BEAN

Name ______________________________

1 LETTUCE	1 LETTUCE	1 LETTUCE
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Name ____________________

1 SPINACH	1 SPINACH	1 SPINACH
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1 SPINACH	1 SPINACH	1 SPINACH

Name ____________________

1 TOMATO	1 TOMATO	1 TOMATO
1 TOMATO	1 TOMATO	1 TOMATO
1 TOMATO	1 TOMATO	1 TOMATO
1 TOMATO	1 TOMATO	1 TOMATO
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1 TOMATO	1 TOMATO	1 TOMATO

Name ______________________________

1 WATERMELON	1 WATERMELON	1 WATERMELON

Name ____________________

MASTER 5.3

THINKING ABOUT MY GARDEN

Answer the following questions. Explain your answers.

4. List at least 3 ways that you thought about the environment when planning your garden.

5. What are some things that might be wrong if your garden was not growing well? Explain.

6. Explain why fertilizers can be one way to help plants grow better.

ID# ____________________

STUDENT KNOWLEDGE SURVEY 1

Choose the best answer to the following questions.
Choose "I don't know." if that is your best answer.
This will NOT be graded.

1. NUTRIENTS

_________ are needed for plants to grow.
_________ are not required but plants grow better with them.
_________ keep insects away from plants.
_________ keep plants from growing too big.
_________ I don't know.

2. PLANTS TAKE NUTRIENTS IN

_________ through the air.
_________ through their leaves.
_________ through their roots.
_________ Plants don't take nutrients in.
_________ I don't know.

3. PLANTS GROW BEST IF THEY HAVE

_________ the right amount of the nutrients.
_________ extra nutrients so they don't run out.
_________ lower amounts of nutrients because nutrients are harmful.
_________ I don't know.

ID# ______________________________

4. SOILS HAVE ____________________ NUTRIENTS IN THEM AFTER PLANTS GROW.

________ more
________ less
________ the same amount
________ I don't know.

5. FERTILIZERS

________ make the soil change color.
________ keep the soil moist for plants.
________ remove extra nutrients from the soil.
________ add nutrients to the soil.
________ I don't know.

6. SOIL INCLUDES NONLIVING THINGS AND THINGS THAT WERE ONCE LIVING ORGANISMS.

________ True
________ False
________ I don't know.

7. IF PLANTS ARE GROWING IN SOIL THAT HAS LOW LEVELS OF NUTRIENTS, THEY

________ will grow well because nutrients aren't really needed.
________ will grow well because they are ok as long as they get any nutrients.
________ won't grow well because the nutrients are needed in the right amount.
________ won't grow well because nutrients harm the plants.
________ I dont know.

ID# ___________________________________

8. LIST 2 THINGS THAT ARE PART OF A PLANT'S ENVIRONMENT.

____

____

9. BESIDES KNOWING THE TYPE OF SEED (PLANT), NAME 2 THINGS YOU NEED TO KNOW ABOUT IT BEFORE PLANTING IT IN YOUR GARDEN.

____

____

ID# ____________________

STUDENT KNOWLEDGE SURVEY 2

Choose the best answer to the following questions.
Choose "I don't know." if that is your best answer.
This will NOT be graded.

1. NUTRIENTS

_________ are needed for plants to grow.
_________ are not required but plants grow better with them.
_________ keep insects away from plants.
_________ keep plants from growing too big.
_________ I don't know.

2. PLANTS TAKE NUTRIENTS IN

_________ through the air.
_________ through their leaves.
_________ through their roots.
_________ Plants don't take nutrients in.
_________ I don't know.

3. PLANTS GROW BEST IF THEY HAVE

_________ the right amount of the nutrients.
_________ extra nutrients so they don't run out.
_________ lower amounts of nutrients because nutrients are harmful.
_________ I don't know.

ID# ____________________

4. SOILS HAVE __________________ NUTRIENTS IN THEM AFTER PLANTS GROW.

_________ more
_________ less
_________ the same amount
_________ I don't know.

5. FERTILIZERS

_________ make the soil change color.
_________ keep the soil moist for plants.
_________ remove extra nutrients from the soil.
_________ add nutrients to the soil.
_________ I don't know.

6. SOIL INCLUDES NONLIVING THINGS AND THINGS THAT WERE ONCE LIVING ORGANISMS.

_________ True
_________ False
_________ I don't know.

7. IF PLANTS ARE GROWING IN SOIL THAT HAS LOW LEVELS OF NUTRIENTS, THEY

_________ will grow well because nutrients aren't really needed.
_________ will grow well because they are ok as long as they get any nutrients.
_________ won't grow well because the nutrients are needed in the right amount.
_________ won't grow well because nutrients harm the plants.
_________ I dont know.

ID# ____________________

8. LIST 2 THINGS THAT ARE PART OF A PLANT'S ENVIRONMENT.

____

____

9. BESIDES KNOWING THE TYPE OF SEED (PLANT), NAME 2 THINGS YOU NEED TO KNOW ABOUT IT BEFORE PLANTING IT IN YOUR GARDEN.

____

____

10. WHAT DID YOU LIKE BEST ABOUT THESE LESSONS?

11. WHAT DID YOU LIKE THE LEAST ABOUT THESE LESSONS?

ID# ____________________

STUDENT INFORMATION

What grade are you in? ________________

Are you a boy or a girl? ________________

CIRCLE YES OR NO TO ANSWER THE FOLLOWING QUESTIONS:

Are you Hispanic or Latino/a?	**yes**	**no**
Are you African American?	**yes**	**no**
Are you White?	**yes**	**no**
Are you Native Hawaiian or Other Pacific Islander?	**yes**	**no**
Are you American Indian or Alaska Native?	**yes**	**no**
Are you more than one race?	**yes**	**no**

Student ID Log

To evaluate the curriculum materials and determine whether students gained understanding through participation in these lessons, we need to be able to compare each student's responses on Knowledge Survey 1 (given before starting the unit) with his or her responses on Knowledge Survey 2 (given after completing the unit. **It is important that students do not write their names on their surveys.** We ask that you help students enter an ID code on their surveys (both 1 and 2) using the following format.

Teacher's first initial   Teacher's last initial   0#

For example if your name (as the teacher) is Johnny Appleseed, the ID code for your first student would be JA01. The ID code for your second student would be JA02, and so forth.

YOU CAN USE THE FOLLOWING ROSTER TO KEEP TRACK OF THE NUMBERS YOU ASSIGN TO EACH STUDENT.

STUDENT NAME	ID CODE NUMBER	STUDENT NAME	ID CODE NUMBER