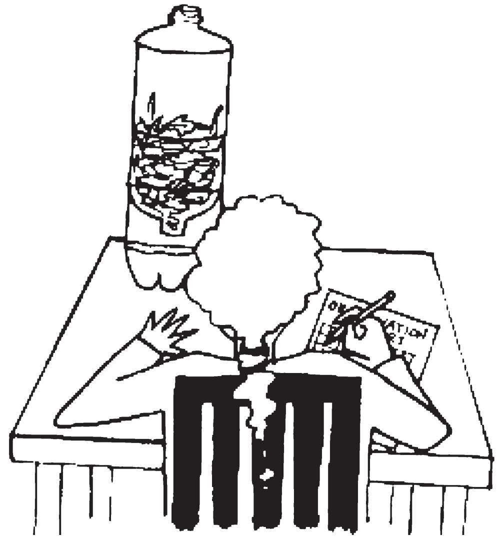

Rot It Right: The Cycling of Matter and the Transfer of Energy

4th Grade Science Immersion Unit

This draft document is the result of several months of writing and discussion as part of the SCALE Math and Science Partnership. It is a living document open to change based on feedback from pilot testing and input. It is intended to be circulated for consultation to the SCALE community and other interested parties. A final version will be made available near the end of the SCALE project in 2007.

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Rot It Right:
The Cycling of Matter and the Transfer of Energy

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This Grade 4 Immersion Unit is being developed in partnership with the Los Angeles Unified School District and is being tested and revised by teachers, scientists, and curriculum developers associated with the NSF-funded Math/ Science Partnership, System-wide Change for All Learners and Educators (SCALE) and the DOE-funded Quality Educator Development (QED) project at the California State University – Dominguez Hills and Northridge.

Development of this Unit is a collaborative effort involving educators from partner universities and k-12 school districts. Numerous administrators, professors, teachers, and students were involved in rigorous content review, field-testing, and focus groups that provided valuable insight for development and subsequent revisions of the Immersion Unit version presented here.

Rot it Right builds on activities and ideas that were shared with SCALE by the Bottle Biology / Wisconsin Fast Plants program, an instructional materials development program funded by a grant from the National Science Foundation and administered by the University of Wisconsin-Madison.

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Navigating the Unit

This Immersion Unit provides a coherent series of lessons designed to guide students in developing deep conceptual understanding that is aligned with the standards, key science concepts, and essential features of classroom inquiry (as defined by the National Science Education Standards). In Immersion Units, students learn academic content by working like scientists: making observations, asking questions, doing further investigations to explore and explain natural phenomena, and communicating results based on evidence. Immersion Units are intended to support teachers in building a learning culture in their classrooms to sustain students' enthusiasm for engaging in scientific habits of thinking while learning rigorous science content.

This Immersion Unit is comprised of several steps; each step contains between one and four lessons. The unit begins with the Unit Overview, which includes a description of the key concepts, evidence for student understanding, assessment strategies and other relevant implementation information. The Unit Overview outlines the conceptual flow and rationale for the structure of the unit.

Each step in the unit begins with an overview, which describes the individual goals and activities of the specific step, and its relationship to the previous and following steps. The title and approximate length of time needed for each lesson is also shown. Within the step, each lesson contains:

- Snapshot
- Background Information
- Implementation Guide
- Student Pages
- Teacher Pages

Snapshots are printed on a single page and provide key information for implementing the lesson. Each snapshot includes the key concept(s), evidence of student understanding, list of materials, procedures for lesson implementation, key words and REAPS—a strategy for assessing student learning. This page is designed to have on hand while you implement the lesson.

The Background Information and Implementation Guide sections provide learning experiences such as investigations, reading research, or other engaging supporting strategies designed to teach a specific concept(s). They include instructions for any advance preparation required, explain the design of the lesson, include strategies for assessing student learning, and provide teacher background information on relevant science content. The Implementation Guide for each lesson addresses teaching methodology, including specific examples and information related to effective teacher implementation. If research identifies common misconceptions related to the content, a detailed explanation of common misconceptions is provided with suggestions for addressing them.

Student pages may include readings, guides, handouts, maps or instructions to engage students during the lesson. These pages assist you as you guide students through the lesson, and are intended to be readily adapted to suit a variety of classrooms with diverse student populations.

Teacher pages may include overheads, maps, data charts and other materials that can help you implement the lesson.

(continued on following page)

Snapshot Page

The information on the Snapshot page includes the following:

- Lesson Title
- Key Concept
- Time Needed
- Materials
- Key Words
- REAPS Questions

This Immersion Unit contains a variety of opportunities for modifying content and methodology based on your students' needs and your classroom situation. The basic structure of the unit is designed to support you in anticipating the particular needs of your students to foster understanding of inquiry, nurture classroom communities of science learners, and engage students in learning key science concepts.

Unit Overview

Unit Overarching Concepts

- Organisms need matter and energy to live.
- Science knowledge advances through inquiry.

Unit Supporting Concepts

- Energy is transferred from the sun to producers; from producers to consumers; and from consumers to consumers;
- Matter is cycled from organism to organism;
- The sun is the source of energy for almost all organisms, and its energy is stored in matter by producers;
- Scientists use inquiry to gather evidence, design experiments, collect data, and build evidence-based explanations.

Evidence of Student Understanding

By the end of this unit, the student will be able to:

- understand that organisms need matter and energy to live;
- describe how energy is transferred from the sun to producers to consumers;
- explain how matter is cycled from organism to organism;
- identify the sun as the source of energy for almost all organisms;
- use inquiry when gathering evidence and developing explanations.

Unit Preview

The goal of this unit is to provide students with an opportunity to explore the interdependency of living and nonliving factors in an ecological system. Students investigate the process of decomposition and examine the role that decomposers and other organisms play in the transfer of energy and matter.

At the beginning of this unit, students participate in a class investigation into the role of light in plant growth. This investigation provides an opportunity to introduce students to scientific inquiry. Students learn about asking scientific questions, designing experiments, collecting data, and building evidence-based explanations. This investigation provides the foundation for the unit by guiding students to explore how energy from the sun is brought into food chains by plants. Students then expand their focus to look at how energy is transferred and matter is cycled from producers to consumers.

Next, students are asked to observe several two-week old Decomposition Columns and make observations, drawing and describing what they observe. Based on their observations and discussions, students brainstorm ideas about what causes the change in the Decomposition Columns and what they want to investigate using a Decomposition Column. Student groups design an investigation that explores the process of decomposition by changing only one factor in the Decomposition Column.

While collecting data on their decomposition investigation, students continue to build content knowledge through readings and a food web activity that illustrate the complex interactions of organisms, including decomposers. After several weeks of making observations and collecting data, students present their findings and evidence-based explanations. This step provides an opportunity for students to connect what they

Unit Standards

California Science Content Standards

2. All organisms need energy and matter to live and grow. As a basis for understanding this concept:
   a. Students know plants are the primary source of matter and energy entering most food chains.
   b. Students know producers and consumers (herbivores, carnivores, omnivores and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.
   c. Students know decomposers, including many fungi, insects, and microorganisms, recycle matter from dead plants and animals.
3. Living organisms depend on one another and on their environment for survival. As a basis for understanding this concept:
   a. Students know ecosystems can be characterized by their living and nonliving components.
   d. Students know that most microorganisms do not cause disease and that many are beneficial.

California Science Investigation and Experimentation Standards

6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, have students develop their own questions and perform investigations. Students will:
   a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
   b. Measure and estimate the weight, length, or volume of objects.
   c. Formulate and justify predictions based on cause-and-effect relationships.
   d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
   f. Follow a set of written instructions for a scientific investigation.

have learned about interdependency with their prior knowledge. In the final step of this Immersion Unit, students reflect on and demonstrate their understanding of interdependence of living and nonliving things by writing an informational article about trash problems. This lesson challenges students to relate their research on decomposition to issues of trash in the larger community.

Assessing Student Understanding

Continuous Assessment

The focus of this unit is on continuous assessment—the day-to-day observation/documentation of student work for the purpose of moving them forward in their understanding and practice of science (O'Brien Carlson, Humphrey, Reinhardt. 2003). Continuous assessment is an inquiry into what students know and are able to do.

The following section contains ideas for teachers to assess and document student learning throughout the unit for the purpose of modifying instruction and ensuring student learning using a variety of assessment techniques.

Formative Assessment

Formative assessment provides information to students and teachers that is used to improve teaching and learning. It is often informal and ongoing (NRC 2001).

Many opportunities for formative assessment are embedded in this unit. Students are asked to complete a variety of worksheets, charts, and data tables. Unit worksheets are provided to support and guide student learning and to make their thinking evident to the teacher. Use the worksheets throughout the unit as benchmarks of understanding, and as a portfolio to represent the work of each student. You can collect and review the worksheets periodically to assess the progress of each student.

In addition to worksheets, students maintain a science notebook. They can record observations, take notes on readings, record questions that come to mind, and write responses to questions. Students can use the science notebook as a self-assessment tool as well as a record of their learning for documentation purposes.

REAPS

REAPS is a method of formative assessment that combines the time-tested ideas of Blooms Taxonomy with new research on student assessment. The level of thinking increases from basic recall to complex analysis and predictions. On each Lesson Snapshot page is a series of REAPS prompts. This series of prompts is a simple tool that can be used throughout or at the end of each lesson. They can be used individually, in pairs or in groups to review what students know and are able to do. This provides an opportunity for the teacher to modify instruction as necessary based on student responses.

Here are the types of prompts included in the REAPS.

The prompts increase in cognitive difficulty with Recall as the easiest and Predict as usually the most advanced. Students will most likely demonstrate confidence and ability when responding to the first few prompts, while demonstrating continuous improvement in responding to the Apply and Predict prompts. Students are not expected to master all of the skills, but are encouraged to extend their thinking.

Suggested responses are included in italics after the prompts. More detailed responses are included in the implementation guides for each lesson. While these are good responses, other responses may be valid with supportive evidence and reasoning.

More about REAPS prompts is available in the Immersion Unit Toolbox.

Summative Assessment

Summative assessment refers to the cumulative assessments that capture what a student has learned and is able to do. They also can be used to assess student performance based on standards. Summative assessments are often thought of as traditional objective tests, but this need not be the case (NRC 2001). For example, summative assessments can be an accumulation of evidence collected over time, as in a collection of student work or a science notebook.

R **Recall** new knowledge: Determines whether the student has learned the basic knowledge that is related to and supports the key concept including lists, drawings, diagrams, definitions.

E **Extend** new knowledge: Determines whether the student can organize the basic knowledge related to the key concept such as compare, contrast, classify.

A **Analyze** knowledge: Encourages the student to apply or interpret what they have learned including developing questions, designing investigations, interpreting data.

P **Predict** something related to new knowledge: Engages the student in thinking about probable outcomes based on observations and to engage them in a new topic that builds on prior knowledge.

S **Self/Peer Assess**: Encourages students to take responsibility for their own learning. Includes methods and/or activities for students to assess their own learning and/or that of their peers.

Summative assessments are often performance-based, and require students to actively engage in activities such as writing, presenting, demonstrating, manipulating materials, and applying their learning in multiple ways.

Within this unit are several opportunities for formal documentation of student progress. These techniques provide the teacher with information about student learning for instructional decision-making as well as offering a tool for formal reporting of student progress.

Support Materials

Immersion Unit Toolbox

The Immersion Unit Toolbox is central to this curriculum. It is a separate guidebook that discusses the concepts inherent in teaching science through immersion units. These concepts include engaging in scientifically oriented questions, giving priority to evidence in responding to questions, and formulating explanation from evidence.

The Toolbox also describes several pedagogical approaches (Think Aloud strategies, for example) that are key to how these units work. Most of the strategies in the Immersion Unit Toolbox support student engagement in scientific inquiry based on the Five Essential Features of Classroom Inquiry (NSES, 2000).

Before you use Rot it Right in your classroom, spend some time becoming familiar with the concepts addressed in the Immersion Unit Toolbox. Here is a brief overview of some of those strategies.

Science Inquiry Map

The Science Inquiry Map on the following page illustrates the Five Essential Features of Inquiry. You can use this map in your classroom when you introduce Immersion Units to your students.

The science inquiry process is dynamic and does not necessarily follow a linear order. For example, a student may develop an explanation that leads to a new scientific question, or that student may revisit evidence in light of alternative explanations. On some occasions multiple features of an explanation may overlap, or, depending on the type of lesson, some features may have more emphasis than others may. These variations allow learners the freedom to inquire, experience, and understand scientific knowledge. The Five Essential Features of Inquiry describe how engaging in science inquiry unfolds in the classroom.

Student Groups

In this unit, students often work in groups. When making observations, the groups are large (7–8 students) because they work individually and share a column from which to make observations. When working as a team in a group, the ideal is to have groups no larger than 4–6 students. Whatever the group size is, all students in the team need to have a job to do so they are individually accountable for focusing on the current science lesson. When assigning groups, keep in mind that the students will remain in the same groups for the duration of Step 3, Step 4, and Step 5.

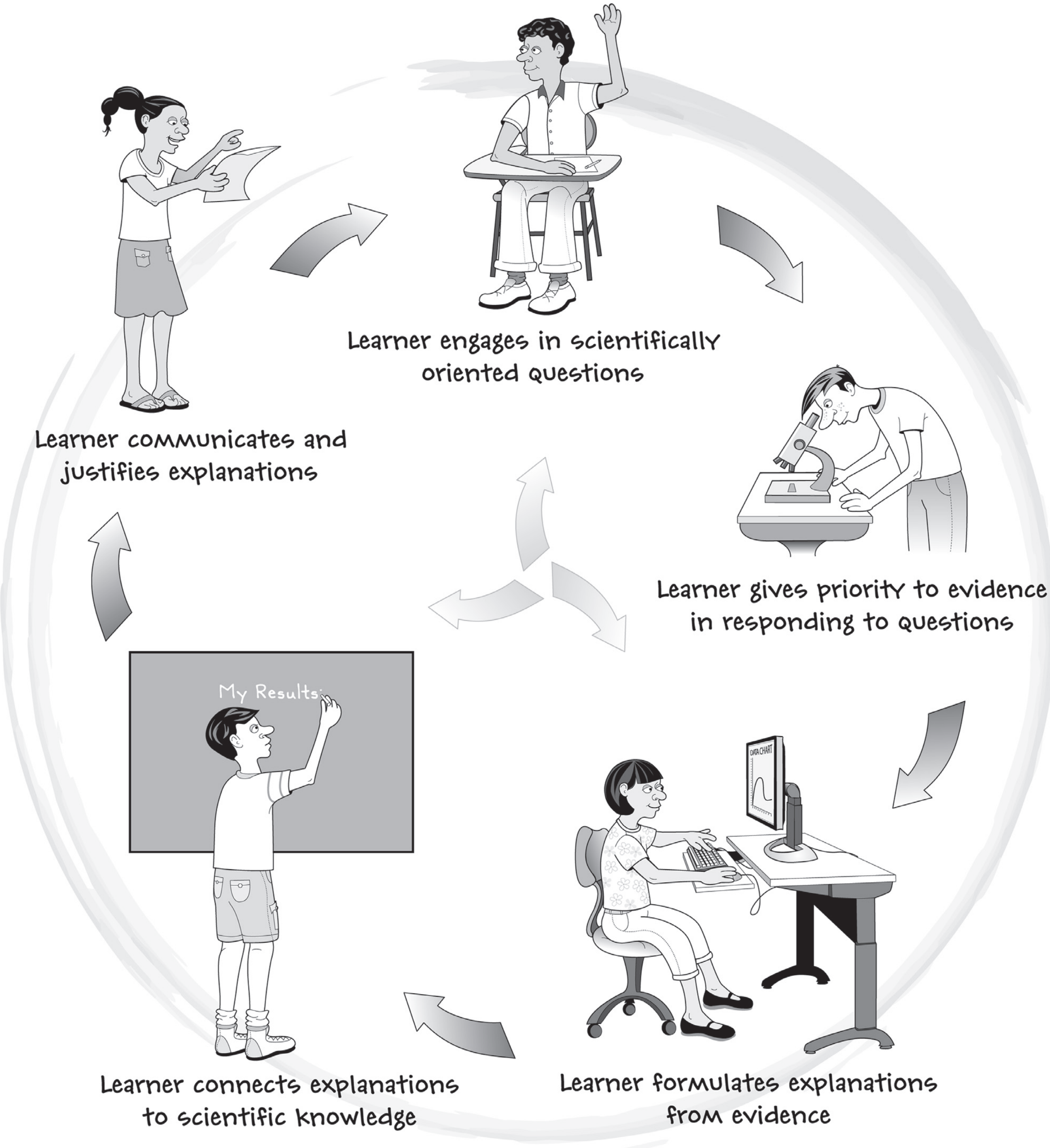
Think Aloud Strategy

Rot It Right uses the Think Aloud strategy throughout the unit. The Think Aloud is a teaching approach whereby the teacher makes important thinking and reasoning processes explicit for learners by describing aloud the thinking process involved in a certain activity. In this way, the teacher makes visible to students the otherwise invisible thought processes that are essential for scientific reasoning to occur. Example Think Aloud dialogs are included in many of the lessons.

Think-Pair-Share

Think-Pair-Share is a cooperative learning technique that allows students to think before they respond to a prompt, to test their response on their partner, and then to share their response (possibly revised) with a larger group. Specific instructions for implementing the Think-Pair-Share strategy are discussed in the Immersion Unit Toolbox. *Rot it Right* uses this technique throughout the unit.

SCIENCE INQUIRY MAP



Adapted from the National Research Council. 2000: Inquiry and the National Science Education Standards. Washington D.C.: National Academy Press

SCALE SYSTEM-WIDE CHANGE FOR ALL LEARNERS AND EDUCATORS

Instructional Timeline

Step	Lesson	Class Time	Key Concepts
Step 1	Terraqua Column Investigation	60 min	Producers require sunlight for growth and development.
	The Role of Producers	45 min	Producers convert sunlight into energy that can be used by living things.
Step 2	Food Chains and Energy Transfer	45 min	Organisms need matter to live and grow. Energy is transferred from the sun to producers and from producers to consumers.
	The Role of Consumers	20 min	Consumers get energy by eating producers or other consumers.
Step 3	Observing Decomposition Columns	45 min	Ecosystems can be characterized by their living and nonliving components.
	Designing a Decomposition Investigation	60 min	Scientific progress is made by asking meaningful questions and conducting careful investigations.
	Column Construction and Initial Data Collection	75 min	Scientists collect quantitative and qualitative data to support explanations.
	Decomposition Data Collection	30 min	Scientists collect measurements and observations in order to formulate and justify explanations.
Step 4	The Role of Decomposers	30 min	Decomposers are consumers that recycle matter from plants and animals.
	Creating Food Webs	60 min	A food web illustrates the transfer of energy among multiple food chains in an ecosystem.
Step 5	Developing Evidence-based Explanations	45 min	Scientists develop explanations using observations and what they already know about the world.
Step 6	Waste and Recycling	20 min	In decomposition, dead matter is broken down and recycled by living organisms.
	Reducing Waste	60 min	Not all waste material can be recycled through the natural process of decomposition.

Unit Advance Preparation

Before beginning this unit, you, as the teacher, must prepare demonstration Decomposition Columns and Terraqua Columns. The Decomposition Columns are for student observation and the Terraqua Columns grow radishes for a producer investigation. The Terraqua Columns provide a means for students to study plant growth through a class investigation in Step 1. Decomposition Columns are used later in this unit, beginning in Step 3. Because they require two weeks to begin the decomposition process, the demonstration Decomposition Columns must be completely assembled at least one week before beginning Step 1.

Ask students to start collecting bottles 4–6 weeks in advance to ensure that you have plenty of bottles to work with. Terraqua Columns require 2-liter plastic bottles. Decomposition Columns require 16 oz. plastic bottles. Make sure that a few extra bottles are available for student groups that encounter a problem while constructing the columns and need to start over.

The following sections provide descriptions of how to prepare materials for, and construct the Terraqua Columns and the Decomposition Columns.

Terraqua Column Preparation

Before beginning Step 1 with the class, you must prepare the materials for the students' Terraqua Column investigation. You need to assemble three columns ahead of time, adding all but the water and radish seeds. The fourth column needs all the materials prepared ahead of time, but is assembled with students during Step 1 Lesson 1 as part of the experiment set-up. Advance preparation saves more instructional time for designing the investigation and observing the columns.

To prepare the columns, use the instructions provided on *Teacher Page 1.1a: Terraqua Column Construction,* which you can find with the Step 1, Lesson 1 materials.

Decomposition Column Preparation

Decomposition Columns are used twice in this Immersion Unit. For best results, allow the columns to sit for at least two weeks before beginning this lesson. Usually, Steps 1 and 2 take about 2 weeks, so you must build the Decomposition Columns before starting Step 1 of the unit.

Using a mixture of organic materials, such as grass clippings, green leaves, soil, small critters, fruit, and vegetable peels will ensure a lively column. Fruit and vegetable peels provide the most dramatic results. DO NOT include any dairy or meat products. The high fat content in these products causes a horrible smell as they decompose.

The columns can be used to compare the relative rates of decomposition between organic and inorganic materials. One column could contain items commonly found in the garbage or a landfill, such as plastic utensils, straws, Styrofoam cups, and paper. These items will not change much over the course of the unit and provide the context for an interesting discussion about waste disposal problems.

Once the demonstration columns are assembled, set them out in the classroom to initiate student interest. Preferably, place columns near a window, but somewhere out of direct sunlight. Try to find a place with a relatively consistent temperature. Do not place on top of a heater or air conditioner. Keep the contents of the columns moist to aid the process of decomposition. Check the bottles every few days and add a small amount of water as needed.

For specific directions on assembling the Decomposition Column, refer to *Student Page 3.3A* included with lesson 3.3. That procedure uses 16 oz. bottles. To use larger 2-liter bottles, please refer to www.bottlebiology.org for more information on construction with 2-liter bottles.

Each column needs 1 cup soil and between 1/8 and 1/2 cup of water. Vary the ingredients in each column by choosing a few from the following list.

Suggested ingredients for each Decomposition Column:

- 2–4 isopods (pillbugs)
- 1 radish
- 1 apple core
- a penny
- a twig
- 2–3 green leaves
- corn husk
- 1 handful of grass
- 1 banana peel
- 2–3 packing peanuts
- a candy wrapper
- a paperclip
- 2 brown leaves (dead)
- feather

STEP 1

Overview

This step provides an opportunity for the teacher to model the process of scientific investigation, including how to ask questions, design an experiment, collect data and build explanations. Using Terraqua Columns, students participate in a class experiment to investigate the role that sunlight plays in the growth and development of plants (radishes). Students make brief, regular observations of the radish experiment and use these data to develop evidence-based explanations that support the investigative question. Student observations and explanations are then reinforced by a short reading on the important role producers have in an ecological system.

Lesson 1

Terraqua Column Investigation (60 min)

Lesson 2

The Role of Producers (45 min)

Step 1 – Lesson 1 Snapshot

Key Concept

Producers require sunlight for growth and development.

Evidence of Student Understanding

The student will be able to:

- identify prior knowledge about plant growth and development;
- develop questions about the role of the sun in the growth of plants;
- record observations to document and prioritize gathered evidence.

Time Needed

60 minutes

Materials

For the class

- 3 prepared Terraqua Columns
- 1 set of materials for a 4th Terraqua Column
- 2 cups soil
- 4 cups water
- 40 radish seeds

For each student

- science notebook
- copy of *Student Page 1.1B: Observations*
- rulers

Key Words

experiment, investigation, control, variable, observation, data, producer, energy, ecological system

Terraqua Column Investigation

1. To set the tone for this investigation as an exploration, generate a class discussion and class list about what plants need for growth and development.

2. Use the Think Aloud technique to model how to refine a wondering into a good scientific investigation. From the students' list about what plants need, form the question—What affect does sunlight have on radish plant growth and development?

3. Continue the Think Aloud to model assembling the Terraqua Columns using proper experimental procedures, and designing an experiment that has only one factor that is varied.

4. Have students record and explain their predictions for each set of columns for later reference.

5. Guide students in recording their initial observations on *Student Page 1.1B: Observations* and in their science notebooks.

6. Encourage students to carefully observe the columns at least three more times over the next 7–10 days.

7. Use the REAPS throughout and after the lesson as appropriate.

REAPS

R – What factor is varied in our experiment?
Sunlight.

E – Why do we try to control all the conditions in our experiment except the amount of light they receive?
Because then we will know that any differences in how the plants grow will be from the different amounts of light they received.

A – What is another factor that could have varied in your class experiment?
Water, soil type, temperature.

P – What will happen to the radishes grown without sunlight? Why?
Encourage students to include a logical explanation for the prediction.

S – How is what you did in your class experiment similar to other experiences you have had with plants?

Background Information

Scaffolding Student Learning

This lesson is the foundation for the more student-directed investigations found later in this unit. The goal of this lesson is for students to see and hear the scientific way of thinking about questions, evidence, experiments, and explanations. Using the Think Aloud technique helps make these ideas explicit to students. The Immersion Unit Toolbox provides general information on using Think Alouds and this lesson's Implementation Guide provides an example Think Aloud script for this lesson. There is no need to follow the example script exactly. It is simply a representation of a Think Aloud that worked well for others teaching this lesson, and exemplifies a high quality Think Aloud that helped make scientific thinking explicit to students. Many field-test teachers have found that practicing how they were going to present the Think Aloud ahead of time helped increase their comfort and effectiveness in using this technique with their students.

About Terraqua Columns

Terraqua Columns are a growing system that can be described as a physical model of the natural world. Scientists often use physical models of natural ecological systems, some similar to the Terraqua Columns, to conduct investigations because it is often not possible to conduct scientifically controlled experiments in nature.

The Terraqua Column has four basic components: soil, water, air, and plants. Plants grow in the upper portion of the Terraqua Column by taking nutrients from the surrounding soil and, with the aid of the wick, take water and other substances from the aquatic portion below. Radishes are recommended for this investigation because they germinate and grow quickly, providing many opportunities for observations. Water added to the terrestrial section on top will move down through the soil and drain into the aquatic section,

Teacher Preparation

This lesson requires 4 Terraqua Column as follows:

- Prepare materials for 1 column. Use this column to demonstrate the entire column construction process.
- Prepare 3 columns for planting in advance, including the soil, but without the radish seeds and water. Use these columns to demonstrate the rest of the investigation process, to make the demonstration more efficient, like a cooking show.

Refer to the *Teacher Page 1.1a: Terraqua Column Construction* for details on constructing the columns and the Implementation Guide for details on how to model their construction with students.

For demonstrate planting, you need:

- a few cups of soil,
- 40 radish seeds,
- a few cups of water,
- a measuring cup, and
- a cardboard box (typing paper size works well).

Begin this lesson at the end of the week, on a Thursday or Friday, so that seeds can germinate over the weekend, and students can make observations and collect data during the following week. Radish seeds will sprout in approximately four days.

preventing the plants from becoming over-watered.

Experimental Design for the Terraqua Columns

In this investigation, students examine the effects of sunlight on plant growth and development. The investigation has two primary purposes:

1. To reinforce for students in a very concrete way that plants need sunlight because that is key to understanding the transfer of energy and cycling of matter.

2. To introduce to students the thinking that goes into asking a scientifically oriented question and designing and conducting an experiment to look for an answer.

In this experiment, the varied factor will be the amount of sunlight the Terraqua columns receive. All other components including the amount and type of soil, water, seeds, and temperature need to be kept the same (controlled) for all columns.

Scientific Observations and Illustration

If this is the students' first experience with recording scientific observations, spend some time discussing a protocol for recording observations before students observe the columns. Encourage students to use as many descriptive terms as possible in their written descriptions and to use colors, labels, and an appropriate scale in their scientific illustrations. Sometimes students have a hard time differentiating from artistic drawing and scientific illustration. Remind them that when drawing something scientifically, the goal is to draw only what they see and to do so as accurately as possible.

Good written notes and illustrations help students assess their own progress and provide evidence for developing scientific explanations about what they have observed. Encourage students to ask many questions about the columns as they arise and to record both questions and ideas about possible answers in their science notebooks.

Implementation Guide

1. Introduce this unit by explaining that the class will be exploring over the next few weeks how a wide variety of organisms live together and get what they need to survive and develop. Consider starting with a quick class discussion about what humans need to survive, so students have an opportunity to practice with a familiar organism. Then, ask students to think on their own for 2 minutes about what plants need to live and grow, and to write or draw a picture that represents their ideas in their science notebooks. Have students use their notes to contribute to a class list of what plants need. Use this list as a formative assessment to determine students' prior knowledge about plants and what the basic needs are for living organisms to survive.

The goal of this discussion is NOT to generate a correct list of things that plants need; rather it is to allow students to WONDER about what plants need to live and grow. This way there is a reason to investigate what happens if plants do not get sunlight. Guide the discussion so that by the end, the class has listed and wondered about whether plants need water, nutrients, air, and sunlight to survive. See the sections below for suggestions on how to facilitate the discussion when students do not readily mention these four basic needs.

- If students have not identified sunlight as a possible plant need, ask students: Where do you remember seeing that people usually plant flowers to grow outside, or put houseplants to grow indoors, and why? You might also ask: Where do plants get the energy they need to grow and live? If students have trouble with the idea that plants need energy, remind them that plants are (like humans) alive, and ask how humans get energy to live and grow. Once they identify that what we eat provides us with the energy we need to live and grow, have students relate this to what plants need to "eat." Prompt with questions like: Do plants "eat" food to get their energy? Do plants have a structure to eat food with, like a mouth?
- If students did not identify air as a plant need, tell students to hold their breath for several seconds. Then, ask: What need were you depriving yourself of? Do plants also need air? How do you know that plants need air?
- If students identify that plants need soil rather than nutrients to survive, ask them to think about how they know plants need soil, or try a questioning path like: Do you know of any plants that live without soil? What about kelp? It floats in the ocean. Hydroponic gardens are grown without soil. How do those plants survive if they don't have soil? What does soil provide to the plants that live in it? Where do plants that don't live in soil get their nutrients?
- If students identify things like a good habitat, tender loving care, or an insect-free home as plant needs, ask students to think about whether plants need these just to survive or to thrive. Remind students that plants will survive if they meet their basic needs. Once their basic needs are met, other factors may allow them to thrive. Then, question them as to whether or not their idea was something that is required for survival or is needed to thrive.

2. Explain to students that the class is going to conduct a scientific investigation to explore one of the ideas from the class list about plants' basic needs. Explain that the goal is to gather evidence about what plants need to grow, develop, and be healthy. Explain, also, that they will practice how to behave and think like scientists. An example for how to explain this to students is described below.

- To investigate our ideas about what plants need, we are going to conduct an experiment. Scientists often use evidence gathered from experiments to help them explain what they see and wonder about. They value evidence-based explanations more than explanations that don't have any evidence. To develop evidence-based explanations, we need to behave and think like scientists. For this first investigation in this unit, we will work together as practice for all of us about behaving and acting like scientists. In the next few weeks, you will design and conduct your own scientific investigations, so pay close attention.

In this activity, the class investigates a predetermined question to ensure that the science content learned from the investigation provides the foundation for understanding the sun as the primary source of energy for food chains. The question is, "What affect does sunlight have on radish plant growth and development?" Students do not need to know that the question was predetermined; instead use a Think Aloud to model how you might have developed this question.

The Immersion Toolbox section *Engaging in Scientifically Oriented Questions* describes the process of refining "wonderings" into scientifically oriented questions in general. The Toolbox also provides general information and a description of the characteristics of the Think Aloud strategy. See the *Supporting Student Inquiry: The Think Aloud Strateg*y section. The following paragraphs provide an example of how a Think Aloud may look in this specific investigation.

- I have noticed that the plants in my front yard seem to grow bigger and taller, and make flowers more often than the ones in the back yard. Let's take a minute and think about what kinds of questions I could ask about this difference in plant growth. Write down a few questions in your science notebooks that this observation causes you to wonder about.

Allow students to share the questions that these observations spark in their minds. This is an opportunity to assess your students' current abilities at asking scientific questions. To build student skills in this area, reinforce the aspects of student questions that make them good scientific investigation questions (e.g. limiting variables, building off prior knowledge, or being manageable in terms of materials or time).

If students suggest a hypothesis instead of a question, work with them to change their statements into questions. For example see this teacher/student vignette:

- You shared your idea that the plants made more flowers because I watered them more. Is that a question that we could investigate or a statement about what you think the explanation is? The idea was a statement. How could we change that statement into a question that an experiment would be able to gather evidence about? We could ask "Does having plenty of water make plants grow better?" Another way to say that might be "How does the amount of water affect plant growth?" That way we don't hint at our idea for the explanation in our question.

After students share their questions, explain that while there are a lot of interesting question to investigate about plants, there is one particular question about sunlight that you want to explore right now. Continue the Think Aloud to model how you might have developed and refined your question. For example:

- I personally was wondering if I could design an experiment that would provide me with evidence about this question "What effect does sunlight have on radish plant growth and development?" I was interested in this particular question because I don't think the plants in the front yard that are doing better get the same amount of sunlight. To test this idea I was thinking that I could somehow block the sunlight from the plants that were doing really well, and see if they started to die. The problem with that test is that I really don't want to kill those plants because it would be expensive and difficult to do. Outdoors, there are just too many other things besides the amount of sunlight that

I would have to control to be sure that light was causing the difference.

- Instead, I thought we could do a scientific investigation here in the classroom that could provide us with some evidence that might help explain what is going on in my yard. Scientists often do experiments in the lab and then use that evidence to generalize an explanation for something in the natural world. We could behave like scientists and do a similar thing.

- I thought carefully about how we could conduct our investigation in the classroom. My initial question was "How come the plants in my front yard grow better than the ones in the back yard?" but we can't investigate that question easily. There were too many factors to consider. So, I revised my question and asked, "Does the amount of sunlight affect how the plants in my yard grow?" But even that question was too difficult to conduct. It would be too expensive and difficult to somehow block sunlight from just some of my plants yet keep the amount of water they get the same. I needed to revise my question so that we could do the test in the classroom and control as many things as possible. So, I refined my question into "What affect does sunlight have on radish plant growth and development?" Notice how I was specific about the type of plant—a radish—and what exactly I was going to test—the affect of sunlight. I picked a radish, instead of the kinds of plants I have in my yard, because radish seeds are inexpensive and they sprout quickly. This way we can start gathering our evidence really soon. Let's write the question I decided to investigate in our science notebooks so we can reference it later as our investigation progresses—What affect does sunlight have on radish plant growth and development?

3. Show students the three Terraqua columns that were prepared ahead of time. Explain that the class will use these columns to help them investigate the question "What affect does sunlight have on radish plant growth and development?" Use a Think Aloud to model the construction of the last column and how to think and behave like a scientist. For example:

- We will conduct an experiment with these four Terraqua Columns to help us gather evidence to explain our question. I made three columns ahead of time, but I made them in exactly the same way that I am going to make this one. (Build the column now, the same way you built the first three columns.) When we do a scientific experiment, it is important to keep as many things the same as possible. This column is the same size and shape as the other columns, and I am going to add the same amount of soil and make sure the wick is in the middle of the soil, just like I did on the other columns. Now, I am going to add 10 radish seeds and then sprinkle a thin layer of soil over the top of the seeds. Finally, I will water the columns with 1 cup of water, making sure I get the top completely wet.

- Now that I have the columns prepared all the same way, I am ready to think about my experiment. If I want to figure out if sunlight affects radish growth, what will I need to do with my columns? Give some light and others no light. How many should I keep in the dark inside this cardboard box? I want to use the same number in the light as in the dark, so I will put two in the dark and two in the light. Which two should I put in the dark? It doesn't matter because they are all the same. Okay, let's label each bottle with a 1, 2, 3, or 4, and then put columns 2 and 4 in the dark and keep 1 and 3 in the light. Why do you think I made 4 columns instead of just 2? I could have made 2 and put one in the light and one in the dark. Because something might go wrong with one of them, you wanted to have a back-up. This is also like something scientists do. Scientists often do multiple runs of the experiment so that in the end they have some data even if something goes wrong. Scientists also make multiples because it gives them more evidence to help them develop a stronger explanation.

- The one thing that is going to be different about our bottles is whether they get sunlight. What did we take care to make sure was the same in all four bottles? The amount of soil, the size of the bottle, the amount of water, and the number of seeds. I was so careful to keep everything else the same because if I see a difference in the two columns I want to be able to say what I think caused it. If everything else is the same, it is probably because one was in the dark and one was in the light. If I had different amounts of soil in each bottle, I wouldn't know if it was the amount of soil or the amount of light that mattered.

4. Explain to students that scientists often make predictions about their experiments before they begin. Ask the students to think about the columns and predict what they think will happen to the columns in light and those in the dark. Have students individually record their prediction in their science notebook and the reasons they believe that prediction so they can refer back to it later. Circulate among students to be sure they write both a prediction and reason for the prediction. Having students each think about and record a prediction often increases individual buy-in and heightens curiosity.

5. Explain that when scientists conduct an investigation they do three things: They ask a good question, they take care to control as many factors as they can, and they make a plan for how to collect data to use as evidence for explaining their question. Ask the students to think about what kinds of data they could collect from the columns to determine if light is affecting plant growth and development. Allow students a few minutes to individually brainstorm some things they might look for in their Terraqua Columns that would help them determine how well the plants are growing. Then, allow students to share their ideas with the class.

As students suggest characteristics, ask them to think carefully about how they will measure that characteristic and how their measurements can be consistent. For example if students say they will measure height or color, get them to think more specifically about how they will do the measuring. Try questions like:

- Where will you stop and start your measurement? Will you measure from the top of the soil to the first leaf stem or from the bottom of the column to the tallest part of the plant, or some other place?
- Do you think it is important to use the same unit for all your measurements?
- In science, is it better to use inches or cm?
- How will you collect data on what color the plants are? Is there any way to make your method of describing the color more consistent or accurate?

Explain that some characteristics such as height, number of leaves, length of leaves, and number of sprouts can be measured and recorded numerically. Other characteristics such as color and texture can be recorded as an observation but are not directly measurable and are therefore more difficult to record in a consistent way. Both types of observations are valid ways to study the columns. One way to improve the consistency in color measurements is to use a set of crayons. The students can try to match the plant's color to a crayon color. This also works with a color wheel or paint sample cards from hardware stores.

As a class, agree on two or three characteristics that students will look for in the columns as a way to help answer their investigation question. Hand out one *Student Page 1.1B: Observations* to each student. Have students write in the characteristics (one for each table on their student page) and the numbers of the bottles that are in sunlight and the numbers of bottles that are in the dark (from the column labels).

Explain to students that scientists are very careful about recording their observations accurately because their observations will be used as evidence when they try to develop explanations about their question. If their data is inaccurate, messy, or inconsistent, this interferes with them making good explanations. Instruct students that since they are trying to do a similar thing to what scientists do, make an evidence-based explanation, they will need to make sure their data is as accurate as possible.

Ask the students what they will need to pay attention to when they collect their data. They may suggest things like the method of collecting data, recording the date, making their notes legible. Demonstrate how to record observations on the student page. Remind them that when they make observations it is important to look very carefully, so that they will notice even very small changes.

Divide the class into two groups, and give each group one bottle that will be placed in the sunlight and one bottle that will be placed in the dark. Ask students to record their first sets of observations on each bottle. Then, place Bottles 2 and 4 in the dark and Bottles 1 and 3 in the brightest sunlight available.

6. Over the next week or so, have students make at least three more observations of the columns and record the data on *Student Page 1.1B: Observations*. Observations can be done as a whole class or in two groups, giving each group one column that has been in sunlight and one column that has not been in sunlight. Be sure each group observes the same columns each time. Allow approximately 10 minutes for observations. Do not allow Columns 2 and 4 to be kept out in the light for any longer; this could affect the results of the investigation.

During the observation process, travel around the room and remind students of some guidelines for observations, including recording questions and general observations in their science notebooks, practicing good data collection techniques, and double-checking their work. For example, you might prompt students by saying:

- I heard you ask an interesting question about the color of the radish leaves. Did you record that in your science notebook?
- It sounds like you are having trouble writing down a description of your plant. Try drawing what it looks like in your science notebook and use crayons to get the colors as close as possible. That way it will be there for you to look back at later.
- These plants look like they are about twice as tall as the others are, but your measurement says they are shorter. How can you explain that? Did you use the same units on the ruler?
- What do you notice about this piece of data? Does it seem to make sense with the other data you have collected? Are you sure that you recorded it on the right line?

The Immersion Unit Toolbox section *Science Notebooks* provides general information about implementing the use of science notebooks.

7. Use the REAPS throughout and after the lesson as appropriate.

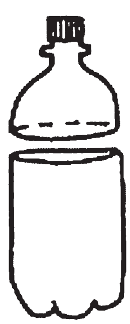
Terraqua Column Construction

Materials

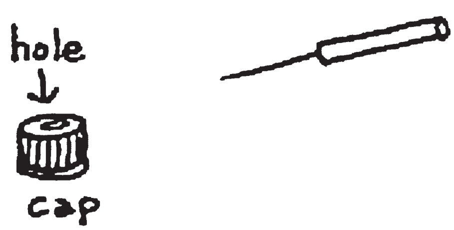
- 2-liter bottles with caps
- wicking material—fabric interfacing or cotton string
- soil, Water, Radish seeds
- ruler
- utility knife
- scissors
- awl, darning needle or nail

1. Remove the labels from each bottle. (An old hair dryer can be used to heat up the glue on the label, so that it is easier to remove.)

2. Cut the bottle approximately 4 cm below the shoulder (where it begins to round).

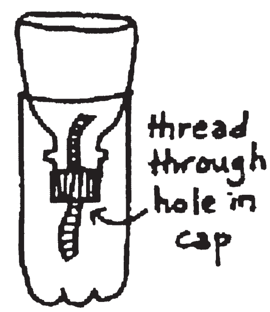


3. Using a nail or an awl, puncture a 1 cm hole into the bottle cap.



4. Place the cap on the top of the bottle and thread a thoroughly wet wick (approximately 15 cm) through the bottle top.

5. Invert the top and set into the base of the bottle. Be sure the wick reaches the bottom of the reservoir and thread loosely through the cap.



6. Add soil to the top chamber. To be effective, be sure the wick runs up into the soil, not along the side of the bottle.

Student Page 1.1B: Observations

Name: ______________________________

Date: ______________

Terraqua Column Observations

Characteristic ________________________

Date	Column with Sunlight Column #_______	Column without Sunlight Column #_______

Characteristic ________________________

Date	Column with Sunlight Column #_______	Column without Sunlight Column #_______

Key Concept

Producers convert sunlight into energy that can be used by living things.

Evidence of Student Understanding

The student will be able to:

- identify plants as producers that need sunlight;
- explain how energy is stored in plants;
- compare observations to formulate explanations;
- develop explanations based on evidence from an investigation.

Time Needed

45 minutes

Materials

For the class

- *Matter and Energy Chart*

For each student

- completed *Student Page 1.1B:Observations*
- science notebook
- copy of *Student Page 1.2A:Producer Power*

Key Words

evidence, explanation, producer, consumer, organism, food, energy, matter

The Role of Producers

1. Refer the class back to the question being investigated, What affect does sunlight have on radish plant growth and development?

Guide students in analyzing the data from the class experiment, searching for patterns, and developing initial explanations about what they see. To reinforce their ideas, have students record their response to this question in their science notebooks: What did our experiment tell me about the role of sunlight in radish growth?

2. Explain that scientists value evidence gathered from experiments, and they also value other evidence related to their questions that comes from talking with other scientists and reading books and articles. Share that you have a short article related to their question that can provide additional evidence to help them develop even richer explanations.

3. Have students read the short article on producers, check for understanding, and search for evidence related to their investigation question.

4. Allow students to work in pairs, and then as a class, to develop evidence-based explanations about sunlight and plants. Assist them in using both evidence from their investigation and the reading.

5. Use the REAPS throughout and after the lesson as appropriate.

REAPS

R – What differences are observed among the four Terraqua Columns?
Those in light are different than those in the dark.

E – What patterns or trends are evident from the observations?
Answers may include trends in the height of the plants in the dark compared to the plants in the light, color of the leaves, thickness of the stems, direction the plants are growing.

A – Where does the energy that living plants use come from?
Sunlight.

P – Where do other organisms get the energy they need to live?
From eating producers or other consumers.

S – Think about and write in your Science notebook what else you might need to know to predict where organisms get energy to live.

Background Information

Expected Experimental Data

The radish seeds in the Terraqua Columns without sunlight will still grow; in fact, these seedlings will most likely be taller than the seedlings with sunlight. However, they will have an abnormal appearance. They will be pale in color, thin, and have smaller leaves.

Developing Scientific Explanations

In this lesson, students are involved in developing a scientifically accurate explanation to their investigation question, **What effect does sunlight have on radish plant growth and development?** and in learning what makes a strong scientific explanation.

They begin by analyzing the data collected from their investigation and use it to develop a preliminary explanation. Then, they evaluate that explanation in light of other scientific evidence (i.e. the information contained on *Student Page 1.2A: Producer Power*). Finally, they communicate and justify their explanation by discussing it in pairs and then as a class, and writing their own evidence-based explanation in their science notebooks. This process of explanation development is critical to students forming accurate understandings of the scientific content.

These Immersion Unit Toolbox sections provide detailed information designed to help teachers understand the importance of each step in the process of explanation development and provide tips and tricks for facilitating this process with students.

- Giving Priority to Evidence in Responding to Questions
- Formulating Explanations from Evidence
- Connecting Explanations to Scientific Knowledge
- Communicating Results and Justifying Explanations

Teacher Preparation

This is the last lesson in this unit that will require students to use the Terraqua Columns. It is recommended, however, that the Terraqua Columns be left in the classroom so students can make informal observations of them. If left to grow long enough (approximately 4 weeks) students will be able to harvest small radishes that have developed from the plants in the sunlight. Many students are not aware of the different parts of plants that we eat. The radishes without sunlight will eventually die. Add these to the Decomposition Columns.

Developing Vocabulary

Several readings in this unit introduce new vocabulary to students. Consider having students underline, circle, or highlight the important words in the article and discuss their meanings. Also, consider having students create a word list for the new vocabulary in their science notebooks to solidify their understanding of the words. Instruct students to copy the words into their science notebooks and write a definition in their own words.

Photosynthesis

In this lesson, it is important for students to understand that producers use the energy from the sun, carbon dioxide from the air, and water to produce living tissue. The tissue takes many forms—the roots, stems, flowers, and leaves. Plants also store food in certain parts for growth next year or as stored energy for times when conditions are poor for growth.

Although this lesson focuses on the importance of sunlight in providing energy for this process, producers need several other important ingredients to make their own food. Producers need carbon dioxide, water, nutrients from the soil, and sunlight to produce food. This process is called photosynthesis. Fourth grade students do not need to know the term photosynthesis. However, they do need to know that plants produce their own food.

In photosynthesis, producers use the carbon, hydrogen, and oxygen molecules found in carbon dioxide and water to make sugar. This sugar is what the plants use as food. It is a common misconception that plant matter comes from the soil. While the soil does provide important elements and minerals, the actual plant matter comes from the recombination of carbon dioxide and water powered by solar energy. This distinction becomes clear when thinking about floating aquatic plants that have no soil to grow in.

Carnivorous Plants

Since soil does provide important elements and minerals, plants need nutrient-rich soil for growth and development. Some plants have a special adaptation for living in nutrient-poor soil. Most commonly known as carnivorous plants, these plants have the ability to trap and digest insects. The insects provide them with the important elements and minerals they cannot obtain from nutrient-poor soil. The Venus Fly Trap and Pitcher Plant are examples. Carnivorous plants are still producers since they must produce their own food through photosynthesis. The insects they digest only provide nutrients that they cannot receive from poor soil. They are not a food source.

Implementation Guide

1. Remind students that they have been doing this experiment with the Terraqua Columns to help them collect evidence for developing an explanation to their investigation question. Tell them that they are going to work together as a class to analyze the data from their experiment and develop an initial explanation for their question, What affect does sunlight have on radish plant growth and development?

Have students take out and review their copies of *Student Page 1.1B: Observations* and other data and drawings they recorded in their science notebooks.

Gather the attention of the class and direct them to look at one specific characteristic at a time. For example, a process like the following can be used for each characteristic:

- First, ask students to discuss what happened to the one observed characteristic.
- Second, ask students to summarize what happened with that characteristic in one sentence. Next, have students write that sentence in their science notebooks.

After they have a sentence for each characteristic, ask them to talk with their neighbor about what this information tells them about the role of sunlight in plant growth and development.

Finally, write a prompt on the board like "What did our experiment tell me about the role of sunlight in radish growth?" and have students record the prompt and a detailed response in their science notebooks. Remind students that scientific explanations are more valuable when supported by a lot of evidence. Ask students to refer to specific evidence for their explanation, like the data from their experiment that lead them to form this explanation. Provide an example of how to state a logical explanation, give the evidence that supports it, and explain the reasoning you use for linking that evidence to the logical explanation. For example:

- I think that radish plants need light to grow and develop well because when they did not receive light in our experiment they developed leaves that were on average half the length of the leaves that developed on radish plants that we grew in the light.

2. Explain to students that, like scientists, they have used and given priority to evidence gathered from experiments in developing their explanations. Remind students that in science, explanations that are supported by evidence are stronger than those that have no supporting evidence. Usually, the more evidence a scientist has in support of an explanation, the better the explanation is. Engage students in a discussion about examples they can recall when having more evidence strengthened their position. For example, they may have found an adult more likely to believe an excuse that was backed by evidence than one with no evidence.

Point out that while scientists value experimental evidence, they also value evidence from other sources. Ask students to brainstorm some other sources of evidence that scientists might use when developing explanations. Students may identify things like talking with other scientists, watching videos of natural phenomena, or reading books.

Explain to students that often before or after scientists develop an explanation based on experimental work, they review what is already known about their question. Learning about what is already known helps when forming an explanation because the scientist can check to see if their explanation makes sense and is complete. Share that you have a short article related to the class' investigation question. Explain that students read this article to see if their explanation makes sense or can be strengthened.

3. Provide each student with *Student Page 1.2A: Producer Power*. Have students read the article on producers.

Note: If you are using the Developing Vocabulary strategy described in the Teacher Background section of this lesson, explain to students what procedure to follow when creating their word lists.

Check for student understanding of the article by asking students to do a Think-Pair-Share on these three questions and monitor their responses.

- What kinds of organisms can make their own food? Producers, plants, trees, flowers, vegetables, etc.
- Where do plants get the energy they need to make their own food? The sun.
- Where do plants get the matter they need to make their own food? The air, water, and nutrients.

  Then, have them review the article in light of their experiment. Guide students by asking questions like:

- Does our evidence support the idea that plants need sunlight to grow and be healthy?
- Which of our plants had matter available for growing? Which of our plants had energy available for growing?
- Do plants need both matter and energy? What did we learn from our experiment happens if radish seedlings don't get energy from the sun?

4. Refer students to their investigation question What affect does sunlight have on radish plant growth and development? and consider it in light of their evidence from the experiment and the article. First, have the students work in pairs, and then as a class, to develop an explanation for this question. Ask students to write down an explanation in their science notebooks. An example of a strong student explanation follows:

- Plants need energy from the sun to be healthy. Our experiment showed that radish plants without sun energy grow skinny and weak. They will grow for a while even if they don't have energy. But they won't look healthy and I think they are going to die soon. They are healthy with sunlight because they can make food. The reading says that plants are producers and can't make food without sunlight. The plants in the dark haven't had any food in a while.

5. Use the REAPS throughout and after the lesson as appropriate.

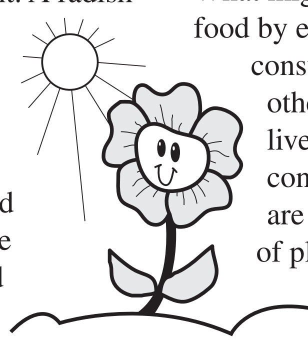
Producer Power

Do all living things need food? Yes, they do. Food provides energy to live and grow. All living things need energy. Without energy, organisms die. How do plants get energy to live and grow? Did you ever wonder how plants can get food without a mouth?

Plants do not need a mouth because they do not eat their food the same way animals do. Plants make their own food! Plants produce their own food. That is why we call them producers. But it takes energy to produce food. Where do plants get their energy? From the sun. They use that energy to produce food. Plants need this food to live and grow.

Plants can also store the food they make, to use later when there is no sunlight or when other conditions are not good for producing food. Plants can pass this stored food on to other living things. Think about some of the parts of plants you eat. A kernel of corn is the seed of a corn plant. A radish is the root of a radish plant.

Producers do more than produce food. Most producers release oxygen, too. Why is that important? Animals and most other organisms need oxygen to live. Plants, like radishes, use sunlight, water, and air to produce food and oxygen. Next time you eat or breathe, thank a plant!



Plants are not the only producers. Some types of bacteria and algae are also producers. A producer is any organism that can make its own food. Producers are very important. We could not live without them. Producers are the only organisms that can make their own food directly from sunlight and the matter around them.

Scientists use the name matter for the stuff that plants combine to make food. We say that producers take matter from the air, water and soil to make their own food. Producers use energy from the sun to make food from matter. When another living organism eats a producer, it gets the producer's matter and some of its energy. That is what happens when you eat a radish. You get the radish plant's matter and some of the energy that was used to grow that radish. All organisms that cannot make their own food depend on producers.

Many living things cannot make their own food. What might you call an organism that must get food by eating something? Scientists call them consumers. Consumers must consume, or eat, other organisms to get matter and energy to live and grow. Consumers have to eat other consumers or plants to get food. Humans are consumers. We consume many kinds of plants and other organisms. We are lucky to have producers, since we can't eat sunlight or air!

STEP 2

Overview

This step invites students to use their knowledge of how producers get energy from the sun and how consumers eat producers in order to make simple food chains. Students study food chains by (a) creating food chains from their Terraqua Column investigation, (b) creating food chains from the organisms that provide humans with an example breakfast, and (c) creating food chains for a variety of domestic and wild plants and animals.

Lesson 1

Food Chains (45 min)

Lesson 2

The Role of Consumers (20 min)

Step 2 – Lesson 1 Snapshot

Key Concepts

- Organisms need matter to live and grow.
- Energy is transferred from the sun to producers, and from producers to consumers.

Evidence of Student Understanding

The student will be able to:

- develop a food chain that shows how energy is transferred.

Time Needed

45 minutes

Materials

For the class

- breakfast pictures
- source organism pictures

For each pair

- 2 copies of *Student Page 2.1A: Food Chains*
- copy of *Student Page 2.1B: Organism Cards*
- pair of scissors
- science notebooks

Key Words

producer, consumer, organism, energy, matter

Food Chains

1. Use the food chain sun → radish → human to review the concepts that plants get energy from the sun and that by eating consumers they get the matter and energy stored in plants.

2. Post the Breakfast Ingredient Pictures on the board. As students identify the organisms that provide the food, replace the pictures with the Source Organism Pictures. Use a Think-Pair-Share to label each organism as a producer or consumer.

3. Develop two food chains on the board using these organisms. Model how the sun begins a food chain and explain that the arrows go in a specific direction. Have students record these on *Student Page 2.1A: Food Chains*. Discuss how energy and matter move in a food chain.

4. Have students work in pairs to arrange the *Student Page 2.1B: Organism Cards* to create additional food chains and continue recording them on their student page.

(continued on following page)

REAPS

R – What is the difference between a producer and a consumer?
Producers are plants and other things that make their own food. Consumers have to find food to eat.

E – What was the very first source of energy for this food chain?
grass → mouse → snake → hawk
The sun provided the energy that entered this food chain when a producer, the grass, used the energy from the sun to build food. Then the mouse ate the plant, and the energy was further transferred to the snake and then the hawk.

A – What does a consumer get by eating a producer?
The consumer gets energy and matter (tissue, nutrients, minerals, water, etc.) from the producer.

P – In what ways is a food chain not like real life?
In real life, more than one kind of animal uses a plant or other animal for food; there are many more interactions between organisms; consumers compete for their food with other consumers who eat the same things.

S – Think about what you learned about food chains and share your ideas with a partner. What did you learn from your partner that you did not know before? How has your thinking changed?

5. Review with the class the steps in creating food chains and the relationships that food chains explain. Introduce the Matter and Energy Chart and work with students to add new facts and concepts for each column.

6. Use the REAPS throughout and after the lesson as appropriate

Background Information

Food Chains: Transferring Energy and Cycling Matter

All living things depend upon energy and matter to live. This energy and matter moves from one organism to another through the **food chain**. Producers are the primary source of matter and energy for consumers. Producers use matter (carbon dioxide from the air, minerals and nutrients from the soil, and water) and energy from the sun to make their own food through photosynthesis. They use this food to create living tissues and to live. Plants, some bacteria, and some algae are all capable of this process. As producers, they provide food for many consumers.

Consumers eat producers or other consumers. They take in matter (plants or other animals) and break it down through the digestive process to release the energy they need to sustain life and to grow. Eventually, all animals and plants die and decay into the soil. Organisms called **decomposers** feed on this dead organic matter. They use some of the matter and energy to sustain their growth and daily energy needs. However, their specialized role in an ecosystem is that they also break down matter so that it is available for producers.

Food Chains: Arrow Direction

Students often have difficulty drawing food chain arrows in the proper direction. They know that the chicken eats the corn, so when they add an arrow to the diagram, they draw it from the chicken into the corn. However, the arrow in a food chain or food web is used to show the direction in which the energy is being transferred, not who is eating who. Here we suggest some strategies for dealing with this issue.

First, recognize that it may be related to how the students structure their sentences about who eats whom. They often start their sentence by saying the consumer and end with the producer. So, if they follow their statements, they start the arrow at the "chicken" and end it at the "corn," which is backwards. Encourage them to say things like "the corn is eaten by the chicken" or "the corn goes into the chicken's mouth" instead.

Model how to talk through drawing an arrow and encourage them to do the same. For example, "The energy from the sun (start the pencil at the sun) goes (pull the pencil over toward the corn) INTO (make the arrow point) the corn." Talk them through it each time an arrow is drawn.

Another strategy to make sure the arrow is going in the correct direction, is for the students to ask themselves, "Does this make sense?" "Does the energy go from the chicken to the corn?" Or "Does the energy go from the corn to the chicken?"

Matter and Energy Chart

Throughout this unit students are asked to create a class Matter and Energy Chart. The chart serves as a tool for recording key concepts and facts that students learn about matter and energy. It also provides a reference point for beginning discussions and a source of evidence for student explanations. As students learn more about matter and energy, encourage them to add things to the chart and to revise what is already listed on the chart. The chart is meant to be a fluid description of their understanding, so if they want to add more details to clarify or qualify an entry they should do so, providing they have evidence for thinking that way.

A simple table drawn on two pieces of chart paper is all that you need. Label one page "What we know about matter" and one page "What we know about energy."

Implementation Guide

1. Draw a simple food chain: sun → radish → human on the board. Remind students that when sunlight shines on the radish, the radish uses that energy to make its own food. Ask students to recall from the reading about producers and previous class discussions what else plants need to make food besides energy from the sun (matter) and where plants get their matter (air, water, nutrients).

Engage students in the discussion by asking them to explain what happens to the energy and matter stored in the radish when a human eats it. Guide the discussion to explain how when a human eats the radish the matter and energy from it go into the human. Check that students understand that by eating something, a consumer gets the matter and energy stored in the organism it eats. Be sure they can explain what matter and energy allow organisms to do. For example, organisms need matter to grow bigger, develop, and repair injuries, and they need energy to breathe, digest, move, play, study, think, etc. Review the students' entries on the Matter and Energy Chart as appropriate.

2. Have students imagine that they ate a big healthy breakfast this morning, including warm corn tortillas, eggs, sweet apple slices, and ice-cold milk. Tape the Breakfast Ingredient Pictures on the board. Ask the students what their bodies would have gotten from eating this breakfast. Reinforce any student ideas that have to do with matter and energy.

Then ask students to identify where these breakfast items came from. As students correctly identify the organism that provides that particular type of food, replace the food picture with the Source Organism Picture.

Use a Think-Pair-Share strategy to label organisms as either producers or consumers. The Immersion Unit Toolbox provides a general description of this strategy and the following paragraphs explain how it would look in this particular lesson.

Have the students write a list of these source organisms in their science notebooks (corn, chicken, apple tree, and cow) and label each one as either a producer or consumer. Then, ask students to compare their ideas with a partner, discuss their explanations, and revise as needed. Explain that this process of using evidence, discussing explanations, and revising explanations is a technique that scientists use to develop stronger and more accurate explanations. Travel around the room and reinforce student explanations that are based on evidence and challenge those that are not. For example, consider using prompts like:

- Let me see if I understand your idea, you labeled a cow as a consumer because you have seen cows eating grass for food, and that it couldn't be a producer because it doesn't make its own food. Your evidence for this idea was something you have seen—the cow eating grass—and something you had read—that producers make their own food. Does your partner agree with your explanation?
- I heard your partner say that she labeled corn as a producer because she knows it is a plant that grows from a seed and doesn't have a mouth. Like a scientist, she used evidence in her explanation. What evidence did you have for labeling corn as a consumer?

As a class, work to label each Source Organism Picture as either a producer or consumer. Encourage students to explain the evidence that made them decide it was either a producer or consumer. Remind students that the more evidence there is, the more likely it is that a strong, logical scientific explanation can be made.

3. Guide the students in forming a food chain with some of the source organisms. See the example discussion below:

- Let's look first at the corn plant. I heard some convincing evidence that corn was a producer. If corn is a producer, where does it get its energy? The sun. (If students struggle with this, ask them where the radishes that they grew earlier got their energy?

- Draw a sun on the board a few inches to the left of the corn. Draw an arrow that indicates how the sun's energy moves into the corn. Talk students through it explicitly. For example,

- The energy from the sun (start the marker at the sun) goes (make a line over toward the corn) INTO (make the arrow's point) the corn.

Sun → Corn

Try this series of questions to determine how well students understand what the arrows represent.

- What would it tell you if the arrow was going the other way, from the corn to the sun?

- Could that be possible? Can corn give energy to the sun?

Explain that talking themselves through how to draw the arrow is a good strategy for checking their own work to see that arrows are drawn the correct direction. Another strategy is to stop after drawing the arrow to ask: Does this arrow make sense? Is that the way the energy goes?

Hand out *Student Page 2.1A: Food Chains* and ask students to record this food chain on the first line.

Now have the class look at the other organisms listed on the board and identify an organism that might get its energy from corn. Once students identify either the chicken or the cow, repeat the arrow-drawing process using the same strategies.

Sun → Corn → Cow

Explain to students that this diagram is something that scientists call a food chain. It shows the way that energy goes from the sun to a producer, and the matter and energy stored in the producer go to a consumer. Ask the students to think of another organism that they could add on to their food chain. An example dialogue follows:

- What other consumer might we be able to add onto our food chain? In our breakfast example, who ate something from a cow? Humans. Display the Human Picture from the set of Source Organism Pictures.

- Are humans producers or consumers? Consumers. Who can give me a piece of evidence for why I ought to label humans as consumers? We have a mouth. We can't make our own food. We have to consume things to live. We eat plants, and producers don't eat.

- Listen to how I talk myself through adding humans to the food chain. I am going to ask myself what is going into the human? Matter and energy from the cow's milk. So, I start my arrow at the cow and draw it toward the human, and say "the energy and matter from the cow goes into the human". Then, I step back and double check my work. I ask, "Does how I drew this arrow make sense? Is that the way the energy and matter go?"

Sun → Corn → Cow → Human

Repeat the entire process with another food chain, so that students have a chance to practice before generating their own food chains. Have students record this food chain on the second line of *Student Page 2.1A: Food Chains*. This way they will have two correct food chains as reference for the next section of this activity.

4. Distribute a set of *Student Page 2.1B: Organism Cards* to each pair of students. Explain that the first step is to label each organism as either a producer or consumer. Remind them to think about evidence when making their decisions. Explain that next that they will cut the organisms out and work with their partner to develop food chains from the organisms on these cards. Instruct partner groups to make as many food chains as possible. Travel around the room to:

- Model talking through the direction of the arrows and ask if the direction they have placed arrows makes sense.

- Make sure students record their food chains on their student page so they have practice writing down food chains.
- Challenge students who are succeeding to make their chains longer by providing them with blank cards. They can draw different organisms on the cards and use them to lengthen their food chains. Remind them that they need to label the cards as producers or consumers.

When a group has an incorrect food chain, guide them to discover their own error. Explain what their food chain tells you about the way matter and energy moves. Then, prompt them to explain the food chain. In their effort to explain, it usually becomes clear to them that it is not quite right. This might sound like:

- This diagram tells me that the crow's energy goes into the corn and the corn's energy goes into the sun. Can you explain to me how that works?
- This diagram tells me that the sun is food for the chicken, and that chickens are food for humans. I see how a human might eat a chicken, but I'm struggling with how the sun could be food for a chicken. Can you try to explain that to me?

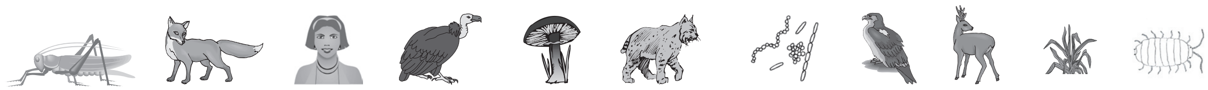
5. After students have several food chains on their student page, have them share some of their diagrams with the class. Review the steps for creating food chains—arrow direction and transfer of energy from the sun to producers, producers to consumers, and consumer to other consumers and the concept that organisms need both matter and energy to survive. Food chains show the movement of matter and energy from organism to organism. Guide student attention to the Matter and Energy Chart. Review their previous ideas (revise if needed) and add any new pieces of evidence that the students identify having learned about matter and energy from this lesson.

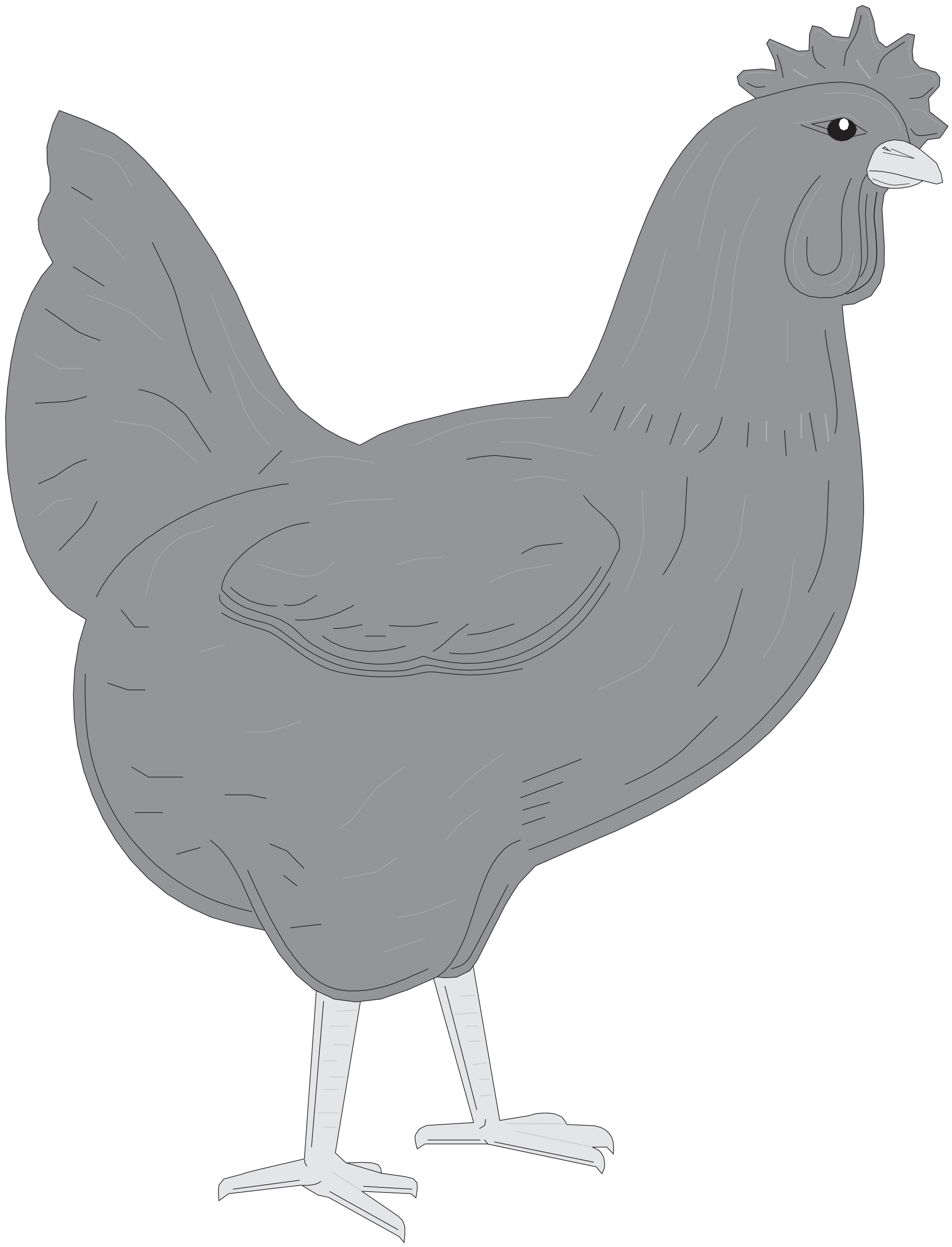
6. Use the REAPS throughout and after the lesson as appropriate.

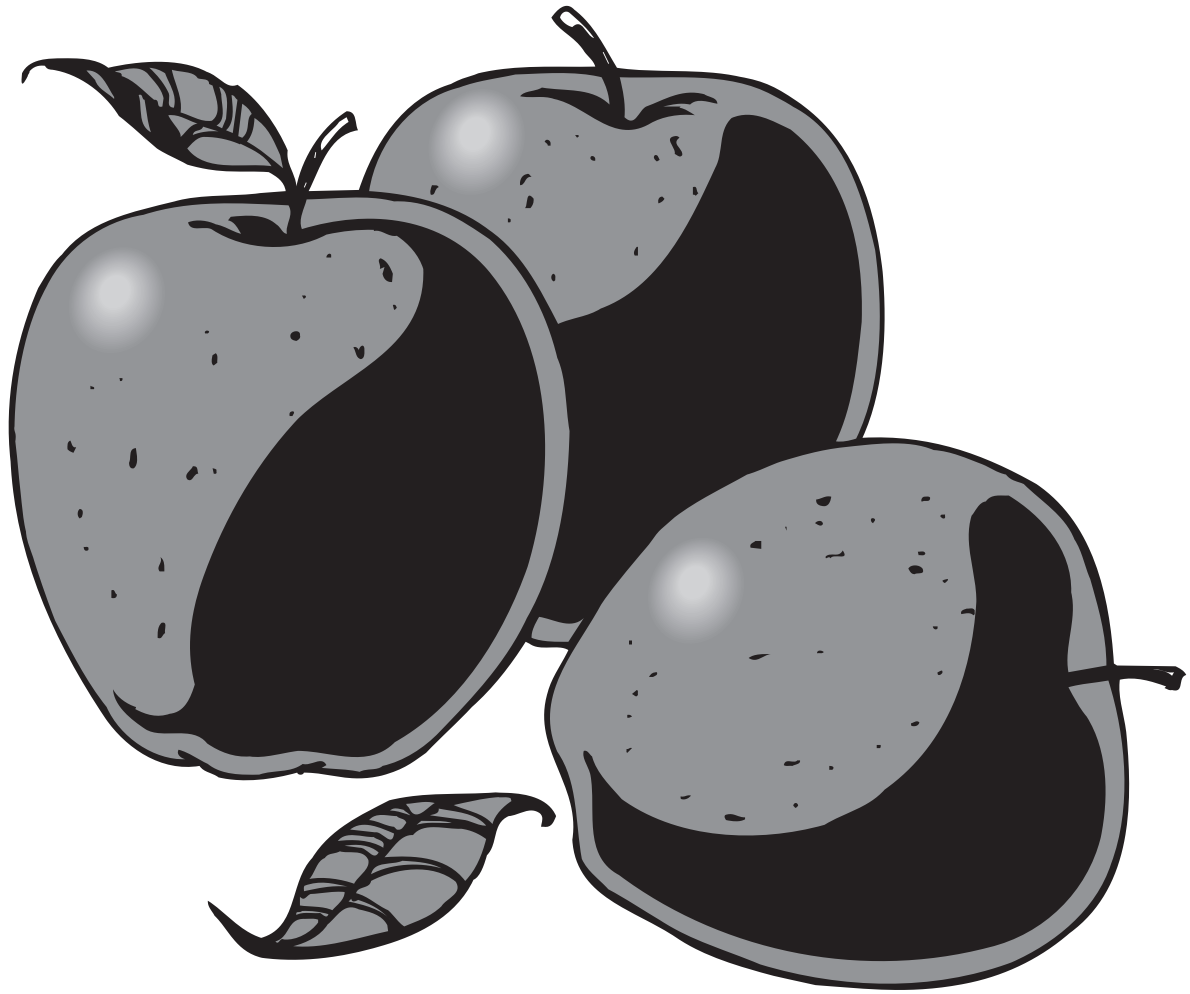
Student Page 2.1A: Food Chains

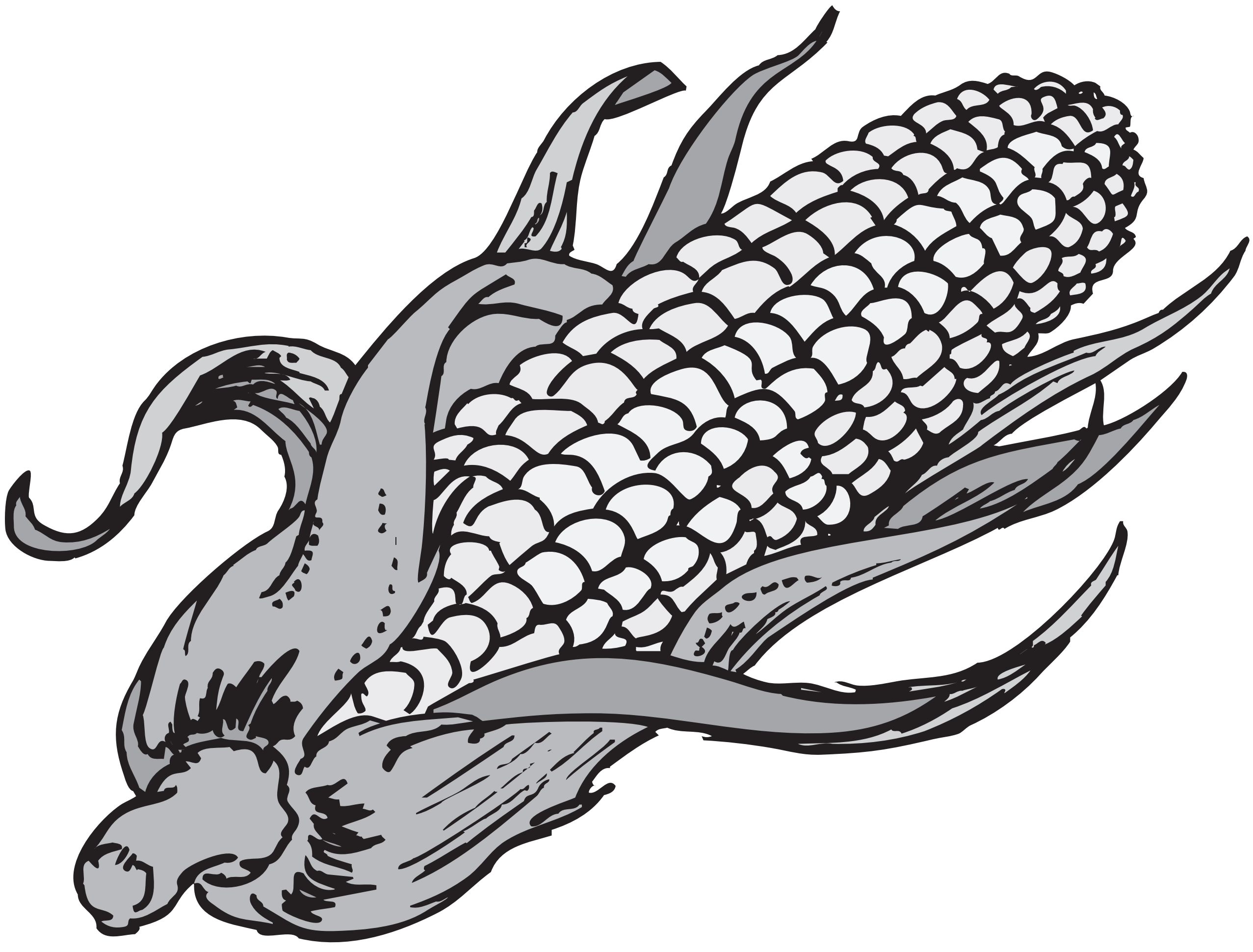
Name: ______________________________

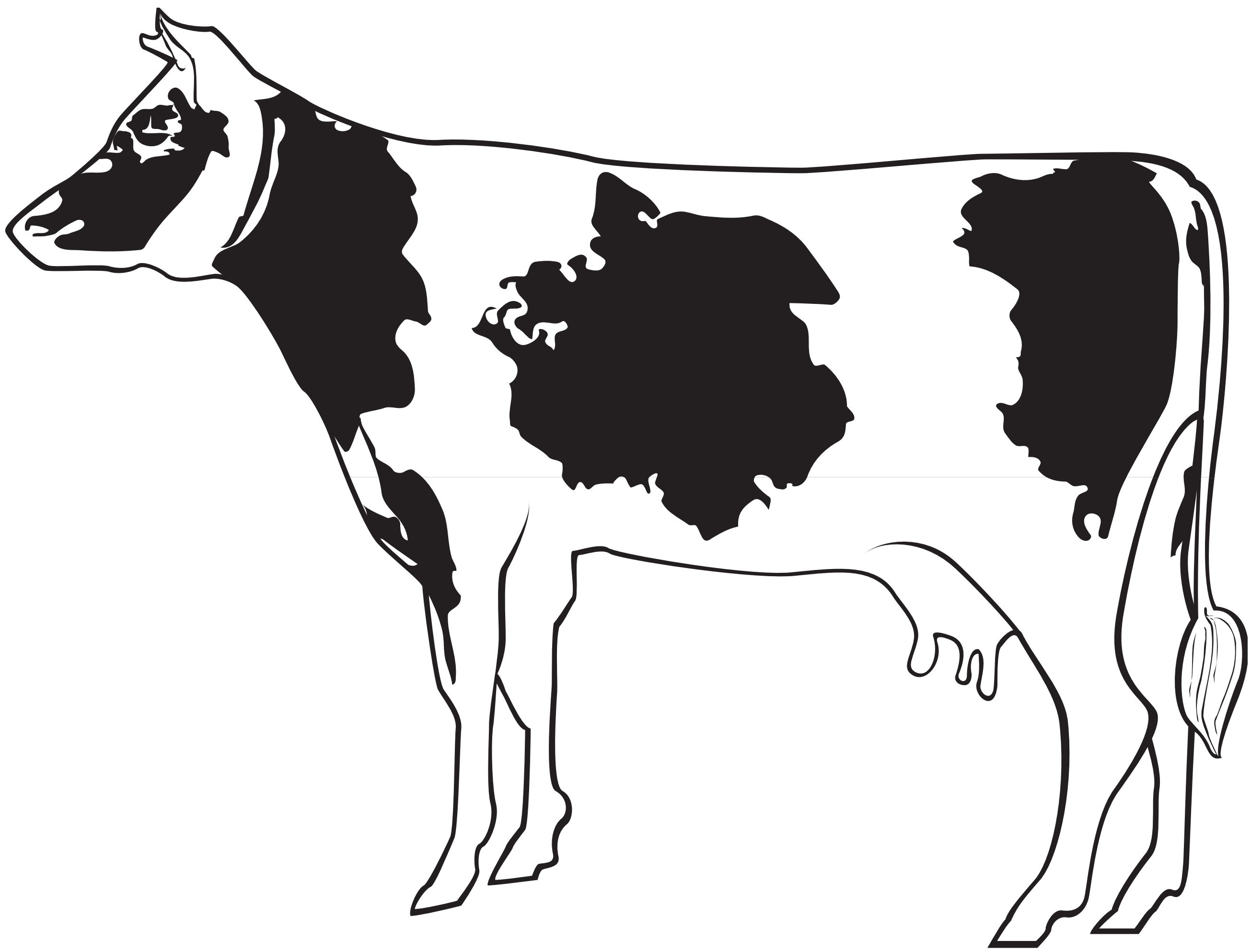
Date: ______________________________

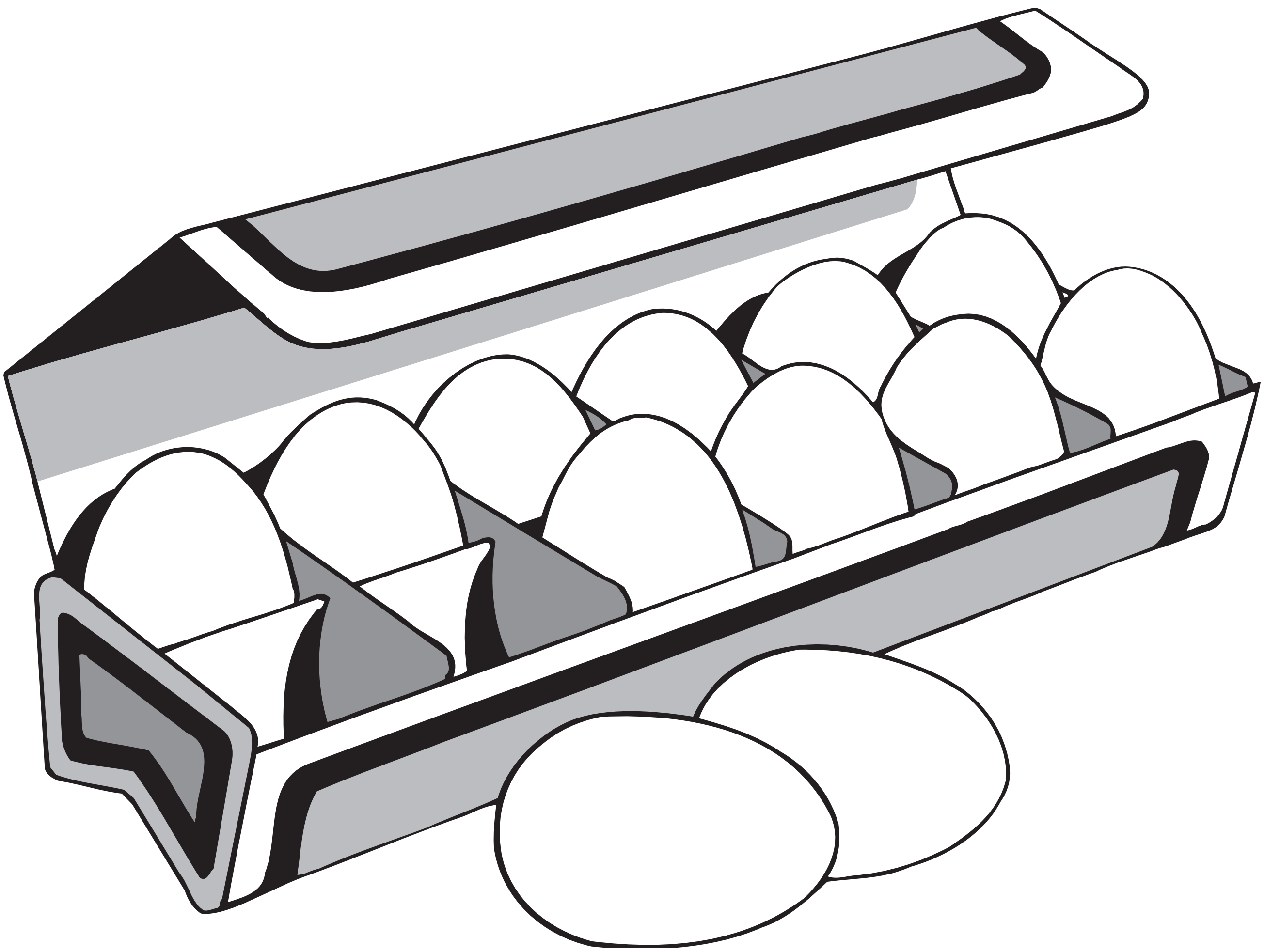


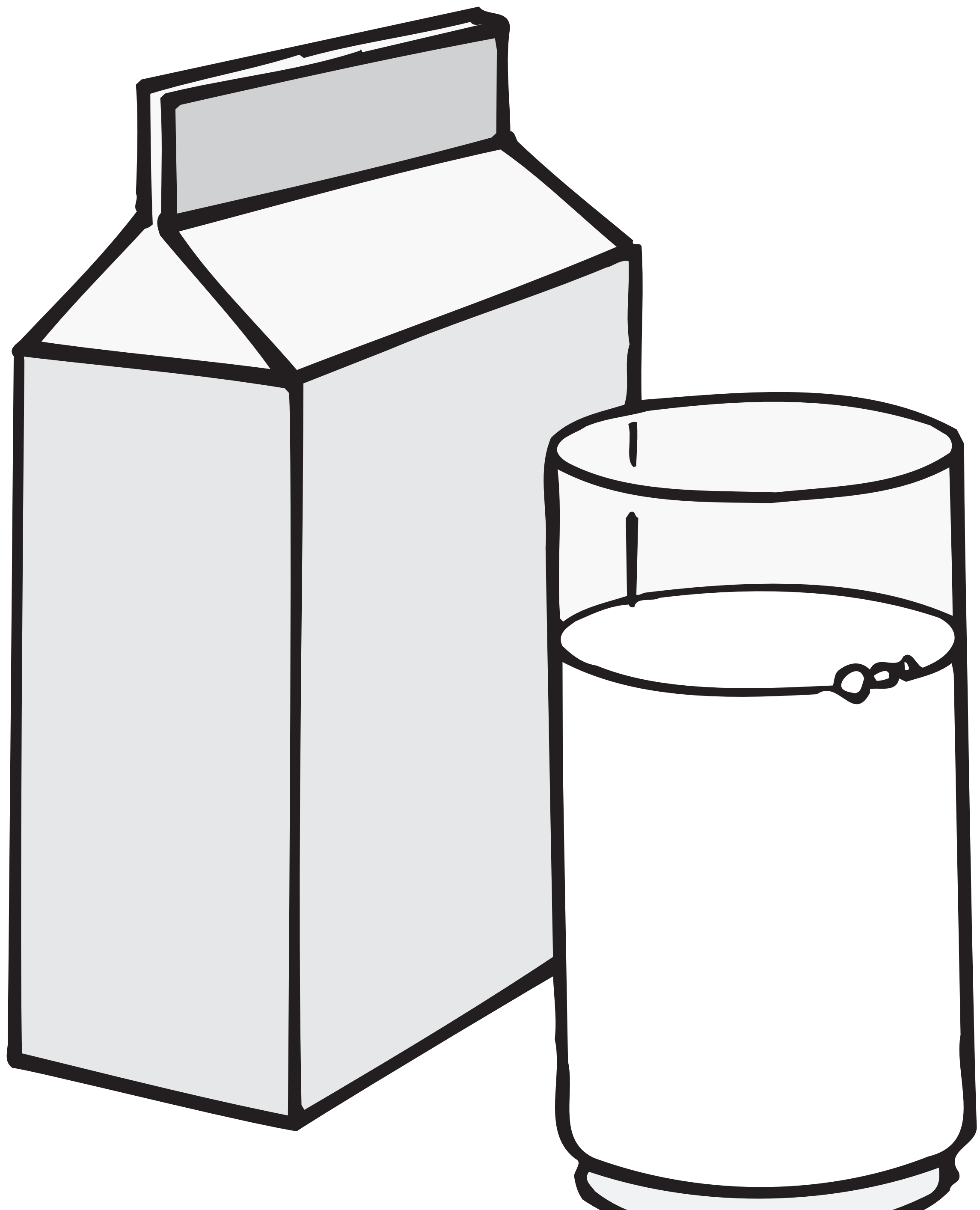


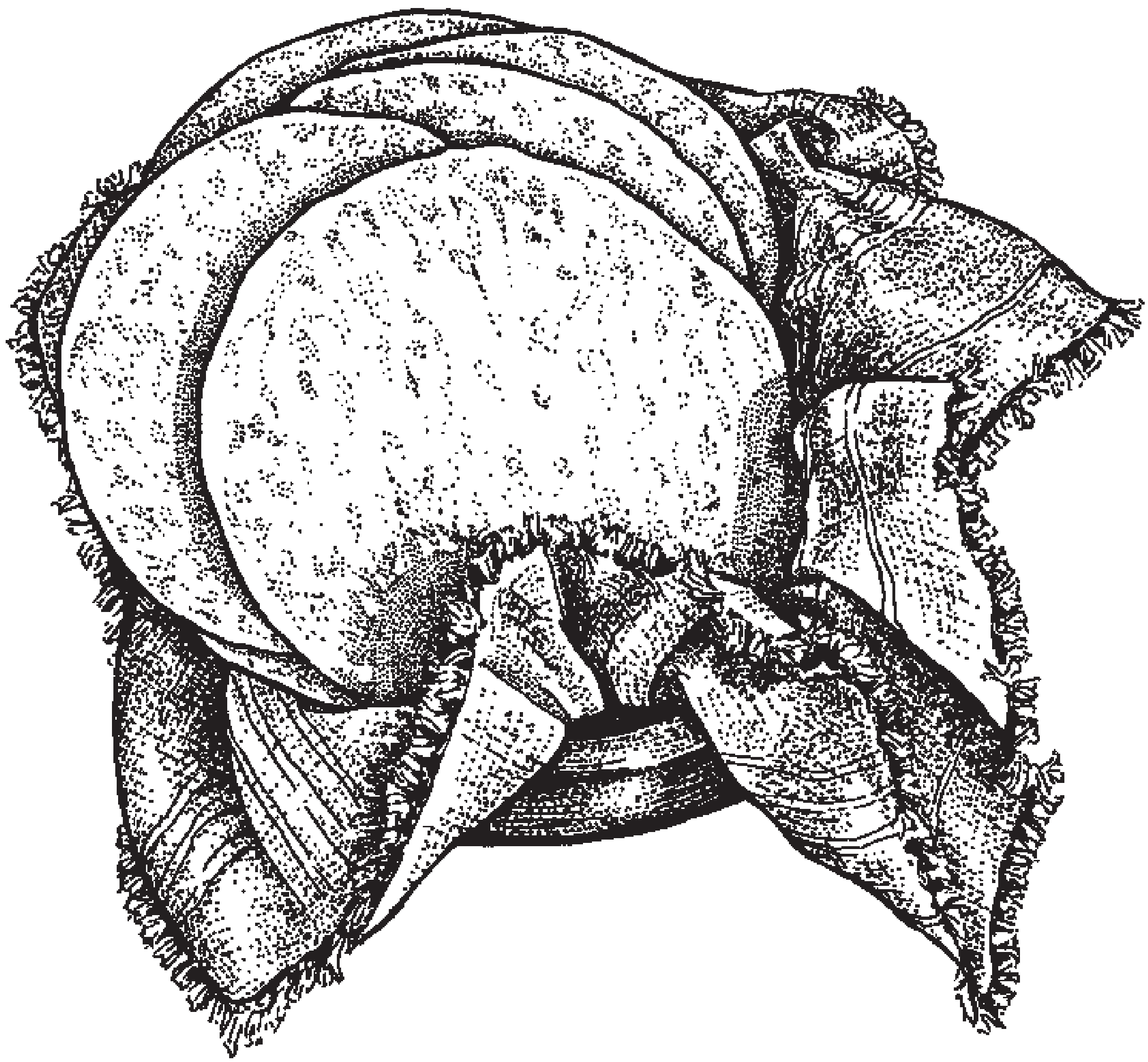


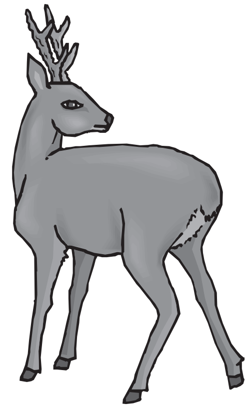












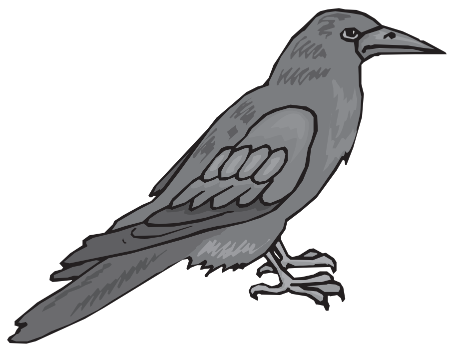
Deer

Fox

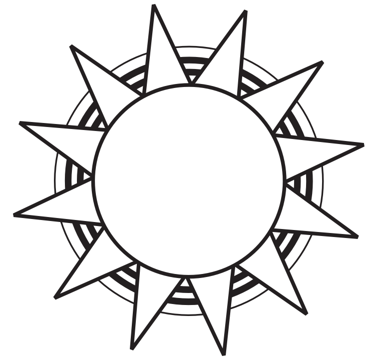
Vulture

Grass

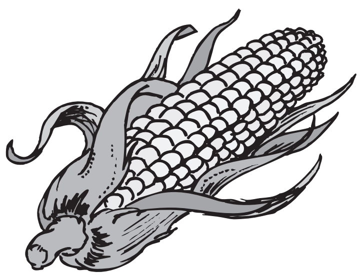
Human



Crow

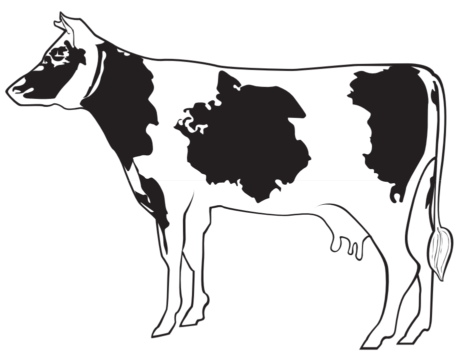


Sun

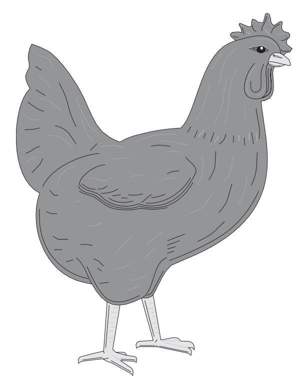


Corn

Apple Tree



Cow



Chicken

Step 2 – Lesson 2 Snapshot

Key Concept

Consumers get energy from eating producers or other consumers.

Evidence of Student Understanding

The student will be able to:

- classify organisms based on how they get matter and energy from food;
- describe that energy is stored in the matter that makes up food.

Time Needed

20 minutes

Materials

For each student

- copy of *Student Page 2.2A: Consumers*
- science notebook

Key Words

consumer, herbivore, omnivore, carnivore

The Role of Consumers

1. Review the term consumer and producer using the *Matter and Energy Chart* as needed. Check to see what students currently know about the terms herbivore, omnivore, and carnivore. Introduce the reading as a source of evidence for further explaining these terms.

2. Have students read only the What do you consume? section of the of *Student Page 2.2A: Consumers*. Ask them to recall any evidence that was in the article that has to do with their explanation of what a consumer is or that could be added to the *Matter and Energy Chart*.

3. Have students read the rest of the student page. At each "Can you think of others?" question, allow students to pause and write down a few organisms that they think might be of that type.

4. Allow groups of students to generate lists of organisms for each type of consumer. Reinforce the need to use evidence and question each other's suggestions to create evidence-based lists. Use group lists to create class lists and discuss the evidence used in classifying the organisms.

5. Use the REAPS throughout and after the lesson as appropriate.

REAPS

R – What makes a consumer different from a producer?
A producer is able to make its own food; a consumer must get food by consuming a producer or other consumer.

E – Explain why herbivores and carnivores are both consumers.
They both need to eat other organisms to get food and matter.

A – Why can't a consumer follow the sun in a food chain?
A consumer cannot use energy from the sun directly; only a producer can directly use the energy from the sun.

P – What happens to the leftovers from food chains, like chicken feathers and corn husks?
Student responses will be based on prior knowledge of decomposition and they are not expected at this time to be able to thoroughly explain what will happen to these wastes.

S – Write in your Science notebook one thing that you learned about herbivores, omnivores and carnivores from the classroom reading. Compare your answer with a partner.

Background Information

The Human Diet

Scientists classify humans as omnivores and most humans are omnivorous. Even most vegetarians eat some sort of animal matter—eggs, cheese, or milk. This makes them omnivores. However, not all humans are omnivores. The human species is omnivorous, but some individual members choose to adopt an herbivorous, or vegan, diet.

Vegans have many reasons from limiting the type of food they eat to only plants. Some people have moral reasons for not killing and eating animals. Other people choose a plant-based diet because it reduces their impact on the environment. Medical reasons and fear of contracting an animal disease play a part in other people's decisions. Whatever the reason, some humans choose not to be omnivores. Be sensitive to the students and their families who may have adopted vegetarian (still omnivores but significantly less reliance on animal products) or vegan (plant only) diets.

Implementation Guide

1. Begin by reviewing what a consumer is. Refer to any Energy and Matter Chart entries that refer to consumers. Then, ask students if they have heard any of the terms, herbivores, omnivores, and carnivores.

Say the terms herbivore, omnivore, and carnivore aloud, and write them on the board so the students can both hear and see the words. Generate a class discussion about what students think these terms mean and when they have heard or read them before. Encourage students to share evidence for what they believe the terms to mean. Following the discussion, explain that you have a short article that will provide more evidence for explaining these terms and understanding when they are used to describe organisms.

2. Have students read only the What do you consume? section of the of *Student Page 2.2A: Consumers* . Ask them to recall any evidence that was in the article that has to do with their explanation of what a consumer is or that could be added to the Energy and Matter Chart.

3. Have students read the rest of the article. At each "Can you think of others?" question, allow students to pause and write down a few organism that they think might be labeled that type (herbivore, omnivore, carnivore).

4. Arrange students in small groups. Explain that each group will develop a list of herbivores, omnivores, and carnivores from everyone's individual ideas. Instruct students to take turns sharing one animal from their lists. Like scientists, explain that group members need to challenge what their classmates say. For example, before adding an animal to the herbivore list, the group must talk about what evidence they know so they can label each organism correctly.

Once each group has a few animals for each list (herbivore, omnivore, and carnivore), bring the class back together. Instruct each group to share the name of one organism from each type and their evidence for deciding that organism fit into that category. Have the class do a quick vote—"thumbs-up if you agree, thumbs down if you don't agree or aren't sure about their idea." Discuss the evidence students know for assigning an organism to a particular category if there are students that give the thumbs-down or if you recognize an error in the labeling.

After each group shares an organism for each category, ask students if any groups had organisms that they could not classify. Ask the students to think about what evidence they would need to have to be able to classify it. Once they identify that they would need to know what it ate, encourage them to research the organism outside of class and bring evidence so it can be added it to the correct list.

5. Use the REAPS throughout and after the lesson as appropriate.

What Do We Consume?

We get energy from the food we eat. Now, think about our class radish experiment. Where did those plants get their energy? Plants can get energy from the sun. We cannot eat sunlight! Only producers can get energy from the sun. People eat foods like hamburgers, tacos, and vegetables. One thing we get from our food is energy.

We eat food so that we can grow. Our bodies grow from the matter we get from food. Do you remember reading about how plants get matter from the air to make food? Scientists use the name matter for the stuff that makes up living and nonliving things. Food is made of matter. We need matter from the food that we eat, in order to live.

We get the matter and energy we need from lots of different foods. Think of all the different foods we eat. We might eat cereal for breakfast. We might eat chicken for lunch. And for dinner, we might eat a radish in a salad. Remember that we use the name consumer for anything that must eat other organisms to get matter and energy. Humans are consumers. We must eat to live.

Types of Consumers

Scientists use special names for different types of consumers. Their names come from the different ways they get their food. Three types of consumers are herbivores, omnivores, and carnivores.

Some animals eat only plants. Scientists call animals that eat only plants herbivores. Herbivores might eat grass, leaves, grains and roots. They get their matter and energy from plants. Think of an animal that eats only plants. One example is a cow. A cow eats grass, corn, and grains. A cow is an herbivore. Can you think of others?

Herbivores can become food themselves. Other consumers may eat herbivores. As an example, many humans eat cows. Hamburgers are cow meat. If we eat a hamburger, we are a consumer eating an herbivore. When we eat a hamburger, we get some of the cow's matter and energy.

Scientists use the name omnivore for consumers that eat both other consumers and plants. Omnivores get their matter and energy from the plants and consumers that they eat. Humans are omnivores. Humans eat parts of plants, such as potatoes and apples. And many humans eat meat that comes from consumers. Pork chops, bacon, and steak come from animals that are consumers. Some omnivores like berries and fish. A bear is an omnivore. Can you think of others?

Scientists use the name carnivore for consumers that eat only other consumers. Carnivores do not eat producers, such as plants. They get their matter and energy from the other consumers they eat. They are good hunters. Often they are large animals. Mountain lions eat rabbits and deer. Sharks eat fish and seals. Neither mountain lions nor sharks eat plants. Can you think of others?

Producers and Consumers

First, we learned that there are producers and consumers. Producers can produce their own food using energy from the sun. Producers get matter from the air, earth, and water. Without producers, consumers could not survive. Consumers must consume other organisms to get matter and energy to live. Three kinds of consumers are herbivores, omnivores, and carnivores. Herbivores eat plants. Omnivores eat other consumers and plants. Carnivores eat other consumers and not plants. Did you ever think that there could be so many names for types of organisms? Now you know. And these names are all about matter and energy.

STEP 3

Overview

This step provides an opportunity for students to design and conduct their own scientific inquiry to learn more about decomposition. To ensure students have the skills needed to achieve success in gathering evidence from an investigation to use in an explanation, they use involved discussions and purposeful student pages. The process begins with students observing demonstration Decomposition Columns, studying and classifying their observations, and then developing scientific questions based on them. Then, students work in groups to design their decomposition investigation, build their columns, and collect repeated data on them.

The students reinforce their developing knowledge about decomposers through a short reading.

Lesson 1

Observing Decomposition Columns (45 min)

Lesson 2

Designing a Decomposition Investigation (60 min)

Lesson 3

Decomposition Column Construction (75 min)

Lesson 4

Decomposition Data Collection (30 min)

Step 3 – Lesson 1 Snapshot

Key Concepts
- Consumers get energy by eating producers or other consumers.
- Decomposers are a kind of consumer.

Evidence of Student Understanding
The student will be able to:
- utilize the skills used in observing and recording data;
- identify the scientific skills used in investigations.

Time Needed
45 minutes

Materials
For each student
- copy of *Student Page 3.1A: Observations*
- copy of *Student Page 3.1B: Who Eats Dead Leaves?*
- science notebook

For each group
- 1 Decomposition Column
- tools: (e.g. hand lenses , thermometers, rulers, or balances,)
- colored pencils, markers, or crayons

Key Words
record, decomposition

Observing Decomposition Columns

1. Review the student predictions from Lesson 2.2 about what happens to the leftovers, like corn husks and chicken feathers, from their food chains. Optional: read Shel Silverstein's poem "Sarah Cynthia Sylvia Stout Would Not Take the Garbage Out." Have students evaluate their explanations and recognize that they need more evidence.

2. Explain that two weeks ago you made some models of a forest floor for the class to investigate. Give each group one Decomposition Column to observe for ten minutes. Ask students to complete *Student Page 3.1A: Observations* and draw the column in their science notebooks.

3. Generate a class discussion about their column observations, inferences about what has occurred in the columns, and preconceptions about what causes decomposition.

(continued on following page)

REAPS

R – In your science notebook, draw or write at least 2 types of things scientists call non-living.
Soil, water, air
What types of things do scientists call living?
Animals, plants, living organisms

E – What types of observations from the decomposition columns would be useful for including in your science notebook?
Size, shape, color, texture, odor and any other descriptive words.

A – Where in everyday life can something be observed that is similar to the decomposition columns?
Refrigerator, compost pile, garbage can.

P – How have the columns changed in the last two weeks?
Encourage students to include reference to specific, *observed evidence.*

S – Complete this sentence and write it in your science notebook: "I acted like a scientist when I ___".

4. Model how to generate questions from observations and encourage students to do the same. Record student questions on chart paper and in their science notebooks.

5. Call attention to how some observations are about living things and some nonliving. Use a Think-Pair-Share strategy to generate working definitions for the terms *living* and *non-living*. Highlight student observations related to interactions between living and non-living things.

6. Use the REAPS throughout and after the lesson as appropriate.

Background Information

What is Decomposition?

Decomposition involves a whole community of large and small organisms that serve as food for each other, clean up each other's debris, compete for nutrients, and convert materials to forms that other organisms use. Bacteria and fungi initiate the recycling process by feeding on dead matter and, in turn, becoming food for other organisms. Microbes, earthworms, snails, beetles and mites, all of which may feed on the bacteria and fungi, in turn, feed larger insects and birds. All of these decomposers produce waste. The decomposer's waste is full of nutrients and replenishes the soil for new producers to grow in.

Why is Decomposition So Important?

Decomposers are so critical to life around us that it is hard to imagine what life might be like without them. Most scientists believe that without decomposers there would be no life on this planet. The soil has only so many nutrients in it. Producers use the nutrients in the production of plant tissue. Without decomposers, the nutrients that they pulled out of the soil and trapped in their living tissues would never return to the soil for another producer to use.

Without decomposer organisms, the amount of waste on the planet would be astounding. Dead plants would litter the ground and with no decomposers to break them down they would remain there. Dead animals and animal waste products would pile up. Without decomposers they would not rot.

Eventually, the planet would not be able to support life because the producers would run out of available nutrients or because there simply would not be any place left to live. The surface would

Teacher Preparation

Demonstration Columns

The demonstration columns for this lesson need to be built two weeks ahead of time. The Unit Overview provides a detailed description of how to build the bottles and recommendations for the contents of the demonstration columns.

Material Tips

Discuss and decide ahead of time if students will be allowed to remove the tops of the columns during observation periods. Students can be encouraged to remove the tops of the columns and take out a small sample for data collection. This can provide unique observation opportunities for students.

If small samples are going to be removed, direct students to do so very carefully. It is helpful to have white paper plates available to spread out the sample. It is much easier to see things on a white background and this makes for easier cleanup. Small plastic spoons make great retrieval tools. Encourage students to work slowly and intentionally so that the rest of the sample is not disrupted. Molds and fungus can be disturbed if rubbed off the side of the column or broken into pieces. Removing samples from the demonstration columns will not disturb these columns, because they will not be used for an investigation.

be covered with dead plants, dead animals, and animal waste. The role of decomposers is critical to sustaining life on the planet.

How Will the Columns Help My Students Learn About Decomposition?

The Decomposition Column can be thought of as a miniature compost pile or landfill, or as a pile of leaf litter on a forest floor. It is a model of the real decomposition process. Scientists often use models as a basis for study when the actual system or organism is too cumbersome to study. The decomposition process in a real ecosystem is not accessible to students. It is hard to manipulate the process of decomposition in the natural setting. Decomposition bottles replicate the process of decomposition on a scale that students can handle.

Add some of the dead or dying radishes from the Terraqua Column investigation to the demonstration Decomposition Columns. The purpose of this is to make the link between producers and consumers, like decomposers, more concrete.

The columns provide the students with an authentic model to investigate. Interesting smells and occasional fruit flies are to be expected with the column, just as they would be in nature. Don't be alarmed, this indicates a thriving ecosystem!

Implementation Guide

1. Ask students to review the responses they wrote in their science notebooks to the REAPS Predict question from Lesson 2.2. Ask a few students to share their responses. Generate a class discussion about these predictions focused on the evidence used to support these explanations. Question students about what evidence they know about that supports or contradicts their own ideas as well as their classmates' ideas. Encourage students to question each other and ask for clarification.

Ask students if they think they have complete and accurate explanations for what happens to food chain leftovers and dead organisms in nature. Prompt them to identify ways that they could gather more evidence so that they can build explanations that are more scientific. If students do not identify conducting an experiment as one source for additional evidence, remind them that to think like scientists do and consider how they could do research to gather more evidence.

Ask students how they learned about the affects of sunlight on plants. Review how they conducted an investigation and read an article. Both provided evidence for developing a scientific explanation for how plants need energy from the sun to live and be healthy. Remind them of how the Terraqua Columns were models of a backyard that allowed them to do the investigation in the classroom.

2. Explain that you made another kind of model two weeks ago called a Decomposition Column. These columns represent the forest floor. You put soil, dead organisms, water, corn husks, feathers, and other things into the columns so the class could observe what happens on a forest floor without having to go to a forest. Students will gather evidence from these models, then design their own experiments with their own columns. In addition, they will gather evidence by reading a few short articles about decomposition.

Review the scientific observation skills that students used in Step 1 to observe their Terraqua Columns. For example, ask students:

- Which of the senses did you use to observe the Terraqua Columns? Sight. Smell.
- What characteristics did you observe when you studied the radish seeds? Size, height, color, shape, texture, and moisture of materials in the column.
- How easy was it to observe all the aspects of the Terraqua Columns? What did you have to do to make sure you noticed the details? Look carefully. Make good measurements. Record observations to make comparisons.

Establish rules for working with the Decomposition Columns. For example, establish in advance whether the students can open the columns. Explain that the columns can contain molds that must not be breathed in, and review with the students their responsibilities for keeping the columns safe and for staying focused on the task. Distribute copies of *Student Page 3.1A: Observations* to each student. Explain that they can use this data sheet to help them keep track of what they observe.

Explain that students also need to make scientific drawings of their observations in their science notebooks. These can be used during later observations for comparison, to help remember how the column looked before. Remind students of the guidelines for scientific illustrations—that scientists draw what they see. They use the appropriate colors and include as much detail as they can. Scientists also include their name, date, and column number, and label their drawings as carefully as possible.

Explain to the students that they may want to describe their columns with words that they do not yet know how to spell. To prevent this concern from limiting their science observations, considering starting a word bank in the classroom.

Provide each group of 3–5 students with one of the two-week-old Decomposition Columns.

Travel around the room and ask guiding questions to prompt students to notice finer details. Guide them to observe aspects of the column they may have not noticed yet, or make more accurate observations and drawings. For example, try questions like:

- What have you noticed about the column? How did you discover that? What other sense or tool could you use to observe your column?
- What do you mean the column is wet? What did you observe that told you it was wet? Is that in your drawing? How would you describe how wet the column is?
- Is the leaf really that color green? What color is closest to the color of the leaf that is actually in the column?
- How would you tell another person about your column? What words or pictures would you need to use?
- What do you wonder about the column? Write that down in your science notebook so you can refer to it later.

Provide the students with some simple tools to allow them to make observations that are more thorough. Hand lenses help students observe finer details. Rulers and thermometers give students an opportunity to quantify what they see. They can measure the height of the contents of the columns or the temperature inside the columns. Consider allowing students to remove an item from the column and inspect it closely.

Allow about 10 minutes for observations. As the columns are collected, ask the groups to identify three notable things about their column to share with the class.

3. Gather the class together and ask each group to share three things that they found interesting about their column. Tell students that it is still good to share something that another group may have already shared because it is important to know if something is similar in multiple columns. However, explain that it is also important to share unique observations so the class is aware of differences among the columns.

As a group share their observations, record them on the board. Student observations may include:

- When students describe something inside the column as rotting, molding, breaking apart, or dissolving, ask "how do you know that?" so that they describe specific evidence. At an appropriate time, explain that mold forms and column contents break down when they are decomposing. Ask students which kinds of things have mold, rot, or slime on them or are falling apart into pieces. Guide students to notice the pattern that natural things like leaves, paper, grass, and fruit have as evidence of decomposition, and things like foam cups, plastic pens, and candy wrappers lack. At this point, share that humans make some things that don't decompose well.

Ask students what they think is causing the natural things in the columns to decompose. Record their ideas on chart paper. Students may suggest things like water, "bugs" in the soil, worms, flies, mold, or that things just died and got old. Ask students to evaluate this list and consider what ideas they have evidence for from looking at their columns. Tell students, that like scientists, they will be looking for evidence for these ideas about what causes things to decompose during their investigations.

Keep track of students' ideas, particularly any misconceptions like the notion that water, air, heat, or age cause decomposition. Students need to gather evidence throughout their investigation that allows them to narrow this list down and develop the understanding that the reason why things decompose is because living organisms eat dead matter and waste matter.

During the class discussion, when students suggest an idea that is an inference rather than an observation, call attention to and discuss the terms inference and evidence. For example, try prompting a discussion like the one that follows:

- One student hears another student say that their brown leaves weren't rotting and that their column was dry. The second student then says that in their column the brown leaves were rotting because there was more water in their column.

- Ask the second student if they know for sure that their column had more water than the other group's column, or if they are inferring that it was.

- Explain that an inference is an idea that seems to explain an observation for which we don't really have any evidence. Inferences are not as strong as scientific explanations that are supported by observed or concrete evidence. At this point, students will have many inferences because they have not been observing the columns over time to see how things have changed. Without drawings or recorded observation to refer to for comparison, only inferences can be made about how the columns have changed.

- Share that many of the inferences the students are making could be investigated further. Ask students how they could gather evidence about their ideas and make scientific explanations about what is happening in the columns, rather then making inferences. Make sure they recognize that scientific procedures would require keeping as many factors constant as possible among comparison columns, In addition, a well-designed experiment involves keeping track of amounts and measurements, and making repeated detailed observations and drawings.

4. As students share an observation, model how to form a question based on that observation. For example, you might say:

- It is very interesting that the twig was rotting, but the pen wasn't. I wonder if some things can't decompose? I wonder what kinds of things can decompose?

- You said that the dry leaves weren't rotting and the wet leaves were. I wonder if the amount of water affects how fast something decomposes?

- So, let me see if I understand what you are saying. The leaves in the column that contained very little soil weren't decomposing, but the column with several inches of soil had leaves that were decomposing. I wonder if the amount of soil affects how fast things decompose?

Ask students to take out their science notebooks and write down as many ideas and/or questions that they can think of as they wonder about the columns. Have them also write down things they want to learn more about.

5. Use the students' observations as a basis to discuss the terms living and non-living. One technique that allows students to develop their own explanations is described in the following paragraphs.

Direct student attention to the list of observations recorded on the board. Circle all the words in green marker that are mentioned in student observations and that pertain to living things. Then, circle all the words that pertain to non-living things in blue marker. Record them in another chart like this:

Green Marker	*Blue Marker*
mold	***water***
twig	***rock***
leaf	***air***
apple peel	***soil***
seed	***foam peanut***
feather	***pen***
paper	***wrapper***

Ask students to use a Think-Pair-Share to describe similarities among the words in each column.

Create a chart on the board to collect students' ideas. For example, you might collect similarities like the following:

Green Marker	*Blue Marker*
alive	***part of the earth***
growing	***not alive***
dead	***doesn't grow***
came from trees	***not natural***
rotting	***not rotting***

Tell students that all the words circled in green refer to living things, and those in blue refer to non-living things. Prompt students to develop working definitions for the terms living and non-living using the lists as evidence. Encourage them to ask questions and challenge each other's ideas. These prompts may be useful in guiding this discussion:

- I heard him say that all living things were growing. Do you all agree with him? Does something have to be growing to be a living thing?
- I think she is saying that some of the entries on the living things side may be dead now, but they used to be alive. Is "used to be alive" another way we could describe what it means to be a living thing?
- Does our definition work for plant seeds, like our radishes? Are radish seeds living things?

Some characteristics of living and non-living things that students may use in their definitions include:

- Living things can be alive, dead, once alive, dormant, going to be alive, or have fallen off something that was alive.
- Non-living things are not alive now, were never alive in the past, and are never going to be alive.

Explain that the Decomposition Columns have both living and non-living things in them, just like the ecosystem they represent—the forest floor. Explain that scientists often study both the living and the non-living things in an ecosystem. Highlight student observations that refer to living/non-living interactions or noted differences between living and non-living things and discuss how they might be changed into investigation questions. For example:

- The rock had nothing growing on it, but the stick did. Does mold grow on living things more than non-living things?
- The wet leaves had holes, but dry leaves didn't. Does water affect how fast leaves decompose?
- The plastic things weren't rotting, but the natural things were. Do some things decompose while other do not?

Have students add any additional questions about their columns to their science notebooks.

6. Have students read *Student Page 3.1B: Who Eats Dead Leaves?* Revisit students ideas about decomposition and living/non-living in light of the evidence from the article.

7. Use REAPS throughout and after the lesson as appropriate.

Student Page 3.1A: Observations

Name: ______________________________

Date: ______________________________

Column #: ______________________________

Describe the environment inside of the column.

Colors:______________________________

____

Smells:______________________________

____

Textures: ______________________________

____

I wonder if: ______________________________

____

____

Draw and label the contents of the bottle:

Student Page 3.1B: Who Eats Dead Leaves?

Trees lose hundreds of leaves every year. The dead leaves fall to the ground, but they don't pile up. You don't see dead leaves piled up to the sky in a forest. So, what happens to the dead leaves? Garbage trucks do not pick up dead leaves from the forest. Leaves do not pile up because something eats them.

Think about why something would eat dead leaves. What do organisms get from their food? They get matter and energy! All organisms need matter and energy. What kind of organisms do you think get matter and energy from dead leaves?

First, let's think about producers. Could they get matter and energy from dead leaves? What do you know about producers? Plants like radishes are producers. Do they get energy from dead leaves? No, they get energy from the sun. Do they get matter from dead leaves? No, they get matter from the air, water, and soil.

Producers cannot be eating the dead leaves. Instead, producers make the leaves. Leaves come from trees. Trees are plants. That means that trees and their leaves are producers.

Now let's think about consumers. What do you know about them? You know they are alive. Everything alive needs matter and energy. Consumers need matter and energy. Where do they get matter and energy? They get it from their food. What foods can consumers eat? They can eat producers. They can also eat other consumers. Could they eat dead leaves? Yes, some kinds of consumers eat dead leaves!

Some consumers eat dead things and waste. Scientists have a special name for them. They call them **decomposers**. There are many kinds of decomposers. They eat many different kinds of foods. Some eat dead leaves. Some eat dead plants. Some eat dead animals. Some eat the waste made by animals. Some eat dead fungus like mushrooms. Waste like dead leaves would pile up forever if nothing ate it. Decomposers eat the waste. They keep it from piling up.

When decomposers are healthy, they eat. They eat dead matter. There is dead matter in the columns. Do you think there are decomposers in there too? If so, they will eat the dead matter. As they eat dead matter, the matter will change. The matter might change shape. It might change color. It might change the way it smells.

Why do decomposers eat dead things and waste? To get matter and energy! They need to eat to live. They use the energy in the dead leaves to live. They use some of the matter from the dead leaves to grow. They put the rest of the matter back into the soil and air. Then plants use that matter and energy from the sun to grow.

Decomposers are nature's recyclers. They make room for new things to grow. They also put matter back into the soil and air. They recycle matter. If they didn't do this plants could not live! Putting matter back into the soil makes the soil better for plants to grow in. Plants grow better because of the work decomposers do.

Plants need matter like all living things do. Decomposers help plants get the matter they need. Plants get matter from air, water, and soil. Air, water, and soil are **nonliving** things. Do you see how living things like plants must have nonliving matter to live? Do other living things also need nonliving things to live? Yes, they do. All living things need nonliving things to live. Consumers need air and water. Air and water are nonliving things.

Living things also need other living things to live. **Consumers need producers.** Cows need grass. Chickens need corn. Why? Only producers like grass and corn can use energy from the sun to make food. When a consumer like a cow eats a producer like grass for food, this energy is passed on. Only producers can pass on energy from the sun in the form of food. **Producers need consumers**, too. They need a special kind of consumer to live. They need decomposers. Why?

Without decomposers, plants would not have the matter they need to live.

Food chains and food webs show how energy and matter move among living things. Decomposers are part of food chains and food webs. They clean up whatever is left. They have an important job. It may be a rotten job, but it is important. Do you think they are at work in the columns now?

Step 3 – Lesson 2 Snapshot

Key Concept

Scientific progress is made by asking meaningful questions and conducting careful investigations.

Evidence of Student Understanding

The student will be able to:

- identify the skills used in observing and recording data;
- identify the scientific skills used in investigations.

Time Needed

60 minutes

Materials

For each student

- completed *Student Page 3.1A: Observations*
- copy of *Student Page 3.2A: Design an Investigation*
- science notebook

For each group

- Decomposition Columns
- (optional) paint color samples, color wheels, or crayons

Key Words

cause, effect, prediction, observation, investigation

Designing a Decomposition Investigation

1. Ask students to read and evaluate their own or a peer's science notebook entry from Lesson 3.1 to emphasize the importance of the quality of the entries and discuss how to improve them.

2. Review the class list of column observations and questions. Guide the class to recognize patterns in the types of observations and choose 2–4 categories in which to group the observations. Next, cluster the observations under the appropriate category.

3. Group students into teams of 3–5. Ask the students to insert any additional observations made into the proper category and develop two or more questions about each category.

4. Instruct the team to choose one question that they are interested in and could be answered through an investigation with the Decomposition Columns. Instruct students to record that question in their science notebooks.

(continued on following page)

REAPS

R – What is a scientific prediction?
Predictions are ideas for explanations and the reasons for thinking that way.

E – What kind of observations are going to help answer your investigation question?
Answers will vary; generally, students will look for signs of the materials in the column changing form to indicate decomposition. The greater the decomposition rate, the faster change will occur.

A – Why is the experimental design improtant to being able to answer your investigation question?
By keeping all but one condition in the experiment the same, any differences in decomposition will likely be caused by the one factor that was varied.

P – What will have changed the most in the columns the next time the are observed? Why?
Include reference to specific, observed evidence.

S – Complete this sentence and write it in your science notebook: "I acted like a scientist when I ___".

5. Provide each student with *Student Page 3.2A: Design an Investigation*. Discuss what predictions are and the characteristics of a good question. Have each group discuss their question and investigation plan, determine what materials they need, and identify a way to collect data on their columns.

6. Have a short conference with each group to ensure that they have developed a good question to investigate, have access to the supplies they need, and a plan for collecting evidence.

7. Use REAPS throughout and after the lesson as appropriate.

Background Information

Experimental Design

In this decomposition unit, students often think of designing two different types of investigation. One type of investigation varies the conditions to which the columns are exposed, thus examining environmental effects on decomposition. The second type varies the contents within the columns, thus examining the relative rate of decomposition between two objects. A well-designed investigation allows students to study one difference between their columns and thus be able to attribute a difference in results to just one factor, instead of many.

The Immersion Unit Toolbox section *Giving Priority to Evidence in Responding to Questions* provides background information and tips on facilitating the experimental design process with students. It is critical that investigations be designed thoughtfully and scientifically, so that students gather valuable evidence for helping them develop a conceptual understanding of the science content.

To test the effects of an environmental condition on decomposition, a student puts the same items in two columns, for example, the same amounts of soil, leaves, fruits, etc. He or she would also add them in the same order. Consider if students wanted to explore the question, What effect does light have on decomposition in a column? Then the bottles constructed of the same materials would be positioned so that one of the columns was in the light and the other in the dark. For a well-designed investigation, all other factors to which the columns were exposed (e.g., temperature and moisture) would be kept as constant and similar as possible.

An investigation testing decomposition rates for different materials would involve a similar design, except that one internal variable would be altered. For example, in an investigation designed to answer the question, What decomposes more rapidly, a banana peel or an apple core? students might put soil, green grass and an apple core in Column 1. Then, in Column 2, they might put in soil, green grass and a banana peel. Equal amounts (by weight or volume) of each type of matter would be used in each bottle. Place the columns next to one another, so that each is exposed to nearly identical environmental conditions.

Good scientists try to minimize variability in their experiments. If they are testing the effects of light on decomposition, they will make sure that the columns are the same. If everything is the same except the amount of light, they can attribute any differences in the decomposition rates of the two columns to the different amounts of light. If they allow something else to vary, like putting more water in one bottle than the other, they won't know if it's the different amounts of light or or different amounts of water that is causing a change in the rate of decomposition.

It is critical for students to have a clear understanding of what good experimental design is. They do not need to use the terms testable question, control group, or independent/dependant variable, but they do need to understand that if they want sound evidence to develop an explanation related to their question they have to conduct a fair test. Work with the students to figure out how many things they are varying in their experiment. Pose the question, "If you do find a difference in how the two columns decompose, are you really going to know what caused it, or could it be multiple things?"

Predictions

Predictions are an important part of experimentation. They are more than a guess. A prediction involves using logic and reasoning to suggest what may happen in light of what the questioner already knows. Have students record the reasoning for their prediction along with the prediction itself.

Remind students that predictions will not be judged based on a right/wrong outcome; rather they are evaluated based on how they are analyzed when experimental results are collected. A prediction serves as a benchmark for assessing the results of an investigation.

Tips and Hints for Investigations

Keep it Simple

Keep the investigations very simple by changing only one thing in the system at a time. Remember that in order to best assess differences in decomposition the students need to have their investigation set up to compare only one thing between the columns!

What Can Be Tested?

You can test the effects of biotic (living) factors on decomposition; you can vary the types, amounts, and ratios of plant matter (dead leaves, grass clippings, fruit peels, etc.). Remember, depending on the source, the soil likely contains such life as fungi, insects, and countless microorganisms, so students can vary the type of the soil, too. Small animals can also be added to study their effects on decomposition. Students may decide to set up one column with isopods (pill bugs) and one without to study differences in the rates of decomposition due to the presence of the pill bugs.

You can also test the effects of abiotic (non-living) factors on decomposition: Substances that might affect decomposition include physical factors such as temperature, light, and moisture, or chemical mixtures such as nutrients (fertilizers) or pollutants (salts, pesticides, acids).

Measurable Observations (Quantitative Data)

Measurable indicators that can change as decomposition occurs include the volume of materials (can be measured as height of materials in the column), temperature of the matter in the column, weight of the column, and number of animals present (worms, fruit flies, etc.). Measurable observations are quantitative.

As students brainstorm ways of collecting measurable data, do not shy away from unconventional forms of measurement. There are only a few standard forms of measurement that can be used. The following is a list of possible measurement tools.

- *Temperature:* Students can take the temperature of the column at intervals throughout the investigation. Take the temperature at approximately the same time every day and in the same way (e.g., place the thermometer in the same location in the bottle).
- *Ruler:* Students can use a ruler to measure the depth of the contents of the bottle. They can measure the average depth of the material or the highest part. Either way, consistency in measurement is important.
- *Balance*: The students might be interested in the weight of the materials over time. They can weigh the column before they add the contents and then subtract this weight from the weight of the full column and then they will know how much the contents actually weigh. Alternately, they can weigh the bottles and their contents each time, knowing that the weight of the bottles does not change.
- *Color:* Color is an indicator of decomposition and probably one of the first noticeable signs. Paint sample cards from a hardware store or a color wheel from the art room can be used to create a color gradient. Students can also make their own color wheel using a wide variety of crayon colors. This gives students a benchmark color gradient that the whole class can use to describe the color of the contents. Students can refer to different shades of one color instead of saying that the contents are "brown." When observing color it might be helpful to carefully observe two to three items as benchmarks that will be carefully examined at each observation. This way the color observation does not become too overwhelming for the students.

Non-measurable Observations (Qualitative Data)

Most of the data that students collect is in the form of visual observations, achieved by comparing and contrasting the two bottles. Observable but non-measurable factors that students can record and study include the presence or absence of mold, odor, and color; and the overall shape of the contained materials. Descriptive observations that do not involve measurement are qualitative.

Odor is a by-product of decomposition, and it can provide a lot of information about the materials in the columns. Odors may be strong at first, but can mellow and become musty with time. The strongest odors arise from animal products such as meat and dairy products. Grapefruit rinds and grass cuttings can also produce strong odors. Use food scraps mixed with plant matter such as leaves, twigs and dried grass to temper odors. Layering small amounts of soil on top of contents also lessens the odor.

Students might be interested in writing about the smell of the column over time. They can do this using analogies, recording what other smell the column resembles. They could work together as a class or a group to create a "stink-o-meter." The stink-o-meter could have a numbered scale that corresponds with smells from good to bad.

Keeping Track of Observations

Encourage students to be consistent when writing in their science notebooks. They need to mark their entries with the date and use data tables wherever possible. This approach helps students discover patterns in their observations. Guide students to focus their observations on two or three items in each entry. While they can include additional information in the entries, they will be more likely to notice subtle changes and recognize patterns by watching a few specific items decompose.

How Long Will It Take?

Evidence of decomposition will be apparent in the first few days after filling the column. Three to five weeks are plenty of time to see soft biotic material such as leaves, fruits, vegetables and grain products decompose dramatically. Bark, newspapers, wood chips, Styrofoam cups or plastic bags all take much longer to decompose than will ever be recorded in the classroom. Some take hundreds or millions of years, and some may never decompose!

Implementation Guide

1. To get students thinking about their columns, review the class lists and science notebook entries from the last lesson. Then, have students review their own science notebook entries or exchange then with one of their peers. Exchanging with a peer can be a good strategy for emphasizing the need for neatness and clarity. Ask students to analyze the quality of their own or their peer's work. Prompt them with questions like:

- Are the observations understandable and detailed?
- Do they remember observations or procedures not recorded in the science notebook?

Review the procedure for recording science notebook entries. Have students generate ideas that will help organize and improve their entries. Discuss why good notebook entries are important for documenting and making evidence credible.

2. Gather student attention to the observation charts developed during the last lesson. Explain that the students will work as a class to identify categories based on trends in their observations to organize their evidence.

What follows are three examples of how students might categorize their observations. Since student observations vary extensively, so will their categories. Two to four categories are commonly generated from a typical classroom's observations.

Three examples of how students might classify observations into categories:

Observation Categories	Observation Categories	Observation Categories
Stuff that isn't Decomposing The wet leaves had holes in them. The dry leaves didn't. The plastic bottle had water drops on it. The rock had nothing growing on it. The soil in the bottle was wet. The plastic pen was half in the soil and half out.	***Water*** The soil in the bottle was wet. The plastic bottle had water drops on it. The wet leaves had holes in them. The dry leaves didn't. One end of the stick was slimy and wet, and one end was dry.	***Natural Stuff*** The leaves were covered in white stuff. One end of the stick was slimy and wet, and one end was dry. There was a flying bug in the top of bottle. The wet leaves had holes in them. The dry leaves didn't. The rock had nothing growing on it. The soil in the bottle was wet.
Decomposing Stuff The leaves were covered in white stuff. One end of the stick was slimy and wet, and one end was dry. The wet leaves had holes in them. The dry leaves didn't.	***Growth*** The leaves were covered in white stuff. The rock had nothing growing on it.	***Man-made Things*** The plastic bottle had water drops on it. The plastic pen was half in the soil and half out.
Stuff that is Growing There was a flying bug in the top of bottle. The leaves were covered in white stuff.	***Location*** The plastic pen was half in the soil and half out. There was a flying bug in the top of bottle.	

3. Group students into teams of three to five students. Have groups reflect on their science notebook entries and record any other observations they made that fit into each category but which were not on the class list.

Have each group generate several questions for each category. Some questions may not fit easily into one category. Keep in mind that it is less important for students to assign observations to a single specific category than for them to experience how grouping evidence can be helpful for interpreting it. Using categories is a strategy that may give students ideas and encourage them to ask questions they had not wondered about before.

If the students' questions are not scientific (are simply descriptions of simple things they wonder about), model on the board how to transform a few wonderings into scientific questions.

looking up the answers in a book, and the other group of questions that can possibly be answered through experimentation.

Work with students to transform questions that are too broad or that involve many factors into good investigation questions that they can test with their columns. To help students develop and choose a good question, ask the students to consider their questions in light of these considerations:

- Is it focused on one factor?
- Do you have access to the materials you want to use?
- Will you be able to collect data from your column to use as evidence in explaining your question?

Have each student record their investigation question in their science notebooks.

Observation Category	I Wonder
Natural Stuff The leaves were covered in white stuff. One end of the stick was slimy and wet, and one end was dry. There was a flying bug in the top of bottle. The wet leaves had holes in them. The dry leaves didn't. The rock had nothing growing on it. The soil in the bottle was wet.	***Natural Stuff*** What is that stuff on the leaf? Everything is wet and slimy. How much water was put in these bottles? Why does this one bottle stink so bad and the others don't? How come the rock doesn't have any mold on it? What happened to the middle of the apple, or was only the skin of the apple put in there? Was the same amount of stuff put in all the bottles, or is one rotting faster? Some have a short stack of stuff and others have a tall one.
Man-made things The plastic bottle had water drops on it. The plastic pen was half in the soil and half out.	***Man-made things*** Would a wood pencil change or stay the same? Is the part of the pen that is under the soil rotting or does it look the same as the part that we can see sticking out of the soil?

4. Instruct student groups to choose one of their questions that they think could be answered with a decomposition column investigation.

If they are having trouble doing this, ask them to put all of their questions into two groups: one group of questions that can be answered easily by

5. Provide each student with *Student Page 3.2A: Design an Investigation.*

Explain to students that you will complete this student page together in sections. First, have all students record their group's investigation question at the top of the *Student Page 3.2A: Design an Investigation.*

Discuss the term *prediction* and how to make a prediction. Explain that scientists predict explanations for natural phenomena before they know all the facts. Predictions are ideas for explanations and the reasons for thinking that way. Investigations provide scientists with evidence that may or may not support their predictions. Scientists base their explanations on what the evidence tells them, regardless of whether or not the evidence agrees with their predictions.

Remind students that they make their predictions based on what they already know (from their observations) about decomposition and about the contents of the Decomposition Columns. Explain that predictions are not judged or graded for correctness. Rather, what is important is how well their explanation supports or contradicts their prediction. They need to base their explanations on evidence from the Decomposition Column investigations.

Have each student record his or her own prediction for the investigation, and explain that even though groups are investigating the same question, individual students may well have different predictions. Predictions are based on prior knowledge of decomposition and the observations made in Step 3 Lesson 1. By having the students make and record their predictions individually, each student has a stake in the investigation and in developing an explanation. As they learn more about decomposition, they will be able to evaluate whether or not their own prediction was accurate. Individual predictions also allow for an informal formative assessment of a student's prior knowledge.

Have the students work together as a group to design and record their investigation set-up. Explain that this is to be written and/or drawn and needs to include the following:

- a complete set of directions
- a plan for what each column will contain (for example, Column 1 will have 2 handfuls of soil, 1 slice of apple, and no water. Column 2 will have 2 handfuls of soil, 1 slice of apple, and X amount of water)
- a plan for where the columns will be kept
- any other special instructions
- an explanation for why this design will provide evidence that is relevant for their investigation question.

Explain to the students that they are responsible for collecting data about at least two different characteristics so they will have different types of evidence to use when they develop their explanations. As a class, brainstorm a list of characteristics that could be observed. For example, characteristics might include:

- height of contents in column
- color
- weight
- smell
- visible moisture
- size of particular items
- temperature

Then, have students study the list and identify some tools or techniques that would allow them to measure these things.

Using this information as a starting place, have student groups discuss which of these ideas (or others that they come up with) would work to help them collect evidence for their particular question. Travel around the room and encourage groups to use a standardized tool like a ruler, scale, measuring cup, or thermometer to keep track of at least one of the characteristics they will follow.

For example, if groups are investigating how the decomposition rate of dead leaves is affected by water, they may decide to measure the column height and the color of the leaves in each column. If they are investigating whether dry brown leaves or newspaper decomposes faster, they may want to use crayons to record the color changes they see in the items and the height of each column. If they are investigating whether apples rot faster than bananas, they might want use a homemade stink-o-meter to help them quantify the smells coming out of their columns. They may also want to measure the weight of the fruits.

Have students record what supplies they need for building their columns and list all measuring tools they need. If they need something that is not available, explain that they will either need to bring the supplies to school themselves or change their investigation to fit the available supplies.

6. Travel around the room as the students complete their student pages. Have a short conference with each group to ensure that they have developed a good investigation and to make sure that they are setting reasonable expectations for measuring and using supplies.

7. Use REAPS throughout and after the lesson as appropriate.

Design an Investigation Worksheet

Name: ____

Date: ____

Investigation Question: ____________________________________

____

____

Investigation prediction (I think that by doing this investigation I will find out…):

____

____

Investigation set-up:

What will I put in the decomposition columns? ______________________

____

____

Where will I keep the decomposition columns? ______________________

____

____

Observations and data collection:

What am I going to measure? ________________________________

____

____

How will I measure it? ____________________________________

____

____

The supplies and measuring tools I will need for this investigation: ____________

____

____

Step 3 – Lesson 3 Snapshot

Column Construction and Data Collection

1. Explain that during this lesson the class has the opportunity to design an investigation that will gather evidence to explain an answer to the questions they developed in earlier lessons. Ask each group to review *Student Page 3.2A: Design an Investigation* in preparation for constructing their columns (this was introduced during Lesson 3.2).

2. Provide each student with *Student Page 3.3A: Column Construction* and the necessary supplies. Guide students through constructing their columns.

3. When students are ready to add materials to their columns, provide each student with *Student Page 3.3B: Column Observation*. Students need to list the number of the column and describe the type/amount of material added.

(continued on following page)

REAPS

R – In your science notebook, draw or write the items needed to construct the bottles .
Bottles, soil, water, various other materials as chosen

E – Why did you select those items?
Because experimenting with these materials will generate evidence that may explain an answer to my question.

A – Do you think you could grow radish seeds in these bottles like we did with the Terraqua Columns? Why?
Students need to include a good reason why or why not.

P – How do you expect the items you placed in your bottle to change over time? Why?
Answers need to include a logical explanation for the prediction.

S – Complete this sentence and write it in your science notebook: "I acted like a scientist when ___".

Key Concept

Scientific progress is made by asking meaningful questions and conducting careful investigations

Evidence of Student Understanding

The student will be able to:

- identify the skills used in formulating and justifying explanations;
- identify the scientific skills used in investigations.

Time Needed

75 minutes

Materials

For each student

- completed *Student Page 3.2A: Design an Investigation*
- copy of *Student Page 3.3A Column Construction*
- copy of *Student Page 3.3B Column Observation*
- copy of *Student Page 3.3C Column Data Chart*
- science notebook

For each group

- Demonstration Columns
- 4-8 16 oz. bottles: each pair the same brand of bottle
- measuring tools
- Materials to fill columns (soil, leaves etc.)

Key Words

environment, record, investigation

4. Provide each student with *Student Page 3.3C: Column Data Chart* and explain how to use it. Instruct groups to work together to collect the first row of data. Have each student record the data on his or her own individual student pages.

5. Use REAPS throughout and after the lesson as appropriate.

Implementation Guide

1. Have students review their responses to *Student Page 3.2A: Design an Investigation.* Ask students to reflect on their work using questions like:

- How will your experiment help you explain your question?
- What materials did you decide to use in your columns, and why did you choose them? How much of each?
- How many of each type of columns will you need and why?
- What will be important to observe and record, and how will you collect data?

Try using examples like these if students are having difficulty figuring out how many columns to build, and of what type.

- Imagine that a group asked the question: Does the amount of water in a column effect how fast the materials inside decompose? How many columns does this group need to build?

Students in this group could compare just two columns, one relatively dry and one relatively wet. However, since the group contains four students, the group can make four columns—two dry and two wet. This way they have multiple trials of the same experiment. What would be the benefits of having multiple trials of the same experiment? They have more data to use as evidence when they develop

Teacher Preparation

Plan this investigation so that students are able to complete Lesson 3.4 on the following day, because students need to complete Lesson 3.4 before their columns change too much. In Lesson 3.4 they will evaluate the quality of the science notebook entries made in this lesson as compared to the actual columns.

Material Tips

Column Construction

- Construct a column in advance of this segment of the unit to gain the knowledge needed to help guide the students with their own columns.
- Put out the demonstration columns during the work time so that students have a reference.
- When you make the initial cut on each bottle it is easier to start making a slit with a knife, and then use the scissors to make the complete cut.
- It works best to hold the bottle perpendicular to the table and insert the top arm of the scissors inside the small slit. Snip downwards. Continually rotate the bottle in order to cut downwards around the entire bottle.
- Do not worry if the lines that the students cut are not perfectly straight. The bottles will function with minor imperfections.
- Use the same brand of bottle for all pieces of the column. There are slight variations among brands that could prevent the pieces from fitting together. It is best if one group uses all the same brand of bottles. It eliminates one more variable in their investigations.

their explanation, and if something goes wrong with a column (for example, if the contents spill), they have a backup.

Another approach would be to build one column with no water, one with ¼ cup of water, one with ½ cup water, and one with one full cup of water. With this method the students would test how much water seems to be best for decomposition. The data they get would be more detailed, but they would not have multiple trials. Either method is acceptable, so they must decide which method gathers the most valuable evidence for explaining their question.

2. Distribute *Student Page 3.3A: Column Construction.* Use a Think Aloud to model building the columns effectively and safely. For example:

- The first thing I need to do when I construct a column is to gather all my materials. Then I peel off the labels so we will be able to observe the stuff inside. When I was building the demonstration bottles, I found the easiest and safest way to cut the bottle was to hold it parallel to the desk and then insert my scissors into this hole on the side of the bottle. It is very important to be safe during this process.

- The next thing I do is to cut all the way around the bottle. I try to cut the line as straight as possible. The better the cut, the better the bottles will fit together. Since we need to control as many factors in our experiment as possible, it is important that all our bottles fit together well. Don't worry about minor mistakes, but cut slowly to keep from making major mistakes. Next, I do the same thing with the other bottle, except that I cut it closer to the bottom, right above the base.

- I'll set the bottles aside, and work on the bottle caps right now. The caps serve an important purpose because they let air into the column and water out. Why do you think it is important for the columns to get air? (*Guide students to recall that living things have basic needs to survive, and one of these is air.*) Finally, I can fit the bottles together. Now I have a Decomposition Column.

Have all the students participate in the column construction tasks. Be sure they build all their bottles before adding anything to any of them. See the Materials Tips section at the beginning of this lesson for strategies to make this process run smoothly and safely in the classroom.

3. When students are ready to add materials to their columns, provide each student with *Student Page 3.3B: Column Observation*. Students need to list the number of the column and the type and amount of material included below their drawing. Students can use either standard or non-standard measurements (i.e. 1 cup of soil or 2 handfuls of soil). Encourage the students to document as much detail as possible about what they added. Explain that students will complete this sheet each time they make observations. At the end of their investigations, they will review these data and look for patterns. This means that their data have to be as accurate as possible. Review that scientific illustrations are realistic sketches of what the students see. They are not creative artwork.

During the observation process, travel around the room and remind students of some guidelines for observations.

- Is brown the best way to describe your leaf? Can you think of any more details you could add? I can think of lots of shades of brown and your description doesn't tell me which shade your leaf is.

- I see that you recorded that you added a stick to that column. How big was the stick? What color? What did the bark look like? How will you remember what it looks like today well enough that you can notice changes that might happen over the next weeks?

4. Provide each student with *Student Page 3.3C: Column Data Chart.* Note: Groups may need multiple copies of this data sheet depending on

how many characteristics they investigate and how often they make observations.

Explain to students that they can use this sheet for recording measurable characteristics like height or weight. They can also use it for qualitative characteristics like smell or color, if they come up with some standard way of measuring those things (e.g. a stink-o-meter or paint chips or a hand colored color wheel). Students need to keep this sheet in their science notebooks and add to it each time they make observations of their columns.

Instruct groups to work together to collect the first row of data for each column. Set up a structure so that students take turns measuring things so that no group members dominate during observations. Have students record their observations on their own individual student page and store the page in their science notebook so that every student has all the information at all times, regardless of whether any team members are absent.

Have students complete the first row of their data sheets for each characteristic that they are studying and complete an observation sheet. Have them store these in their science notebooks.

5. Use the REAPS throughout and after the lesson as appropriate.

Decomposition Column Construction

1. Remove the labels from each bottle.

Materials

Two .5L bottles

Utility Knife

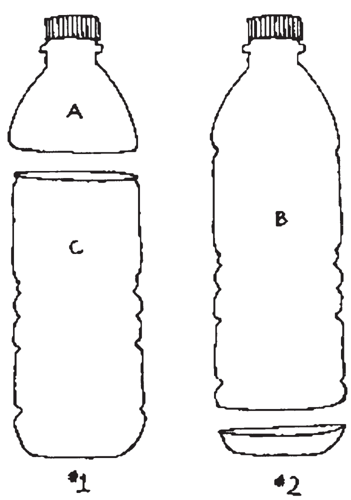
Scissors

Push Pin

Tape

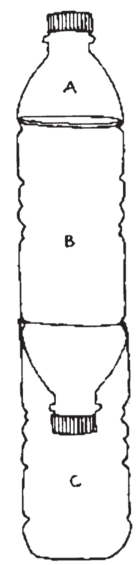
Materials for Decomposition Investigation

2. Cut top off bottle #1, just above the label, so that the top cylinder has straight sides. Cut bottom off bottle #2, just above the base. Make the bottom piece very shallow (about 1cm deep).



3. Remove the two bottle caps and use a push pin to poke 10 holes in each cap. Put the caps back on.

4. Invert piece “B” and stack into base “C.” Using a push pin, poke air holes in the side of piece “B.” Add top “A” and secure it with a piece of tape.



5. Fill the column with the ingredients.

Decomposition Column Observation

Name: ______________________________

Date: ______________________________

Location: ______________________________

____

____

____

____

____

____

Student Page 3.3C: Column Data Chart

Decomposition Column Data Chart

Name: ______________________________

Date: ______________________________

Characteristic: ______________________________

Date	Column #:	Column #:	Column #:	Column #:	Column #:	Column #:

Step 3 – Lesson 4 Snapshot

Key Concept

Scientists take measurements and make observations to formulate and justify explanations.

Evidence of Student Understanding

The student will be able to:

- identify the skills used in formulating and justifying explanations;
- identify the scientific skills used in investigations.

Time Needed

30 minutes

Materials

For each student

- copy of *Student Page 3.3B: Column Observation*
- copy of *Student Page 3.3C: Column Data Chart*
- science notebook

For each group

- Decomposition Columns
- measuring tools
- colored pencils or markers
- hand lenses

Key Words

measure, observation, record

Decomposition Data Collection

1. Use a Think Aloud to model the process of evaluating the quality of the student observations completed during the last lesson. Encourage students to discuss and define what a high-quality observation sheet ought to look like.

2. Have students evaluate the quality of their own or a peer's *Student Page 3.3B: Column Observation* (completed in the last lesson).

3. Provide students 10 minutes to observe their columns and record them on a fresh copy of *Student Page 3.3B: Column Observation*. Have student teams collect a set of data for their columns and record it on *Student Page 3.3C: Column Data Chart*. Make sure students carefully measure and record data in the correct boxes.

4. Use the REAPS throughout and after the lesson as appropriate.

REAPS

R – What changes have you seen in your columns?
Smell, color, shapes of materials, texture, weight, depth of materials.

E – Which of these observable changes are measurable?
Answers may include weight, depth of materials, color (if using a scale).

A – What other questions do you have about decomposition now? How have the questions that you first had changed?
Look for students' questions to have become more specific about decomposition in their own columns and for students to be more aware of the materials and processes in the columns than they were initially.

P – Which bottle do you think is decomposing faster? Why?
The important part of this answer is the students' explanations for what they think constitutes decomposition. Include reference to specific, observed evidence in their explanations.

S – Complete this sentence and write it in your science notebook: "I acted like a scientist when ___".

Background Information

Over the course of the unit, ask the students to make at least six sets of observations of their Decomposition Columns. They made their first set of observations in Step 3, Lesson 3. Step 3, Lesson 4 is the students' second opportunity to collect data on their columns. In Step 4, they will make their four remaining sets of observations—two sets of observations per week. Each set of observations will take about 10–15 minutes. After six sets of observations, have them complete Step 5, Lesson 1 or make a few more sets of observations and then move on to Step 5, Lesson 1.

Keep the bottles in the classroom after the investigations are complete so that students can observe the long term effects of decomposition.

The Immersion Toolbox provides general information about using the Think Aloud strategy in the *Supporting Student Inquiry: The Think Aloud Strateg*y section.

Teacher Preparation

For the Think Aloud suggested in the Implementation Guide, complete an example of *Student Page 3.3B: Column Observation* before teaching this lesson. Students need to study this example observation sheet. Either make copies, scan and display using a data projector, or complete the observations on an overhead transparency. Purposefully make an imperfect set of observations so that you can model why it is important to be accurate. Think AloudChoose some specific things to leave incomplete, inaccurate, or vague.

For examples of what to do poorly, informally assess students' first set of column observations, and replicate some of the incomplete observations that they made. Some possible ideas include:

- us all one color brown for all the leaves in the drawing and describe them only as brown, even though some are still partially green and some are nearly black.
- write that you saw mold on a stick but do not draw it or give any details in the description
- list words, instead of writing descriptive complete sentences

Use the Think Aloud to make visible to students what to think about when observing one of the demonstration Decomposition Columns and how to complete a copy of the student page.

Implementation Guide

1. Students need to make careful, accurate observations in science to develop meaningful evidence-based explanations. Using a Think Aloud, it is possible to let students hear the kinds of planning and logic that go into thinking scientifically. This strategy also provides an opportunity to present scientific reasoning to students in a way that is engaging and invites them to participate in developing their own explanations about why good observations are important. See the following example Think Aloud for one way to implement this strategy.

- I recorded a set of observations on one of the example columns yesterday after school. I thought that since I was asking you to do this, I should try it myself. It was the first time I had recorded my own column observations in a scientific way. I want us to look carefully at my work and see if I am making the kind of observations that, a few weeks from now, will help me figure out how the columns have changed. It is early on in our investigations, so we can change the way we are recording observations if we think we need to. Scientists put a lot of effort into deciding how they will collect and describe their data. We need to do the same, so that we can develop scientific observation about our columns.
- Let's look at my observation sheet. I drew a picture of my column and described it. First, let's talk about my drawing. Don't comment on my art skills, just think about it scientifically. Will this drawing help me three weeks from now, when I have to try to remember what my column used to look like? Is it scientifically accurate? Does it need to be improved? How? What could I do differently next time to make it better?
- What about my description? What parts of it are scientifically accurate? How well did I communicate what my column was like? How could it be improved? What could I do differently next time that would make it better?

Work as a class to develop a list of criteria for a high-quality scientific observation sheet. Write student ideas down on chart paper and number them. Consider writing them down on regular paper after the lesson and providing copies for students to include in their science notebooks for reference. Some example criteria that students may develop include:

- write in complete sentences
- describe what shade of color
- draw things the right size
- don't make things up
- always write down when you see something new
- measure the size of things or say they are about the size of X

2. Ask students to find *Student Page 3.3B: Column Observation* that they completed in the last lesson in their science notebooks. Have them look at each criterion and decide if the observation sheet meets the class expectation for what a good observation sheet looks like. Remind students that it is early in the investigation, so it will not affect their results much if they find their data to need improvement. Explain that part of learning is making mistakes and learning from them—that you do not at this point expect anyone to have an observation sheet that meets all the criteria established today. They are going to observe today, and can practice again.

Alternately, students could do this as a peer assessment—switching papers with a partner, evaluating each other's work (without assigning a grade), and then discussing how to make improvements for the next observations.

3. Allow students to get into their investigation groups. Ask them to observe their columns and record observations on a fresh copy of *Student*

Page 3.3B: Column Observation. During this process, travel around the room and call attention to student observations that are or are not following the guidelines they established for high quality observations. See these examples for guiding students:

- I notice that you used the color green to describe your lettuce. I remember that we agreed as a class that any time we had a color in our descriptions we would also have some sort of descriptive word that helps us understand what shade of that color it is. Can you think of a way to describe what color green the lettuce is?
- The way you organized your descriptions in complete sentences is very easy for me to read and understand; I bet you will be able to remember just what you saw when you read those during our next observation time.
- I see that you drew leaves all the way up to the top of your column. Can you show me which of your columns has leaves all the way up to the top?
- Wow! That leaf drawing looks almost exactly like the one in the column! I can really tell that you were extra careful to make sure the drawing was the same size as the real leaf.

Ask students to find their *Student Page 3.3C: Column Data Chart* in their science notebooks. Have the groups measure the characteristics they are studying and record another line of data. Remind them to make careful measurements with their tools (rulers, hand lenses, scales, color wheels, stink-o-meters, etc.).

Tell students to double-check which box they use to record the data to be sure it matches the column being observed. They need to be sure that the column they are collecting the data from corresponds to the number above the box where they are entering the data. Explain that if students mistakenly add data for Column 1 to the Column 2 box, they will not have strong evidence for explaining their results.

4. Use REAPS throughout and after the lesson as appropriate.

STEP 4

Overview

This step allows students to practice making evidence-based explanations about decomposition as a class in preparation for making their own explanations in Step 5. It also affords teachers the opportunity to assess individual student abilities in making evidence-based explanations.

This step asks students to connect their knowledge of food chains and decomposition to food webs and the natural world. First, they create food chains that diagram the relationships between producers and consumers in their columns. Then, they use these decomposition food chains to make decomposition food webs. Students finish by extending their thinking out to the natural world and create food webs for a forest ecosystem.

Lesson 1

The Role of Decomposers (90 min)

Lesson 2

Creating Food Webs (60 min)

Step 4 – Lesson 1 Snapshot

Key Concept

Decomposers are consumers that recycle matter from plants and animals.

Evidence of Student Understanding

The student will be able to:

- describe how decomposers recycle matter;
- use their understanding of decomposer's needs to explain where decomposers are likely to live.

Time Needed

90 minutes

Materials

For each student

- copy of *Student Page 4.1A: Rotten Work*
- copy of *Student Page 4.1B: Explanation Chart*
- copy of *Student Page 4.1C: Decomposer Needs*
- copy of *Student Page 4.1D: The Woolly Mammoth Mystery*
- science notebooks

For the class

- overhead of *Student Page 4.1B: Explanation Chart*
- overhead of *Teacher Page 4.1b: Explanation Chart Example*

For each group

- Decomposition Columns

Key Words

beneficial, matter, microorganism, organism, recycle, fungi

The Role of Decomposers

1. Remind students about the careful observations they have been making and how some new organisms have been appearing—decomposers. Explain that you have an article with some information about the names of the decomposers that students have been seeing in the columns. Have students read *Student Page 4.1A: Rotten Work*.

2. Instruct students to search their columns for the decomposers mentioned in the article. Have students share their observations, and discuss any differences they see in the number and types of decomposers in the columns. Work with the students to generate a question like the following: ***Why do different columns have different numbers and kinds of decomposers?***

3. Explain that you have a tool to guide students through building an evidence-based explanation for this question, *Student Page 4.1B: Explanation Chart*. Begin with *Page A*—

(continued on following page)

REAPS

R – List the decomposers you observed in the bottle? What is your evidence?
Mold, fungi, fruit flies, etc.

E – Where in your bottle did you see the most evidence of decomposers?
Most evidence is on the surface.

A – Why do you think all the bottles did not have the same decomposers in them?
This depends on the materials originally placed in the bottles.

P – Based on your observations, will you see more or fewer decomposers in the bottles next week?
Why? Include reference to specific, observed evidence.

S – "Think-Pair-Share":
Think about what more you need to know to explain a possible answer to your investigation question, and then find a partner and share your ideas.

Questions and Evidence. Have students summarize the ideas and evidence they have from observing their columns and add to the Explanation Chart. Then, have students read *Student Page 4.1C: Decomposer Needs* and add more ideas and evidence to the chart.

4. Guide students to write an evidence-based explanation including the reasons to believe the explanation using *Page B—Evidence-based Explanations* of the student page.

5. Review, list, and describe the scientific language that is important to making this explanation using *Page C—Scientific Language*.

6. In this lesson or later in the day, allow students 10 minutes to collect a row of data for Student *Page 3.3C: Column Data Chart* and complete another *Student Page 3.3B: Column Observation* for their ongoing decomposition investigation.

7. Use REAPS throughout and after the lesson as appropriate.

8. Assess student skills in building explanations using *Student Page 4.1D: The Woolly Mammoth Mystery*.

Background Information

Developing Scientific Explanations about Decomposition

In this lesson, students develop their first formal scientific explanation about decomposition. They work individually, in pairs, and as a class to practice the skills involved. The Immersion Unit Toolbox has two sections that provide relevant information for facilitating this process: the Formulating Explanations from Evidence section and the Connecting Explanations to Scientific Knowledge sections. Consider reviewing these before guiding students to develop explanations. Students will rely on this experience when developing their own explanations about decomposition from their group decomposition investigations.

Tally Sheets

The class list of decomposers is a resource that students can use in several ways. They can use it to expand their column observations by creating a tally sheet of sightings. Instruct students to add a page to their science notebook with the name of each organism on the side. They can record the absence or presence of each organism during every observation period by marking an X next to each organism that they see. After taking the data on each organism, have the student label that column with a date.

Organism	April 14	April 16	April 19	April 22
White Mold	X	X	X	X
Slime Mold		X	X	X
Small Fly			X	X
Green Mold	X	X	X	X
Isopod			X	

Critter Key

Please refer to the *Teacher Page 4.1e: Guide to Decomposition Critters* for more information on the types of decomposers that might be present in the columns. It is more important for students to accurately describe the critters that they see, not for them to know the names of each critter. However, students are often excited to learn the names of different organisms and to connect this knowledge with other experiences.

Implementation Guide

1. Discuss how the class has been making interesting discoveries while making observations, and explain that you know many students have been asking about the names of the decomposers that are moving into the columns. Explain that you have an article that can help them identify those decomposers. Provide each student with *Student Page 4.1A: Rotten Work*. Assign silent or oral reading of the article using an appropriate reading strategy to support comprehension.

Note: If using the "Developing Vocabulary" strategy described in the Teacher Background section of Lesson 1.2, remind students of the procedure to follow when creating their word lists. Key words to add to the vocabulary list from this reading include microscope, recycle, and bacteria.

2. After the students have finished the reading, have students write in their science notebooks a list of all the decomposers mentioned in the article. Next, provide each student with one of their team's decomposition columns. Ask students to examine it closely, and search for the organisms mentioned in the article. If they see any from their list, have them circle that organism in their notebook. If they see a decomposer that was not mentioned in the article, they should also record that organism and circle it. If they see more than one of something, have them put a tally mark next to that organism's name.

Ask students to share how many different kinds of decomposers they found in their columns. The numbers will vary greatly. Ask the students what kinds of decomposers they saw in their columns. To pique students' interest in the differences among columns, make comments when students share their data like:

- Interesting! Nobody else seems to have seen that decomposer.
- Wow! Many teams have mold in their columns.
- Your column had that many decomposers!
- I wonder why your column had no visible decomposers. I know you looked closely.

If students do not ask this question themselves, pose it to the class:

- I wonder why different columns had different numbers and kinds of decomposers. Some columns have many decomposers. Some have only a few. Some of the columns had only one kind of decomposer visible, some had none, and some had many kinds. It makes me wonder.

3. Explain that you have a tool to guide students through building an evidence-based explanation for this question: ***What is the cause (are the causes) for different columns having different numbers and kinds of decomposers?*** Introduce *Student Page 4.1B: Explanation Chart* and explain that it has three parts that will guide them through making an evidence-based scientific explanation for their question. (Note: *Teacher Page 4.1b: Explanation Chart Example* at the end of this lesson is an example of what the class chart may look like when it is completed.)

Student Page 4.1B: Explanation Chart—Part A, Questions and Evidence

(Note: Page A focuses on recording the question and looking at what evidence is available for explaining the question. It has three sections: Question, Sources of Evidence, and Ideas/ Evidence about the answer.)

Box 1—Question: Share with students that the first thing they need to do when using this chart is to record their question. Agree on the exact wording of the question and record it in the first box. Remind students that it is important to keep track of exactly what their question is asking so they are sure their explanation really answers what they wanted to know.

Box 2—Sources of Evidence: Next, ask students where they can look for evidence to explain this question. Make sure students list "column observations" as a possible source of evidence to explain their question.

Box 3—Ideas/Evidence about the answer: Begin by asking what ideas their "Column Observations" can tell them about the answer. Ask students to think about what their column observation told them about columns with many decomposers and those with few. Generate a class list that describes the properties and ingredients observed in columns with many decomposers and those with few.

Characteristics of Columns with

many decomposers	few decomposers
fruit	dry
vegetables	no fruit
bark	cold
moist	only leaves
wet	soaking wet
egg shells	rocks
plants	only trash
in the dark	frozen
in the light	no air holes

Ask students to look for patterns in the class chart, and ask if these patterns spark any new ideas about the answer to the question, ***What is the cause (are the causes) for different columns having different numbers and kinds of decomposers?*** Record their ideas in the "Ideas about the answer" column of *Student Page 4.1B: Explanation Chart*. Ask students to explicitly share what evidence made them think that way. Then, record both the evidence for the idea and the source of the evidence (in this case "observation") opposite the idea in the "Evidence for each idea" column.

Explain to students that right now they have some ideas about the answer and some evidence for each idea, but they only have one source of evidence. Scientific explanations are stronger when they have multiple sources of evidence.

Share with the class that when scientists try to explain something difficult, they often look at other scientists' work to learn what others already know, and to find more evidence that might be important. For example, articles can be another source of evidence for explaining their question. Have students read *Student Page 4.1C: Decomposer Needs*.

Note: If using the "Developing Vocabulary" strategy described in the Teacher Background section of Lesson 1.2, remind students of the procedure to follow when creating their word lists. Key words to add to the vocabulary list from this reading include protection, need, and survive.

As a class, review the things that decomposers need to survive and where decomposers live, according to the reading. Students need to know that decomposers only live and grow in places where they can meet their needs. Like all living organisms, decomposers need food, water, air and protection.

Guide student attention to the Explanation Chart and work together to add their new knowledge to Box 2 and Box 3 on the chart.

Box 2—Sources of Evidence: Record the reading as a possible source of evidence for explaining the question.

Box 3—Ideas/Evidence about the answer: Ask students to specify any ideas their "Decomposer Needs reading" gives them about the answer to their question. Record any new ideas in the "Ideas" column of the explanation chart. Ask students to remind you of the evidence that made them think that way. Again, ask students to explicitly share which evidence made them think that way. Then, record both the evidence for the idea and the source of the evidence (in this case "reading") opposite the idea in the "Evidence for each idea" column. Review each previously recorded "Idea" and "Evidence for the Idea" that students had listed based on their column observations, and add any new evidence that the reading supplied for those ideas.

4. *Use Page B—Evidence-based Explanations* of the student page to help students write an evidence-based explanation, including the reasons to believe the explanation. Ask the students to study their ideas and evidence and figure out what explanations they can develop for the question, Why do different columns have different numbers and kinds of decomposers?

As students suggest explanations,

- remind them to use evidence and reasoning
- question what evidence they are using and where they got it
- encourage students to question each other's evidence and reasoning
- ask if anyone else has an alternate explanation
- ask if anyone else has ideas to improve the explanation

5. Explain to students that scientific explanations use scientific language correctly. Ask the class to identify the scientific language they used in their explanations. Record each term and a description of the term in the students' own words. The descriptions may include definitions, the kinds of things the term applies to, pronunciation keys, or other information that students think is relevant to their use and understanding of the term.

6. In this lesson or later in the day, have students get into their investigation teams and allow 10 minutes to make another set of observations on their columns. Provide them with another copy of *Student Page 3.3B: Column Observation*. Be sure that they are recording as many details as possible in their science notebooks and on their student pages. Again, encourage students to check each other's work to see that they are recording data in the correct boxes on *Student Page 3.3C: Column Data Chart*.

7. Use REAPS throughout and after the lesson as appropriate.

8. Assess student skills in building explanations using *Student Page 4.1D: The Woolly Mammoth Mystery*. Ask students to read the student page. Make sure students understand that in this scenario scientists found a dead organism (the food of decomposers), with almost no sign of decomposers.

Provide students with their own copy of *Student Page 4.1B: Explanation Chart* to use when constructing an explanation for The Woolly Mammoth Mystery.

Evaluating Student Responses

High-quality student responses cite specific evidence and state the reasoning for why that evidence supports the idea. Students are to focus on what they have learned about decomposers. See the following examples of inadequately supported explanations.

- *"It was too cold in the ice for decomposers to live."*
  Students need to include their evidence that decomposers need temperatures above freezing. They might cite an article that said decomposers need protection from very cold temperatures. They might cite a student experiment that showed no change to a decomposition column kept in the freezer. They might cite their prior experiences that frozen foods do not rot.
- *"There was no air under the ice."*
  Students need to include evidence that decomposers need air. They might cite an article that said decomposers need air. They might cite a student experiment that showed little change in a decomposition column that was sealed from air. They might cite their prior knowledge that living organisms die without air.

High-quality responses will not include explanations like "the decomposers couldn't find the mammoth." Students ought to know from the student readings in this unit that decomposers are everywhere. If decomposers are everywhere, then the mammoth had bacteria and other decomposers on and around it when it died. An explanation stating that decomposers were not present from the start shows a misunderstanding about where decomposers occur. Work with students to revise this type of explanation by suggesting that they revisit other sources of relevant evidence and work with them to improve their skills in constructing evidence-based explanations.

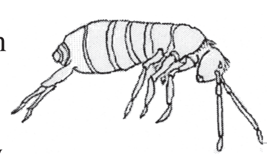
Teacher Page 4.1e: What Might We See?

This guide is divided into three sections: Things that are moving, Things that are not moving, and Things that can only be seen under the microscope. Note: Many of the pictures in this guide are not actual size, but rather are a representation of what some of these organisms look like when magnified. Hand lenses and microscopes provide students more opportunities for detailed observations.

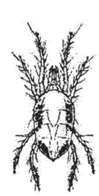
Things That Are Moving

Ants—These common terrestrial insects often move into columns. Depending on the type of ant, they can range in color from black and brown, to red. Although they range in size, they are all visible with the naked eye. Interesting details can be observed with a hand-lens.

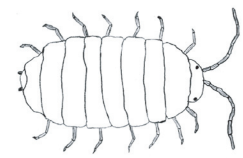
Nematodes—
Nematodes look like very tiny wiggling pieces of thread, often white or tan in color. These thin cylindrical worms are commonly found in outdoor soil. In fact, thousands of these worms may be found in just one handful. Columns that use potting soil, will not have these organisms or many of the other organisms naturally found in soil.



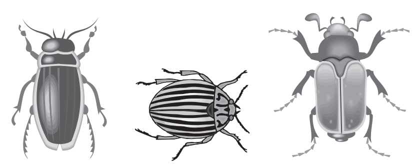
Collembola—Their common name is springtail, hinting at their means of locomotion. They jump and hop as if they are on springs. They are a type of wingless insect, pale-brown to cream in color. Collembola prefer a damp soil environment. Students can observe structural details with hand lens, and will notice that the springtails spring away when disturbed.



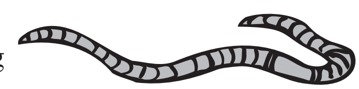
Mites—These organisms can be very small, barely visible to the eye, and many are best viewed with a hand lens. Mites are related to ticks and spiders, and have similar structures. They can be found in both dry and moist columns, and look like slow crawling specks of color. Some common mite colors include red, brown, yellow, green, gray, and black.



Isopods—These small organisms are quite common in columns that include soil and leaf litter from natural environments. They have obvious antennae, seven pairs of legs and a hard exoskeleton. Older isopods are often gray or dark gray. Young isopods can be white or cream colored. When disturbed, some species roll up into balls. Students may see molted isopod exoskeletons. These look like isopods, but are translucent and do not contain the animal itself (much like a shed snakeskin).

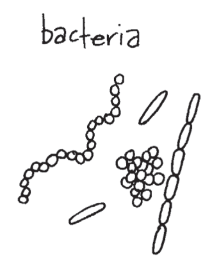


Beetles—These insects are occasionally seen in columns. There are thousands of types of beetles. Most have a hard shiny exoskeleton. They can be found in both dry and wet columns. The larvae of beetles are also sometimes seen. They are called grubs and usually look like fat worms or caterpillars.



Earthworms—These organisms have a long thin body and can range in color from dark brown, purple, red to blue. Earthworms are common in columns that have soil from outdoors and that are moist.

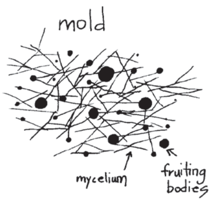
Things That Are Not Moving



Bacterial colonies—They appear as round spots, ranging from brown, to white, to cream. The colonies are made up of thousands, or more, of single individual bacteria. Colonies can be seen with the naked eye or a hand lens. However, individual bacteria are very small and can only be seen with

a microscope. They are so small that 400 of them can exist in an area the size of a pinhead.

Fungi—Mold is one type of fungi that is common in the columns. It often looks like a fuzzy blanket covering rotting matter. The color varies, but it is usually black, green, gray, or cream. Individual mold organisms can be seen with a microscope, and a hand-lens greatly improves the ability to see fine details of the mold's structure.

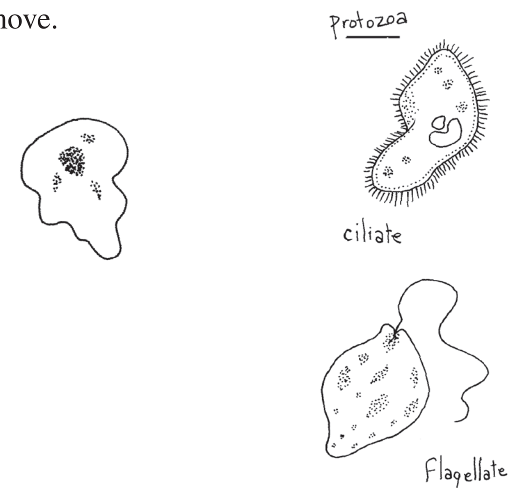


Algal colonies—In the columns, colonies of algae look like a soft green carpet. They range in size from the barely visible to covering many square inches. They require a moist environment and will only be seen in columns with enough water. Algae are photosynthetic. Since they need energy from the sun to grow and reproduce, they are more commonly seen in columns that are located in bright sunlight.

Slime molds—These organisms live in colonies that are often brightly colored and have the appearance and consistency of pudding. They are often shiny and wet looking. Like bacterial and algal colonies, they range in size from the barely visible to covering many square inches.

Things That Are Only Seen Under the Microscope

Protozoa—These single-celled organisms such as amoeba and paramecium are small; about 8 organism could fit on a pinhead. Since they are single-celled, these organisms can be viewed only with a microscope. Under the microscope, students may see the cilia (hairs) or flagella (tail-like appendages) that allow the small organisms to move.



Rotten Work

Instead of a garbage truck to haul things away, nature has a group of organisms called decomposers. Decomposers take care of waste.

Remember what you've learned about producers and consumers:

- Producers use the energy from the sun and matter from the air, water and soil to make food and to grow. Grass is a producer.
- Consumers eat producers. An example is a rabbit eating grass. Consumers also eat other consumers. An example is when a fox eats a rabbit.

What do you think decomposers eat? They eat dead producers and consumers. An example is when a worm eats dead leaves. Decomposers are nature's recyclers.

Decomposers are small. Sometimes they are so small that you can't see them without the help of a microscope. Do you think there are decomposers living in your Decomposition Column? How could you know if they are there? The answer is to look for clues. Do things look kind of brown? Is anything slimy? Does it stink? If you answered yes to any of these questions, the decomposers are probably at work.

Decomposers eat dead things. They might eat leaves, sticks, or other parts of dead plants. They also eat dead animals. They get their energy and matter from the dead organisms that they eat. When they eat the dead organisms, they clean up the environment.

Decomposers make room for new things to grow. In addition, their waste matter becomes part of the soil and air. Decomposers recycle the matter from dead organisms. This makes the soil healthy so that new organisms can grow. It may be hard to believe, but there are hundreds of decomposers at work in your Decomposition Column!

You can see some decomposers. Worms and some insects are decomposers that are big enough to see in nature. Some other decomposers are so small that you can only see them with a microscope. Bacteria are a good example. Scientists call organisms that are very small **microorganisms**. Can you see why they use that name? If you break apart the word microorganism, you find **micro** and **organism. Micro** means very small. A microscope is the tool you need to see microorganisms. Bacteria are microorganisms.

Some decomposers are very small, but you can see them if you look closely. Do you see anything in your column that looks fuzzy? This is probably mold. Other things might be living in the columns, too. Do you see anything green? It might be a producer. Algae are tiny producers. Sometimes they grow in the columns. They look like a soft green carpet.

Do you see any decomposers that are not so tiny? You may see larger organisms, such as fruit flies, mites, and millipedes. Big or small, decomposers do the same work. It is important work.

What is living in your column?

Questions and Evidence

The question that you want to answer:

Sources of evidence to explain the question:

Ideas about the answer	Evidence for each idea

Student Page 4.1B: Explanation Chart—Part B, Evidence-based Explanation

An explanation for the question supported with evidence.

Student Page 4.1B: Explanation Chart—Part C, Scientific Language

Term	Description

Teacher Page 4.1b: Explanation Chart—Part A, Questions and Evidence Example

The question that you want to answer:

- What is the cause (are the causes) for different columns having different numbers and kinds of decomposers?

Sources of evidence to explain the question:

Observations of columns

The reading

Ideas about the answer	Evidence for each idea
1. Observations: Decomposers can't live in columns without food.	1. Observations: columns with little or no food have fewer decomposers. Reading: decomposers need food.
2. Observations: Decomposers can't live in columns without water.	2. Observations: columns that are dry have fewer decomposers. Reading: decomposers need water.
3. Observations: Some decomposers prefer and do best in columns containing fruit and cucumbers.	3. Observations: columns with fruit and cucumbers had the most decomposers and the most different kinds. Reading: decomposers prefer some kinds of food to others.
4. Reading: Decomposers only live in columns that have all the four things they need to live.	4. Reading: decomposers need food, water, air, and protection to survive, not just one or two of them. Observation: the column with water and only Styrofoam peanuts had no decomposers. It had water, but no food. Columns with food, water, air, and that weren't too cold had more decomposers.

Teacher Page 4.1b: Explanation Chart—Part B, Evidence-based Explanation Example

An explanation for the question supported with evidence.

There are more decomposers in columns where they can get all four things they need. Decomposers prefer soft fruit and vegetables for food.

We think this way because we have evidence.

The article says that decomposers need four things—food, water, air, and protection. Without these things, decomposers won't live or grow bigger. The columns tell us the same thing. Columns with only a few of the needs don't have as many decomposers as columns with all four needs.

The article says that decomposer prefer some kinds of food to others. The columns tell us which foods decomposers prefer. There were the most decomposers in ones with fruit and vegetables.

Teacher Page 4.1b: Explanation Chart—Part C, Scientific Language Example

Term	Description
Decomposer	A consumer that needs food, water, air, and protection. They prefer some foods to others. They can't eat everything, especially plastic and metal. Pronounced: de-com-pose-er
Need	When you really need something, you won't be able to live or grow if you don't get it. We need food, water, air, and protection. So do decomposers.
Prefer	is the first choice over other choices
evidence	something that is true, a fact. You can use it to figure out things. Pronounced: Eh-vi-dense

Student Page 4.1C: Decomposer Needs

Your column contains many kinds of decomposers. Some are large. Some are small. Some are too small to see. They all eat food. What do they get from their food? They get matter and energy. Food is matter that stores energy. Decomposers need this matter and energy to live.

What kinds of food do decomposers eat? Do you think they all eat the same foods? Do we all eat the same foods? No, we eat different foods. Decomposers eat different foods, too. Some eat only fruit. Some only eat leaves. They prefer some kinds of food above others, just like you do. You prefer some foods above others.

Did you find a decomposer only on the radishes? It might prefer radishes. It will eat the radishes. Did you find one only on corn? What about the other kinds of waste? What will happen to it? Other decomposers will eat it. There are many kinds of decomposers and they can eat different things.

Decomposers eat dead matter and waste. Your columns have dead matter and waste in them. Where can you find dead matter on Earth? Many environments have dead matter in them. Which one is best for decomposers? It depends on the decomposer. Some prefer a dark moist environment. Some prefer a warm environment with dead fruit. Some live best in hot compost piles.

Decomposers can live in many places, but they can live best where they can meet their needs. They must be able to eat. They must have water. They must have the right kind of protection. For example, it cannot be too hot or too cold. And they must have air. Which columns have everything decomposers need?

What if a column didn't have what decomposers need? They would not live there. What would happen inside the column? Nothing. The column would not change. Even after a very long time, it would not change. The waste would not break down. Is the matter in your columns changing? Then decomposers are at work!

Big or small, decomposers do important work. They live in slimy stinky environments. But they have an important job. What would happen without them? We would be up to our noses in dead matter. We would have no room to live. Producers would have no fresh soil. Most decomposers help humans. They help other organisms, too. They help clear things away. Next time you see a decomposer, thank it for cleaning up!

Name________________________________

Date________________________________

The Woolly Mammoth Mystery

The Story:

Canada is north of the United States. Some parts of Canada are very cold. Some parts are so cold, that they even have big chunks of ice on the ground. One day, someone in Canada found an animal frozen in the ice.

The animal was big, very big! Some scientists came to see it and study it. They dug it out of the ice. They took pictures. They collected data. They talked to other scientists. They figured out what the animal was.

It was a woolly mammoth. A woolly mammoth is like an elephant. They have smaller ears than elephants and thick fur. No woolly mammoths are alive today.

Everyone wondered when the woolly mammoth died. How long had it been frozen in the ice?

Scientists tested it. The figured out that it was about 30,000 years old. It was in the ice that whole time. For 30,000 years, the mammoth was in a big chunk of ice.

It didn't smell bad. It was not rotting. It was not falling apart. Decomposers were not eating it.

The question:

The mammoth was dead for a long time. Why weren't decomposers living on it and eating it?

Your Explanation:

Write your explanation below. Be sure to include your evidence. You can use information in your science notebook, decomposition columns, or student pages as evidence.

Key Concept

A food web illustrates the transfer of energy among multiple food chains in an ecosystem.

Evidence of Student Understanding

The student will be able to:

- apply understanding of the transfer of energy and cycling of matter by completing a food web;
- include the sun as the source of energy in all webs.

Time Needed

60 minutes

Materials

For each student

- food web cards
- science notebooks

For each pair of students

- one piece of chart paper
- glue or tape
- markers or colored pencils
- copy of *Student Page 4.2A: Forest Food Web Cards*

Key Words

producer, consumer, herbivore, omnivore, carnivore, decomposer, energy, food chain, food web

Creating Food Webs

1. Explain that today the students will look more closely at how consumers get energy. Review the Matter and Energy Chart and what students know about producers, consumers, and the types of consumers.

2. Provide each investigation group with their Decomposition Columns and have students work individually to make two lists in their science notebooks—one for all the producers (plants and plant parts) they see in the column and one for all the consumers (decomposers, dead animals or animal parts). Develop a class list of their ideas.

(continued on following page)

REAPS

R – What determines if an organism is called a producer, consumer, herbivore, omnivore, or carnivore? Scientists use these names to group organisms according to how they get their food (matter and energy).

E – Would it be possible to have a food chain without an herbivore?

Yes, a decomposer could eat the dead plant. Sun ➔ Plant ➔ decomposer.

Would it be possible to have one without a producer?

No, they are the only ones that make their own food from the sun.

A – In your science notebook, draw a food chain showing at least two organisms and the original source of energy.

Chains will vary but could be
Sun ➔ Plant ➔ Decomposer

P – Where do you predict on Earth you would find decomposers most like those in your column? Why?

Answers depend on what environment is most like the one in the student's column.

S – In your science notebook, write a reflection about your food web to include an explanation of:
1) where you included the decomposers, and
2) at least one example of a decomposer.

3. Draw a food chain on the board that describes the relationship between producers and consumers in the demonstration column. If the column contains moldy radishes, the food chain would be sun → radish → mold. Ask pairs of students to construct simple food chains for their columns.

4. Introduce the process of combining two food chains to make a simple food web. Explain that food webs show how the energy is transferred from producers to and among consumers more scientifically. Allow student pairs to draw their own simple food webs by combining two or more decomposition column food chains.

5. Ask students where in nature they might find a food web like the one they just developed. Explain that food webs are a representation of how matter cycles and energy is transferred in any system of living organisms in a particular environment (for example, a forest, on the beach, and in the desert). Take time to explain that scientists use the term ecological system, shortened to ecosystem, to refer to a group of living organisms living together and interacting with their environment.

Have students use *Student Page 4.2A: Forest Food Web Cards* to develop a food web for a forest ecosystem on a piece of chart paper.

6. In this lesson or later in the day, provide students 10 minutes to observe their columns and record their observations on a fresh copy of *Student Page 3.3B: Column Observation*. In addition, have student teams collect a set of data their columns for *Student Page 3.3C: Column Data Chart*.

7. Use the REAPS throughout and after the lesson as appropriate.

Background Information

Food Web Extension

In this lesson students work in pairs to develop food webs from organisms found in their Decomposition Columns and from a forest ecosystem. These two food webs were chosen to help students understand what is taking place inside the columns in terms of matter and energy as well as to recognize how the columns are a model for a real environment.

To help you assess what individual students know, individual students can develop food webs for other ecosystems like the ocean, beach, or desert in an extension activity. This allows students to both learn about other ecosystems and to practice drawing food webs correctly.

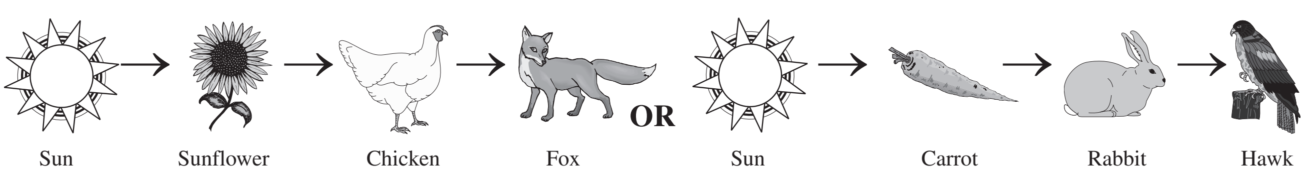
If students chose to diagram a desert ecosystem, they first need to have access to evidence to decide which animals and plants to include. They also need to know what these animals eat. Provide Internet access, non-fiction books, and/or encyclopedias for students to use. Once they know these factors, they can diagram the matter and energy relationships with a food web, and you can evaluate their understanding by both observing the diagram and asking probing questions.

Consumer Niches

Consumers are categorized by the types of food they consume. Each consumer has its own specialized niche, or role within its natural environment. Herbivores are plant-eating consumers, like cows, squirrels, rabbits, grasshoppers, hummingbirds, and deer. Omnivores eat both producers and other consumers. Examples include humans, robins, opossums, raccoons, fox, ants, and black bears. Carnivores are consumers that eat meat, like lions, snakes, most spiders, bobcats, mountain lions, and hawks. Occasionally some carnivores may eat grass or other plants, but most often, this is not for nutritional reasons. Students may be familiar with house cats eating catnip for its intoxicating effects or grass for its digestive benefits. However, this does not make them omnivores.

Food Webs

The standard model of a food chain describes a linear transfer of energy from one organism to the next. Examples of simple food chains:



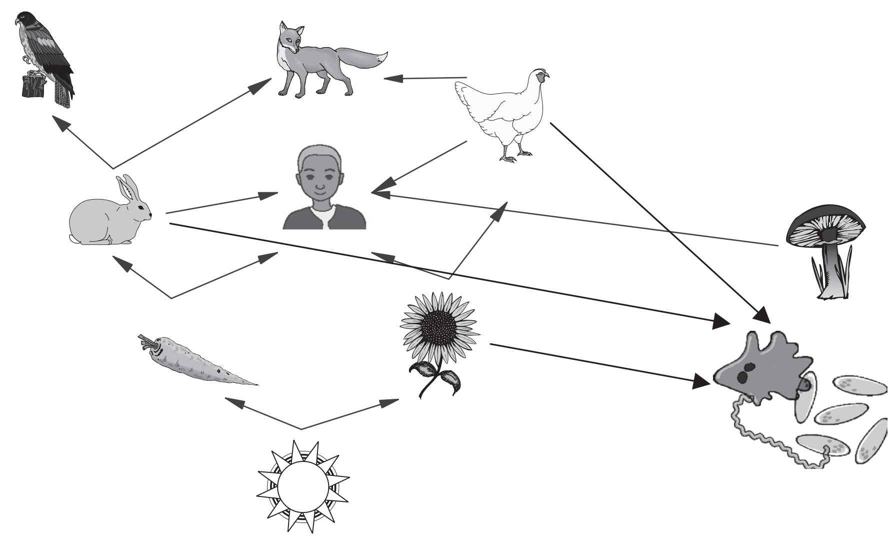
In most ecosystems, however, energy does not flow in simple, straight paths. Very few organisms eat only one thing and rarely is one organism only eaten by one other. Ecological systems are comprised of many interdependent organisms. A food web includes interconnected food chains and shows the competition among organisms for food.

(continued on following page)

The Role of Decomposers in a Food Web

Decomposers are a critical part of food webs because they ensure that producers have healthy, nutrient-rich soil in which to grow. Producers get their energy for growth from the sun, but they also need carbon dioxide, water, and nutrients to grow. Decomposers help ensure that these nutrients are available to producers. They help to provide some of the matter that producers need to grow.

Example of a food web that includes decomposers:



Movement of Energy in an Ecological System

Remind students of the way we use arrows to represent the transfer of energy in the food chain. The direction of the arrows is from the energy source *to* the organism obtaining that energy. It is important that students are clear about how and why arrows were drawn that direction in food chains before moving on to food webs. Food webs are more complex, and keeping track of the correct direction of all the arrows can be challenging if students do not have a firm grasp on what the arrows mean.

As illustrated in the diagram above, arrows show the direction that energy is transferred through the ecological system. The sun provides energy to organisms that produce organic material through photosynthesis—the producers. The consumers obtain their energy by consuming producers or other consumers that have already eaten producers. Decomposers are specialized consumers that obtain their energy from organic wastes and dead producers and consumers.

Implementation Guide

1. Explain that today the students will look more closely at how consumers get energy. Review the Matter and Energy Chart, and discuss what students know and understand about producers, consumers, and the types of consumers. As student share new and appropriate knowledge, make additions to the chart.

Make sure that students know that producers are still classified as producers and consumers as consumers, even though they might be dead. For example, dead leaves, broken twigs, and fruit slices came from producers. Feathers, bones, egg shells came from consumers.

Review what types of consumers students know about and what each eats. For example, the class may want to develop a table like this to help them remember. They could even add specific names of organisms as they learn more about different consumers.

Consumers that eat only producers	Consumers that eat only consumers	Consumers that eat both producers and other consumers
herbivores	carnivores	omnivores and decomposers

2. Provide each student group with the Decomposition Columns from their investigation to use as a reference in this activity.

Instruct students to take five minutes to look at their columns and identify the producers and consumers in their columns. Students may need to be reminded that death doesn't change whether or not something is a producer or consumer.

As students discover a producer or consumer, ask them to make two lists in their science notebooks—one for all the producers they see in the column and one for all the consumers. Travel around the room, and if students have missed an organism, use probing questions to call attention to that organism so that they include it on their list. Keep in mind that students may miss some organisms in the columns for several possible reasons. For example, students may simply not see some organisms, especially if they are tiny; they may think some organisms, particularly decomposers, are nonliving matter; or they may not want to list organisms that they cannot easily name. To determine what students are thinking, ask questions like:

- I see a small flying gnat in your bottle, did you see it, too? How will you decide on which of your lists, producer or consumer, to record it?
- I hear you debating what to do about that brown spot on your apple. Some of your group said it was a decomposer, and others said it was just a soft spot. One piece of evidence that I can share that might be useful is that my Teacher's Guide says that flat, round spots of brown, white, or black are often groups of bacteria. It seems likely that spot is a group of bacteria. If it is bacteria, how could you know if bacteria are producers or consumers?
- Do you think that fuzzy black mold on the lettuce is a producer or consumer? What makes you think that?

If students thinks that something is a producer because it is growing, ask questions like:

- Does growing mean that something is a producer? You're a consumer and you grow, right?
- Look at the Matter and Energy Chart. How did the class describe producers?
- What clues can you look for to help you decide if an organism you don't know much about is making its own food or using another organism as food? Students may be able to point out that the absence of green coloration is evidence for whether an organism is able to make its own food (photosynthesis).

- Once students have a few producers and consumers on their lists, call their attention to the board. Develop a list, using their suggestions of producers and consumers that are either living or dead in the columns.

3. Choose one producer, a radish, from the class list and write it on the board. Ask the students to think about when the radish was alive and identify where the living radishes got their energy. Refer to the Matter and Energy Chart to help students connect what they have been learning to the food chain idea. Once students remember that the radishes got energy from the sun, draw the sun on the board and an arrow from the sun to the producer showing how the energy from the sun goes into the producer. For example,

sun → radish

Now, ask students who had radish in their columns to identify which decomposer they saw using the radish as food. Add that type of decomposer to the radish food chain. For example,

sun → radish → mold

Ask the class if anyone else saw mold growing on something besides radishes, for example, on an apple. Prompt students to explain where the apple got its energy. Then, draw another food chain in the same way for something else that mold grew on. For example,

sun → apple → mold

Explain that the class has just made food chains that describe what is happening in the columns. Remind students that food chains must always start with energy from the sun, because that is where producers get the energy they need to make their own food. Next, a consumer eats the producer—getting the producers matter and energy. Then, another consumer might eat that consumer.

Finally, review the direction that arrows must be drawn. Arrows show which way the energy moves in a food chain.

Ask students to work in pairs to construct food chains for their own columns. They can use their lists of producers and consumers to help them choose organisms. Travel around the room and check to see that students' food chains are correctly drawn.

4. Once students have a few food chains written in their science notebooks, call their attention back to the board. Share any examples that you hear students talking about in which food chains had the same decomposer, consuming different things. Also, highlight examples you observe in which many different kinds of consumers ate the same producer. Explain that this is very common in nature. Often consumers consume many different things. Often, many different consumers eat the same producers.

Ask students how well they think their food chains show these kinds of relationships. Guide the discussion so that students come to understand that food chains don't show the complex relationships among multiple producers and consumers well. A food chain is linear, so it cannot reflect the complexity observed in nature.

Take time to explain that scientists use the term ecological system, shortened to ecosystem, to refer to a group of living organisms living together and interacting with their environment.

Explain that scientists have another model that helps them show how energy is transferred from one organism to another in a particular ecosystem. These models are called food webs. Food webs show the relationships among producers and consumers more accurately than a food chain does. Model how to combine two food chains into a simple food web.

Begin developing the class demonstration food web by starting with the food chains students made on the board earlier. In this example, mold and sun are listed twice. As you work, use a Think Aloud strategy to explain your reasoning as you erase the repeated terms and redraw the arrows one at a time. Be very explicit about how important drawing the arrows in the correct direction is for communicating relationships accurately. Students will need to repeat these types of reasoning and actions when they make their own food webs. For example:

Change these food chains	…to this food web
Sun → apple → mold Sun → radish → mold	Sun ↗ apple ↘ mold ↘ radish ↗ (draw arrows appropriately)

Add another food chain and repeat the process. For example:

Change these food chains And this food chain	…to this food web
Sun ↗ apple ↘ mold ↘ radish ↗ Sun → radish → bacteria	↗ apple → bacteria Sun → radish ↘ ↗ mold (draw arrows appropriately)

Allow student pairs to develop their own small food webs in their science notebooks. They should combine a few of the decomposition column food chains they developed earlier.

Travel around the room and make sure students understand the differences between food chains and food webs. Check to see that each organism is only drawn in the food web once. If it eats multiple things or multiple things eat it, there ought to be multiple arrows coming in or out of it, but it must not be listed multiple times.

5. In this section, students extend their knowledge about the food webs to the natural world.

Ask students where in nature they might find a food web like the one they just developed. Students may suggest many different ecosystems depending on what type of environment exists in their column. Columns with very little water may remind students of prairies or deserts. Columns with lots of moisture, dead plants, and insects may remind them of a forest or beach. Columns with candy wrappers and bark may remind them of the playground.

Tell students that all these ecosystems contain food webs. In every ecosystem producers use energy from the sun and then consumers eat producers and get their energy. Then, other consumers eat them and get their energy. Explain that you have some cards with many organisms pictured on them. All of these organisms live in the forest. The students can use these cards to make a food web that describes how energy is transferred in a forest ecosystem.

Group students into pairs. Provide the students with *Student Page 4.2A: Forest Food Web Cards*. Tell students that the first thing they and their partner need to do is label each food web card as a producer or consumer. This may help them remember how to connect the organisms in the food web. Travel around the room and monitor student progress. Challenge students who finish early to look at all the consumer cards and label them as to what type of consumer they are—herbivores, omnivores, decomposers, or carnivores.

Hand out a large, chart-sized piece of paper to each pair of students. Ask students to begin making a food web by laying their cards and arrows out on their chart paper to represent the way that matter and energy moves in the forest ecosystem. Provide students with blank cards for adding more organisms to their food web if they explain their evidence for needing them.

As the students finish, have each group explain to you the relationships they mapped out on their chart paper. If their diagram makes sense, have them tape down the cards and arrows. If they have errors, ask the students to explain the part of their diagram that doesn't make sense. For example, you might say:

- I notice that you have the arrows from your producers pointing at your sun. Please explain why you drew the arrows that way? If a student answers, "Because the producers get energy from the sun," explain that the way the arrows are drawn does not agree with their explanation.
- I see that you have arrows from all of your

consumers going into your decomposers. I also see that you don't have any arrows going from your producers to your decomposers. Is that because decomposers don't eat producers?

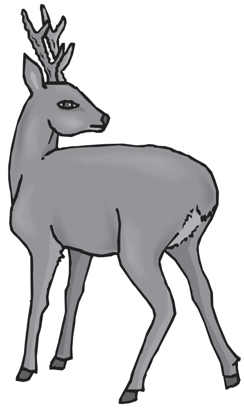
For groups that finish early, consider doing a food web exchange in which the groups can give feedback on each other's work. Challenge students to look for:

- cards labeled correctly
- organisms eating (getting matter from) the appropriate organisms
- arrows pointing in the correct direction
- decomposers taking care of the waste

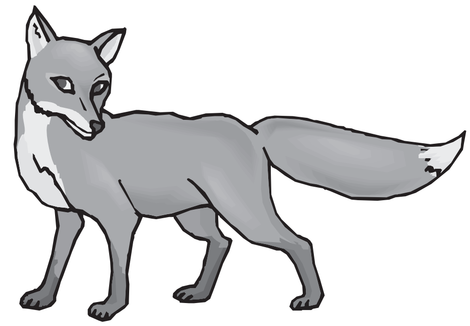
6. Either right after the students complete the food webs or later in the day, allow students to get into their investigation groups. Ask students to observe their columns and record their observations on a fresh copy of *Student Page 3.3B: Column Observation*. During this process travel around the room and call attention to student observations that showcase the guidelines that the class established for high quality observations and challenge all students to keep making the best observations they can.

7. Use REAPS throughout and at the end of the lesson as appropriate.

Student Page 4.2A: Forest Food Web Cards



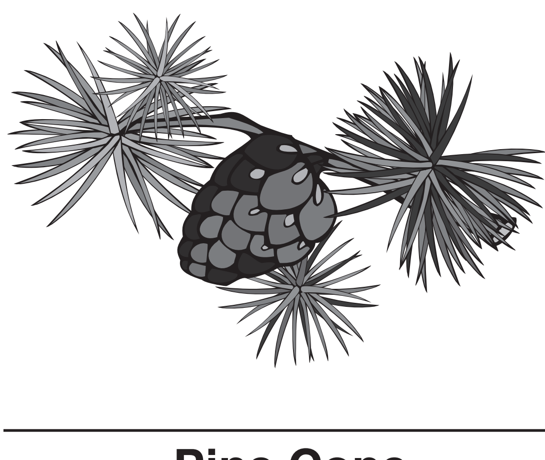
Deer



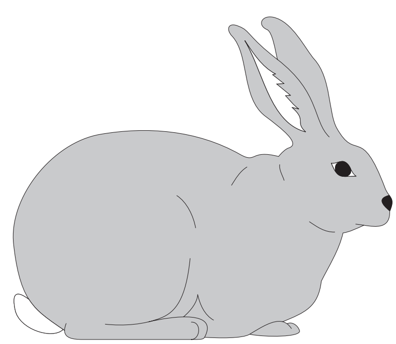
Fox

Vulture

Grass

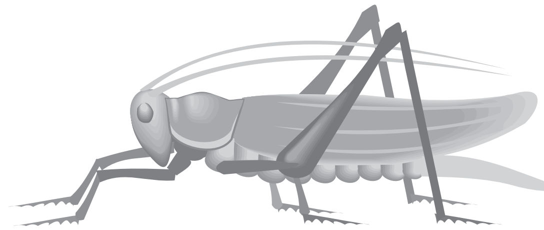


Pine Cone



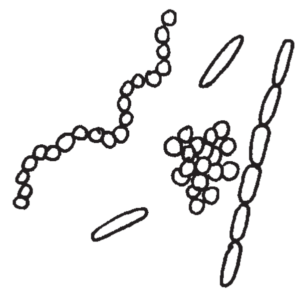
Rabbit

Mushroom

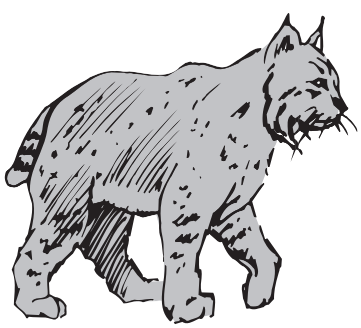


Grasshopper

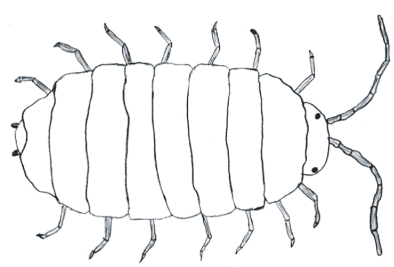
Hawk



Bacteria

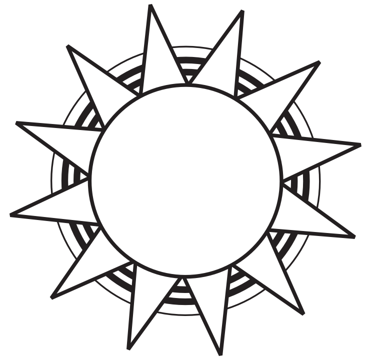


Bobcat



Isopod

Bird

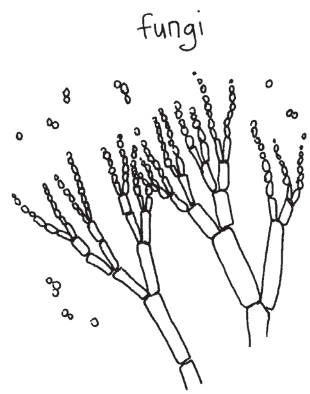


Sun

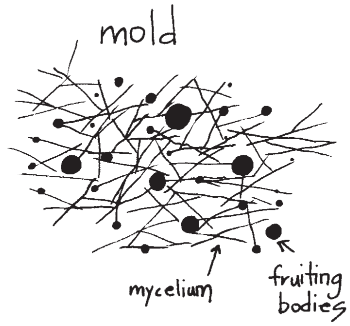
Acorn

Squirrel

Flower



Fungi



Mold

STEP
5

Overview

In this step, students demonstrate their ability to make evidence-based explanations about decomposition using evidence from both their own investigation, other class work, and from readings..

Lesson 1

Developing Evidence-based Explanations (45 min)

Step 5 – Lesson 1 Snapshot

Key Concept

Scientists develop explanations using observations and what they already know about the world.

Evidence of Student Understanding

The student will be able to:

- formulate a scientifically based question;
- gather evidence to explain a scientific concept;
- formulate explanations based on scientific evidence;
- communicate and justify explanations.

Time Needed

60 minutes

Materials

For the class

- overhead of *Student Page 5.1A: Explanation Chart*
- overhead of *Teacher Page 5.1a: Explanation Chart Example*
- overhead of *Teacher Page 5.1b: Example Weight Data*
- overhead of *Teacher Page 5.1c: Example Color Data*

For each student

- copy of *Student Page 5.1A: Explanation Chart*
- all completed student pages
- science notebooks

For each group

- Decomposition Columns

Key Words

evidence, cause and effect, conclusion, opinion, result, explanation

Developing Evidence-based Explanations

1. Use a Think Aloud to model how to analyze data from an experiment to generate ideas and evidence for making an explanation. Use overheads of *Student Page 5.1A: Explanation Chart, Teacher Page 5.1a: Explanation Chart Example, Teacher Page 5.1b: Example Weight Data,* and *Teacher Page 5.1c: Example Color Data.*

2. Gather investigation teams together with the columns and science notebooks. Provide students with *Student Page 5.1A: Explanation Chart* and ask students to complete the page using the data from their experiment as their first source of ideas and evidence.

(continued on following page)

REAPS

R – What changes do you notice in your Decomposition Columns?
Responses need to include reference to the evidence from the students' recorded observations.

E – What patterns do you see in your data?
Patterns may include a decline in the volume of materials, an increase in decomposers observed, an increase in the strength of the smell, an increase in moisture.

A – Using your data, write in your science notebook what you think happens in the process of decomposition. You may use diagrams with labels to help explain
Use an example from their columns as evidence from their observations to explain that materials break down over time when decomposers eat them.

P – What do you think will happen to your column if you let it decompose for another three weeks? Why? Include reference to specific, observed evidence.

S – Have students work with a partner to share their science notebook entries on the process of decomposition.

3. Have teams continue with the process of building explanations by looking for another source of evidence from this unit or from their readings, and add it to the chart.

4. Based on these two sources of evidence, have students make an explanation about decomposition that addresses their original question and record it on their chart.

5. Assign groups to review explanation charts with other groups.

6. Use the REAPS throughout and after the lesson as appropriate.

Background Information

Class Presentations

In this unit, students communicate their scientific explanations about what takes place in the Decomposition Columns by participating in a peer review. While this step does not describe the presentation of explanations, it could be added at the end of this lesson if time permits. The peer review used in this lesson does provide an opportunity for students to both demonstrate their understanding of what makes a strong scientific explanation and behave like scientists by evaluating other evidence-based explanations.

In this lesson, as in Lesson 4.1 (where it was introduced), students use *Explanation Charts* to communicate their scientific explanations for an answer to their Decomposition Column question. You may choose also to direct students to make graphs or other pictures or diagrams to help communicate their data and reasoning.

Developing Scientific Explanations about Decomposition

In this lesson, students develop scientific explanations about decomposition based on their investigations and the other resources they have encountered throughout this unit. This lesson is the crux and culminating activity for the student-directed decomposition column investigation. The Immersion Unit Toolbox sections Formulating Explanations from Evidence section and the Connecting Explanations to scientific Knowledge provide relevant teacher information for facilitating this process. Students also communicate these explanations to other groups. This exchange of ideas is critical to scientific inquiry and developing accurate understandings. The Toolbox section Communicating Results and Justifying Explanations offers guidance on supporting students in developing these skills.

Implementation Guide

1. Explain to students that they have collected a large amount of data during the course of this investigation. Now, they must figure out what all this data tells them about their columns and about decomposition. Today they will build scientific explanations about decomposition that are based on evidence.

To support students in analyzing this collection of data, use a Think Aloud technique to model the process of using experimental data in an explanation.

Before leading the Think Aloud, gather all the materials you need, including the overheads of *Student Page 5.1A: Explanation Chart, Teacher Page 5.1a: Explanation Chart Example, Teacher Page 5.1b: Example Weight Data* and *Teacher Page 5.1c: Example Color Data* for the mock experiment. Tell the students that they have already used *Student Page 5.1A: Explanation Chart* in lesson 4.1, and that in today's lesson they fill it out again using different information. Note also that *Teacher Page 5.1a: Explanation Chart Example* is different than *Teacher Page 4.1b: Explanation Chart Example* (used in lesson 4.1) because it includes a different explanation example.

The following is an example for conducting this Think Aloud:

- I have some data from an experiment that another group did with Decomposition Columns. We are going to practice our data analysis skills and build an explanation using the same explanation charts we used last time. Then, you are going to do the same thing with your own data. Show students *Teacher Page 5.1b: Example Weight Data*.
- I have a couple of things that I want to know first, before I even look at these data. I want to know what their question was. I see it: Does temperature affect how fast apples decompose? Let's record that on our explanation chart so we know that important piece of information.
- We know that they did an experiment to collect evidence to explain this question, so I will write "Decomposition Columns Investigation" under **Sources of Evidence**. Let's see what this group did in their experiment. Show students *Teacher Page 5.1b: Example Weight Data* again.
- It looks like this group decided to build four columns, and keep two out in the classroom, and two in the refrigerator. They decided to measure the weight of an apple piece in grams.
- Let me think that part through. They wanted to figure out if temperature had anything to do with how fast apples decomposed, so they put some columns in a warm place and some in a cold place. Then, they were going to measure the weight of an apple piece.
- The first thing I notice when I look at these data is that all the columns started with an apple slice that weighed 40 grams. That is a good experimental procedure. Can anyone tell me why? Yes, that was something that they kept the same in all the columns. They wanted the only difference in the column to be the temperature. Then, if the apples in the columns weighed different amounts after the columns worked for a while, they could infer that the apples were decomposing at different rates. That would be important evident to have to be able to explain if temperature mattered.
- Okay, let's look at their data. I will focus on Columns 1 and 2 first, then on Columns 3 and 4, because those pairs of columns were kept in the same conditions. Columns 1 and 2 were both out in the classroom. The group must have wanted to have multiple trials so they had more data to look at. It looks like the apple in Column 1 went from 40 grams to 35 grams during

the experiment, and the apple in Column 2 went from 40 grams to 36 grams. Let's figure out how many grams each apple lost, in total, in the experiment. In Column 1, the apple lost five grams, and in Column 2, it lost four grams of weight. I will write that down on the board so I remember it.

- Columns 3 and 4 were kept in the refrigerator. We can figure out the same information about these columns. As I am looking at these data, I notice something a little strange about the data for column 3. Does anyone else see something in Column 3's data that doesn't make sense? Yes, it looks like on March 5, Column 3 lost 10 grams, and then on March 10 it gained 10 grams. This seems odd to me. I am wondering what could have caused the apple to lose 10 grams and then gain it back. Hmmmm. That seems like a lot of weight to lose in five days. And how could the apple have gotten bigger after that? I am deciding that piece of data was a mistake. They must have measured it incorrectly on March 5.
- So, I will set that mistake aside, and go back to figuring out how many grams each apple lost by the end of the experiment. They each lost one gram. I am writing that down so I don't forget it.
- It looks to me like the apples in Columns 1 and 2 lost a lot more weight than the apples in Columns 3 and 4. This gives me the idea that apples do decompose faster in warmer temperatures. My evidence for this idea is that the data says that apples at room temperature lost more weight than those in the refrigerator. I will write both that idea and the evidence for that idea on my *Explanation Chart*.
- This group also collected data on the color of the inside of the apple. Show students *Teacher Page 5.1c: Example Color Data*. I will repeat the same process that I did with the other data. I notice right away that all the apples started out the same color. That is a good experimental design. It would have been hard for me to figure out these data if the apples weren't the same color at the beginning of the experiment.
- First, I'll look at Columns 1 and 2, then at Columns 3 and 4. Columns 1 and 2 both ended up being Mud Brown. Column 3 went from Cream to Light Brown, and Column 4 went from Cream to Tan. Column 1 was Light Brown after just three days. It took Column 3 the whole experiment to get to be Light Brown and the apple in Column 4 never got that dark.
- It looks like the apples in Columns 1 and 2 got the darkest during the experiment. When I look at these data I really think that my idea that apples decompose faster in warmer temperatures is right; it is another piece of evidence for that idea: apples at room temperature changed color faster than those in the refrigerator. I am writing down this piece of evidence for my idea on my explanation chart.
- Now I have two pieces of experimental evidence to use later when I try to build an explanation about decomposition. I wish I had drawings and written observations from this group. What could I do if I had drawings and descriptions? Right, I would have even more experimental evidence to use in my explanation. Is there anywhere else I could look for evidence related to my question? I think I could also look back at the readings about decomposers. I remember that it said something about how they eat fruit. That would be another piece of evidence for my chart.

Explain to students that they will complete this same process with their experimental data. Remind them that since they have drawings and written observations, they will analyze those, too, and record those along with their ideas on their explanation chart. Remind students that they may think of many ideas from looking at their data.

They most likely have been developing ideas every time they made observations, and that is just like what scientists do. Also, like scientists, they are recording all their ideas.

2. Have students gather into their investigation groups. As students get their science notebook materials organized, distribute a copy of *Student Page 5.1A: Explanation Chart* to each student. Instruct groups to look through their science notebooks and review the data they have collected from their columns, including both their data table and notebook entries.

Direct the students to work individually and to write their group's questions on their chart. Next, have students continue to work individually to record all their ideas and experimental evidence in Part 1 of the explanation chart.

Travel around the room and assist students as needed. Remind students of the critical thinking processes demonstrated in the Think Aloud.

3. Explain to students that by now they have several concisely stated ideas and pieces of evidence about decomposition from their experiments. Remind students that scientists look at many different sources of evidence and consider them before they develop an explanation. Ask students to identify other sources of evidence related to their explanations from this unit and add them to Part 1 of the explanation chart.

4. Once students have completed this process individually, have groups work together to develop one final group explanation that represents their combined ideas.

Explain that another group will review this explanation, and that it needs to be easy for someone else to understand.

Here are a few things to keep in mind while students are developing explanations:

- Make sure students are making explanations that are bigger than just what is in their column. They need to be generalizing at this point—relating their explanations to real ecosystems or landfills or perhaps to all consumers, including decomposers.
- If students find a source of evidence that contradicts what they have found, they may not exclude that evidence on their explanation chart. Explain that scientists don't exclude evidence from their explanations, just because it doesn't agree with what they think. Tell students that if they find a source of evidence that doesn't agree with their data, they need to include the evidence from that source on their chart anyway. Then, they can talk to each other and figure out how they could have two pieces of evidence that disagree.
- Challenge students who finish early or who demonstrate proficiency at building explanations to expand their sources of evidence. They might use their textbook, an Internet site, an encyclopedia, or non-fiction books. Or, talk to a neighbor who composts his or her garden.

5. Once all groups complete their explanations, assign groups to exchange explanation charts to review each other's explanations. Challenge every group to find at least one way to suggest an improvement in the other group's explanation. In addition, have every group identify the strongest reasoning and use of evidence in the other group's explanation. Explain to students that they are doing what scientists do, reviewing their peers' work to check for accuracy and to share knowledge.

Limit the time allowed for this review to keep students on task. You may also choose to assign roles to individuals in the group; for example, one student might read the explanation, another record the group's recommendation, and another record the group's comments about the explanation's strengths.

Have review groups write their two points clearly—one suggestion and one commendation—and explain that you will be checking their understanding about what makes a good scientific explanation by reading their comments.

At a designated time, have students discuss reviews with the other group. Travel around the room and monitor these discussions to assess students' progress in developing strong evidence-base explanation. You may choose to have student groups revise their explanations in response to the review received.

6. Use the REAPS throughout and after the lesson as appropriate.

Student Page 5.1A: Explanation Chart

The question that you want to answer:

Sources of evidence to explain the question:

Ideas about the answer	Evidence for each idea

Teacher Page 5.1a: Explanation Chart—Part A, Question and Evidence Example for Decomposition Columns

The question that you want to answer:

- Does how much water there is in a column affect how fast leaves decompose?

Sources of evidence to explain the question:

Observations of columns   Decomposer Readings   Internet site www.compostguide.com

Ideas about the answer	Evidence for each idea
Observations: Leaves don't decompose very fast without water.	Observations: columns that are dry don't smell. Observations: columns that are dry don't have any flying decomposers that we can see. Observations: columns that are dry don't have mold or bacteria that we can see. Reading: decomposers need water Reading: decomposers can eat leaves Internet: Compost piles decompose faster if people add water to them.

Teacher Page 5.1a: Explanation Chart—Part B, Evidence-based Explanations, Example for Decomposition Columns

An explanation for the question supported with evidence.

Leaves decompose faster when they are wetter, because there are more decomposers in the wet columns. I think this way because I have lots of evidence from the experiment, the readings, and the internet.

There are more decomposers in wet columns because decomposers need water to live. I know because the reading said so and I saw more of them in there. I also read that compost piles have leaves in them. The internet said that you could speed up how fast your compost pile decomposes it you put water on it.

I didn't find any evidence that said that anything decomposes faster when they are dry or that decomposers didn't need water or that things could decompose without decomposers.

Teacher Page 5.1a: Explanation Chart—Part C, Scientific Language, Example for Decomposition Columns

Term	Description
Decomposer	They cause things to decompose. We can’t see them all. They are too small. They need water. They won’t live in places without water. When you really need something, you won’t be able to live or grow if you don’t get it. We need food, water, air, and protection. So do decomposers.
evidence	It can be from readings, books, the internet, or experiments. You have to have to say that something is true for sure. When you go to court, they have to have evidence that you did something bad, to put you in jail. They can’t just think it. Scientists are the same way.

Teacher Page 5.1b: Example Weight Data

Question: Does temperature affect how fast apples decompose?

Experiment: 2 columns in the classroom, 2 in the fridge

Characteristic: Weight of apple piece in grams

Date	Column # 1 Room	Column # 2 Room	Column # 3 Fridge	Column # 4 Fridge
March 2	40 grams	40 grams	40 grams	40 grams
March 5	39 grams	39 grams	30 grams	40 grams
March 10	38 grams	39 grams	40 grams	40 grams
March 16	37 grams	38 grams	40 grams	39 grams
March 21	37 grams	36 grams	39 grams	39 grams
March 28	35 grams	36 grams	39 grams	39 grams

Teacher Page 5.1c: Example Color Data

Question: Does temperature affect how fast apples decompose?

Experiment: 2 columns in the classroom, 2 in the fridge

Characteristic: Color of the inside of the apple—matched to crayon colors

Date	Column # 1 Room	Column # 2 Room	Column # 3 Fridge	Column # 4 Fridge
March 2	Cream	Cream	Cream	Cream
March 5	Light Brown	Tan	Cream	Cream
March 10	Brown	Brown	Tan	Cream
March 16	Mud Brown	Brown	Tan	Tan
March 21	Mud Brown	Mud Brown	Tan	Tan
March 28	Mud Brown	Mud Brown	Light Brown	Tan

STEP 6

Overview

This step allows students to apply their knowledge about decomposition to both nature's waste and human trash. They are challenged to think about what kind of waste human trash decomposers can handle, and what happens to the trash that they cannot handle. It also provides students with an opportunity to evaluate their daily decisions about what products they dispose of, and attempt to reduce their contributions to landfills.

Lesson 1

Waste and Recycling (30 min)

Lesson 2

Reducing Waste (60 min)

Key Concept

In decomposition, dead matter is broken down and recycled by living organisms.

Evidence of Student Understanding

The student will be able to:

- describe how decomposers recycle matter.

Time Needed

30 minutes

Materials

For each student

- copy of *Student Page 6.1A The Decomposition Times*
- science notebooks

Key Words

environment, resources, landfill, recycle, waste

Waste and Recycling

1. Provide students with their Forest Food Webs from Lesson 4.2. Use a Think-Pair-Share to address the question What would the forst look like if there were no decomposers living there? Students need to use evidence from readings and their investigation in their explanations.

2. Explain that you have an article that talks about the role of decomposers in the forst and landfill. Provide students *Student Page 6.1A: The Decomposition Times* and have them read the **Nature's Waste** section. Then make a food web from the description in the article. Ask students what waste is left in the forest after all of those organisms live and die. (None.) Discuss where the matter and energy stored in that waste goes. Be certain that students understand these two important concepts.

(continued on following page)

REAPS

R – What do the arrows show in a food chain/web drawing?
Transfer of energy from the sun to producers and from producers to consumers.

E – Where do decomposers get matter and energy from?
Dead plants and animals, other natural waste products.

A – Why do we need decomposers?
Decomposers recycle Earth's matter so that it is again available to producers.

P – What do you think our world would look like if we didn't have decomposers?
There would be nothing to recycle the matter, so it would build up and cover the earth.

S – With a partner, have students share something they have done to help reduce, reuse, or recycle. This is an opportunity for students to share ideas and for the teacher to determine if any further instruction is needed for the whole class or for individuals.

- Matter is recycled by decomposers and made available to producers—matter goes back into the ecosystem.
- The energy that was stored in that matter is not recycled. It is used by the decomposers. In cannot be transferred back to the producers—producers get their energy from the sun.

3. Have students read the **Human Trash** section. To related the reading to their lives, as them to generate a list of things they often throw away. Ask students to predict which of these will not decompose and circle them.

4. Have students read the **Reducing Trash** section. Develop ideas for dealing with the items on their lists that will not be broken down by decomposers using the Reduce, Reuse, Recycle model.

5. Do a Think-Pair-Share working on the question How are decomposers beneficial to humans and other organisms? Remind students to use evidence in their responses.

6. Use REAPS throughout and after the lesson as appropriate.

Teacher Preparation

Be sure to use appropriate reading strategies to introduce students to new vocabulary words and connect the reading back to their prior knowledge. Make it explicit to students in advance that they are expected to connect the content from the article to their experiences with the Decomposition Columns and previous articles.

Culminating Activity

This lesson is the culminating activity for this unit. This lesson provides a key opportunity to assess student understanding of many of the unit's key concepts. Students review food chains and webs, the role and energy requirements of producers and consumers, and the importance of decomposers. Also, this lesson introduces the problems created by trash that decomposers are unable to recycle. Lesson 6.2 is an optional activity that allows students to extend the thinking they begin in this lesson about trash problems.

Recycling

When the idea of recycling comes up in the reading, discuss the items the class or school recycles. Question them on what they think happens to the items in the recycling bin. Some students think that they are cleaned and reused. In the past, this was the case. For example, milk bottles and soda bottles were returned to the bottling plant. They were washed, sterilized, and refilled. If one was broken, it was just thrown out, but most of the bottles were "reused." Today, we reuse the glass from the bottles that we recycle, but not the bottles themselves. The glass in the recycling bin is crushes into little pieces, melted, and reformed into a completely different bottle. They take the tiny little parts and use them to make something new—recycling, or cycling the matter from which the glass was made.

Implementation Guide

1. Provide students with their Forest Food Webs from Lesson 4.2. Use a Think-Pair-Share to address the question What would the forest look like if there were no decomposers living there? Have students first think about the questions individually and write down or draw a few ideas in their science notebooks. Then, have them talk about their ideas with a partner. Encourage them to question each other's evidence. Direct students to sources of evidence like their previous student readings, as needed. These readings provide them with evidence such as, decomposers get their matter and energy from dead organisms and waste, and decomposers recycle matter back into the environment to be used again by producers, and in turn the rest of the organisms in the food webs. Ask students to share their ideas with the class, including the evidence they have for thinking that way.

2. Explain that you have an article that talks about the role of decomposers in the forest and in landfills. Provide students with *Student Page 6.1A: The Decomposition Times*. Have them red the **Nature's Waste** section.

To review food webs and to introduce the idea of nature taking care of its trash, create a food web from the organism described in the first three paragraphs. Ask students to name all of the organisms that they saw mentioned in that section of the article—oak tree, squirrel, fox and decomposers.

Have the class generate a food web using those organisms and the sun. Features that may show student understanding include: having decomposers eating the oak tree (acorn shells) and the squirrel (fur), the sun providing energy for the oak tree, and students explaining that the arrows show the energy from one thing going into another. If students forget about the decomposers, ask them:

- Who ate the acorn shells the squirrel left behind?
- Who ate the fur left from the fox's dinner?
- Who will eat the fox when it dies?

Now, ask student what waste is left over in the forest after all of these organisms live and die. The answer is, none. Decomposers eat all the waste. Even when the decomposers die, other decomposers eat them. Nature has a way of taking care of, or recycling, its waste back into the soil and air for producers to use.

Discuss where the matter and energy from that waste goes. Use this discussion to check for students understanding of the following key concepts for this unit:

- Matter is recycled by decomposers and made available to producers—matter goes back into the ecosystem.
- The energy that was stored in that matter is not recycled. It is used by the decomposers. It cannot be transferred back to producers—producers get their energy from the sun.

You may choose to have students individually write a summary statement or draw a summary diagram of this discussion as a summative assessment.

3. Explain that the rest of the article talks about the trash that humans make. Have students read the **Human Trash** section.

Then ask students to think about what they just read in terms of their own trash production. Ask the students to think about everything that they have thrown away today. Have them write a list in their Science Notebooks. Ask them to circle all the items that they think that decomposers would have a hard time consuming.

Encourage them to use the knowledge they gained through this unit as evidence for their explanations. Remind students that even if they have not experimented with or read about the exact item they threw away, then can make a prediction that is based on what they do know. To explain this to students you may choose to use an example like:

Think about throwing away a broken plastic toy. You may not know if the toy will decomposes for sure, but you do know from our experiments that plastic pens don't decompose well. You could make a prediction that it would be likely that the plastic toy would not decompose well either, and that would be a logical prediction to make.

4. Read the final section of **Reducing Trash**. Then, return to the list of items the students wrote earlier. Ask a few students to share some of the items on their list that they said would not decompose. Ask student to study the class list and figure out what things they could have prevented from sending to the landfill. To guide the discussion, try prompts like these:

Reduce: "Did you really need that in the first place?" If students identify that they really didn't need some of the things on their list in the first place, ask questions like:

- "How could you make a better decision next time you decide to buy something?"
- "What kind of criteria could you use to determine if you really needed something?"
- "How long is long enough to play with something to make it worth have, and then later throwing away?"
- "What solutions could you have for getting rid of it the item when you are done, besides throwing it in the trash?"
- "Are there ways that you can help your household throw out less wasted food?"

Recycle: "What could you do with that other than throw it away?"

Students might identify some things that were needed at one time, but which were no longer needed, such as too-small clothes, or an empty bottle of water from when they were thirsty. When they mention these things, discuss whether or not there was anything they could do with them when they were done other than throwing them in the landfill.

- "What else could you have done with the shoes/toys/clothes besides them them away?" Give them to somebody else that might want them, like a neighbor, friend, or cousin. Donate them to a charity. Sell them at a garage sale. Trade them for something else.
- "What about the leftover food you threw away?" Put it in the fridge and eat it for a snack later.
- "What about the plastic water bottle you threw away?" Put it in the recycling bin.
- "What about all the paper you threw away?" Write on the backs of the pieces of paper, and then recycle it.

Students, like scientists and city planners, may find this discussion challenging. Explain that it is not surprising that the class has a tough time coming up with solutions for reducing how much trash they send to a landfill. This is a tough problem. Even experts sometimes have trouble thinking of how to dispose of some items. Share with students that waste disposal is a problem all over the world. Scientists continue to research new disposal methods. In some cases, the only thing we can do with some waste is to put it in the landfill, or stop producing it all together.

5. Explain to students that while decomposers can't eat everything we throw away, they do plan an important role around the world. Ask students to take out their science notebooks and record the question How are decomposers beneficial to humans and other organisms? along with a short written response. Remind students to use evidence in their responses.

Have students form pairs and discuss their ideas. Remind them to challenge each other's thinking and evidence, and develop a revised explanation.

Finally, ask groups to share their ideas with the class. Discuss these explanations in light of the article, the evidence from the Decomposition Columns, and the Matter and Energy Chart. Use guiding questions like these to assist students in constructing their explanations.

- “What would the forest floor or beach look like if decomposers didn’t exist?”
- “What if the leaves that fell from the tress around the school never went away? Year, after year, after year?”
- “How do decomposers benefit producers like flowers and trees?”
- “What would happen to the matter in ecosystems if there were not decomposers?”

Have students record their explanations in their science notebooks. They might look something like this:

- Decomposers are important because they recycle matter. Plants use that matter to grow and live. I read about that in a reading. If it weren't for decomposers, there would be dead organisms and parts of dead organisms piles up everywhere. That happened in our experiment. In the columns with no decomposers, the dead stuff just stayed there. Decomposers can also be food for other organisms like birds. I have seen birds eating worms. If there were no decomposers, or if their basic needs were not met for them to live, like in some of the class columns, matter would stay tied up in dead stuff instead of getting recycled for producers to use.

Student Page 6.1A: The Decomposition Times

Nature's Waste

What happens to the waste that plants and animals leave behind in nature? Think about a forest with oak trees, squirrels, and foxes.

Oak trees produce acorns. Acorns are the seeds of oak trees. Some acorns grow into new oak trees. Others may be food for squirrels, but squirrels do not eat whole acorns. They eat only the tender insides. They leave the shells on the ground. What do you think will happen to those shells? Will they stay there forever? No, the decomposers will munch their way through those shells in a few months. Imagine if a fox eats one of the squirrels. The fox leaves bits of the squirrel's fur behind. What do you think happens to the leftover fur from the fox's dinner? It may take a while, but decomposers will eat and recycle that fur, too.

Nature makes wastes like squirrel fur and acorn shells. Decomposers take care of nature's waste. They use the enrgy from it to live. They use some of the matter from it to grow. They recycle the rest of the matter back into the soil and air. Then plants can use that matter, combined with energy from the sun, to grow. What would happen to nature's waste without decomposers? It would pile up.

Human Trash

Now think about the kinds of trash people create. Consider the bags of trash that your neighbors put out on the curb. What takes care of your trash? A garbage truck takes it away. Imagine being a tiny decomposer living where the garbage trucks dump your trash. What would it be like to try to eat your way through a bag of trash? Think of all the stuff that you would have to eat to break down human trash!

Getting rid of trash is a big job. In 2003, California made 40 million tons of trash. That is almost enough to fill 700 million garbage cans. If you stacked up those cans, they would reach to the moon and back! We do not have trash cans stacked up to the moon, so where is all that trash? Most of it ends up in big piles called landfills.

What happens to the matter in a landfill? Decomposers can eat some of it, but they don't eat it quickly. In your columns, they ate a piece of fruit quickly. In a landfill, it might take the decomposers years before they get around to eating it. There is just too much other stuff for them to eat.

You learned from your columns that decomposers don't eat everything. What happens to the matter they cannot eat? It stays the same. It does not change. Unfortunately, they cannot eat many of the things we use. We use and throw away things every day that they cannot eat. Most plastic bottles will never get eaten. They will never decompose. It takes them a million years to eat a glass jar. What did you throw away today that will not decompose?

Reducing Trash

What can we do about the trash that decomposers cannot eat? We can recycle some of it. That keeps it from going to the landfill. Plastic bottles and glass jars can be recycled. Paper and metal can be recycled, too. Factories break up these things into very small pieces. Then, the small pieces are processed and used to make new things. Recycling keeps human trash from piling up. That is important since decomposers cannot handle much of our trash.

Think about all this next time you go to throw something away. Could you do anything else with it besides throw it in the trash? If you put it in a trash can, it will go to the landfill. Think about the decomposers. Can the decomposers handle it? If not, can you find a way to reuse or recycle it? That is what humans must do to keep from poling the matter we throw away into more and more landfills.

Step 6 – Lesson 2 Snapshot

Key Concept

Not all waste material can be recycled through the natural process of decomposition.

Evidence of Student Understanding

The student will be able to:

- explain why decomposers have difficulty breaking down the waste of humans.

Time Needed

60 minutes

Materials

For each student

- all completed student pages
- resources (i.e. newspaper, Internet, non-fiction books)

Key Words

Review all key words

Reducing Waste

1. Review what students have learned in this unit using the Matter and Energy Chart as a discussion framework.

2. Introduce the article writing project about trash problems and solutions. Explain to students what information they need to include in their article. Encourage them to use evidence from experiments and readings and the explanations they have developed about decomposition throughout this unit.

3. Students may share their articles with their groups, post them in a hallway or in the school newspaper, or read them to their parents.

REAPS

R – Where does your garbage go?
In a trash can, to the dump, etc.

E – Can all of our garbage decompose?
No, not all plastics can decompose, and some materials take millions of years to break down.

A – How has your investigation made you think about your community trash problems differently?
Answers will vary—may include composting projects, recycling efforts.

P – What are some ways we can reduce the amount of garbage that we send to our landfill?
Include reference to reducing, reusing, and recycling waste.

S – In your Science Notebook, write about how your thinking about waste recycling has changed as a result of this unit?
Depending on student responses, extension activities may be necessary.

Background Information

This lesson is optional. The key concepts and facts that students need to know have been addressed in earlier lessons. The benefit of using this lesson is that it affords students the opportunity to apply their knowledge and experiences with decomposition to ther local community and to the global problem: What can we do about our waste disposal problem? It is an extension of the work they began in Lesson 6.1 around the Decomposition Times reading.

Consider embedding this lesson into literacy instruction, as it is a way for students to practice their non-fiction writing skills in an authentic way.

Waste Disposal

Known as Municipal Solid Waste, we commonly refer to it as trash or garbage. It includes everyday items such as paper products, plastic, packaging, food, clothing, and appliances. In the US, people generate approximately 4–5 pounds of trash per person, per day. Where does it all go? More than 70 percent of this garbage is disposed of in a landfill. The rest is recycled, stored, composted, or burned.

A landfill is a place where garbage is buried between layers of dirt. Landfills have been known to contaminate surface and ground water. Sometimes this can also lead to the pollution of drinking water. Because of these concerns, landfills are built to prevent leakage. They are often lined and covered with impermeable material. This means that landfills are not composting sites. Garbage is buried in a landfill and therefore receives little or no sunlight, water, or air. Because of these conditions, the trash does not decompose very rapidly, if at all.

The United States currently recycles almost 28 percent of its garbage. This number has doubled in the past 15 years. Recycling is good for plastic, paper/wood products, glass, metal, and rubber—things that can be used again or made into new products. The most common recycled items include newspapers, magazines, cardboard, metal, plastic, and glass containers, yard trimmings, and tires. During the recycling process, these items are broken down into raw materials that can later be used to make new products.

Hazardous materials must be disposed of properly so they do not threaten the environment. These include explosives, flammable chemicals and radioactive materials. Special centers can recycle these materials or treat them so they are no longer toxic. Another method for disposing hazardous wastes is to pump the material into deep wells. This method is extremely controversial because of the danger of explosions and even earthquakes that have resulted from waste injection techniques.

Composting is good for organic waste (food scraps and yard clippings) and can be done at the household level or on a larger scale. This is the most natural way of waste disposal. During this process, waste decomposes, just like the process that was observed in the Decomposition Columns.

Some garbage is burned at very high temperatures. This provides a means for generating electricity and reduces waste volume that would otherwise go into a landfill. This method, however, has the potential of releasing harmful pollutants into the air.

In the past, people have come up with many different ways to dispose of their trash including tossing it out on the street or up on their roofs. At one time, trash was even dumped into the ocean. This was banned by law in the 1980s in the US, but sites are still maintained to dispose of dredged material such as sand or silt.

Implementation Guide

1. Remind students of what they have learned about matter and energy in this unit by reviewing the Matter and Energy Chart. Add any additional ideas that students notice are missing through the course of the review.

2. Explain to students that they will use what they have learned about matter, energy, decomposition, and trash to write an article. The article can be similar to the articles they read in the unit. It doesn't need to be very long, but it does need to present key piees of information.

Explain that the key pieces of information that the article must communicate include:

- What they have learned through their research that applies to the trash humans create.
- How their investigation has made them think about trash differently.
- The ideas that they have about reducing trash problems.

Remind students that scientific explanations are best when they are supported with a lot of evidence. Encourage them to use their data, experiences, and readings as evidence in their article.

3. Students may share their articles with their groups, post them in a hallway or in the school newspaper, or read them to their parents.