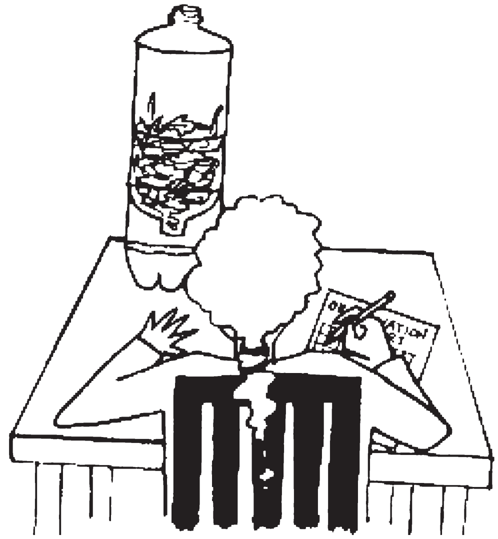

Rot It Right:
The Cycling of Matter and the Transfer of Energy

4th Grade Science Immersion Unit

Los Angeles Unified School District · Board of Education

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SCALE

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

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.

Immersion Units provide a coherent series of lessons designed to guide students in developing deep conceptual understanding that is aligned with the standards and key concepts in science. 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 their results based on evidence.

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Snapshot Page

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- Lesson Title
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Unit Overview

Many students have trouble understanding things they cannot readily see. Because of this, the tiny organisms responsible for decomposition, the process of decomposition itself, and the transfer of energy and cycling of matter, can be difficult concepts for students to understand. 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. This investigation into the role of light in plant growth 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 affects 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 Columns.

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

Unit Key Concepts

- Organisms need energy and matter to live. Matter enters an ecosystem when producers make their own food, using energy from the sunlight. Matter then cycles from organism to organism through food webs.
- Sunlight is the major source of energy for ecosystems. Energy from the sun enters an ecosystem through producers and is transferred to consumers through food webs.
- Food chains identify a simple, sequential relationship between producers and consumers. Food webs identify the interdependent relationships among producers, consumers, and decomposers in an ecosystem.

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 no 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, students should 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.

Unit Formative and Summative Assessment

Formative Assessment

Many opportunities for formative assessment are embedded in this unit. Students will be asked to fill out a variety of worksheets and data tables. These worksheets, in conjunction with science notebook pages can be used as a portfolio to represent the work of each student. The worksheets should also be used throughout the unit as benchmarks of understanding. The worksheets can be periodically collected and reviewed to help the teacher assess the progress of each student.

In addition to the worksheets, reflective assessment questions are included with each lesson. These questions, called *REAP Questions* are a series of questions that progress from recall to extension to applications of knowledge, and, finally, to using existing knowledge to predict.

Using the REAP Questions

At the bottom of each Lesson Snapshot page you will find a series of questions called *REAP Questions*. REAP stands for *Recall*, *Extend*, *Analyze* and *Predict*. This series of questions are a simple technique that you can use in just a few minutes to review what the students have learned. The questions are designed to encourage students to extend their thinking a bit further, prompt them to analyze what they have learned to other relevant related topics, and finally engage them in thinking about something that they have not directly observed, so that you can assess prior knowledge. You can conduct these as a class discussion, in small groups at the center, or even use them individually if time permits. Consider supplementing them with drawings or having students write out simple answers.

- ***Guiding Student Responses***
  Some students will be able to answer the questions right away, while others will need additional guiding questions before they are able to develop a clear answer. The questions increase in cognitive difficulty. Recall questions are the easiest. Predict questions are often the most advanced. Students should demonstrate confidence and ability when answering the first few questions. Students should demonstrate continual improvement in answering the Extend and Analyze questions, but they are not expected to master these skills. The skills for extending and analyzing will be further developed in later grades. The prediction questions will also be easier to complete with practice using logic and reasoning skills. These abilities are critical to science investigations and are a natural extension to students' curiosities.

- ***Right Answers?***
  Some questions do have right or accurate answers. These are most often the Recall and Extend questions. Suggested answers are often included after the questions in italics. Answers that are more detailed are included in the implementation guides for each lesson. While these are good answers, other answers may be valid with proper reasoning.

  The Analyze and Predict questions often have no single right answer, but they do have valid answers. To gauge student understanding, look for what evidence they use to justify their response. If they have good reasons for what they think (i.e., reasons that have some basis in their prior knowledge or their direct observations), then their prediction is likely valid. There may be occasions, however, when student answers may be completely wrong. These misconceptions should be addressed and explained before fishing the unit, but at the prediction stage, it is most important to look for valid reasoning and revisit the question after students have opportunities to learn the concepts directly.

- ***Example REAP Questions***

  The following is an example of how the REAP Questions look in lessons.

> After learning about food webs students:
>
> **R**ecall their new knowledge – Which animals are herbivores?
>
> **E**xtend their new knowledge – Where would an herbivore be placed in a food chain that included grass?
>
> **A**nalyze their knowledge to their daily lives – What would a food web drawing look like for your decomposition column?
>
> **P**redict something related to what they have learned – If you took the contents of your column outside and dumped them under a bush, what might change about your food web?

Summative Assessment

At the end of this unit, students are asked to directly apply their data and research findings to think about answers to a social problem. They will think about the relationships between the processes of decomposition and waste disposal problems. Students will write an informational article to be submitted to a mock newspaper. The students will share their articles with others and discuss how their findings will inform their trash decisions in the future.

Unit Content Background

In 2002, the city of Los Angeles generated 3.5 million tons of solid waste. LA County generates 38,000 tons of solid waste per day, 13.9 million tons per year. We are constantly looking for ways to recycle goods and reduce our consumption. With state mandated recycling in many states across the country, we are looking for new and innovative ways to recycle. Perhaps we should look back to nature. Nature has its own way of recycling.

Ecosystems provide a complete system, producing food, creating waste and recycling the waste to make room for new organisms. Producers use energy from the sun to make food from matter that comes from the air and water and nutrients from the soil. Consumers eat producers to gain matter and maintain energy. Decomposers break down waste and return the matter to the soil. They pick up where humans often fall short.

The *Rot It Right: The Cycling of Matter and Energy* Immersion Unit gives students an opportunity to explore this transfer of matter and energy in mini-ecosystems. They can see the living (biotic) and nonliving (abiotic) worlds interact as they test their ideas about producers and decomposers.

The amount of trash we generate is a real world problem. Scientists strive to invent new ways to recycle and produce materials that will decompose more quickly. Many landfills seal garbage in the earth, excluding air and moisture. How might this affect decomposition? Will a foam cup or plastic bag ever break down or decompose? These are they kinds of questions that we as a society are faced with everyday. Students can use their experiences with the Terraqua Columns and Decomposition Columns to think about solutions to these worldly problems. They can even apply their knowledge in their own school community, educating themselves and others about responsible consumption.

Instructional Timeline

Step	Lesson	Class Time	Key Concept
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 (biotic) and nonliving (abiotic) 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 Time Management

If done twice a week this unit will take approximately 8 weeks to complete. The lessons vary in length and can be built into other subject areas as well. For example, the science readings can be read and discussed during a literacy time period. The following table gives a sample timeline for a schedule that includes science twice a week for approximately 60 minutes. In this case, the schedule shows science occurring on Mondays and Wednesdays.

Of Special Note:

1. **The unit should be started at the end of the week** to give the radishes time to germinate over the weekend.
2. **The lessons in boldface type are the lessons where students will be collecting data**. It is important to spread the decomposition data collection lessons out over at least a two-week period of time. The contents of the columns need time to decompose.

Week #	Monday	Wednesday
1	Begin this unit at the end of the week	**Step 1, Lesson 1 Terraqua Column Investigation 60 minutes**
2	**Step 1, Lesson 2 The Role of Producers 45 minutes**	Step 2, Lesson 1 Food Chains and the Transfer of Energy 45 minutes
3	Step 2, Lesson 2 The Role of Consumers 20 minutes	Step 3, Lesson 1 Observing Decomposition Columns 45 minutes
4	Step 3, Lesson 2 Designing a Decomposition Investigation 60 minutes	**Step 3, Lesson 3 Column Construction & Data Collection 75 minutes**
5	**Step 3, Lesson 4 Decomposition Data Collection 30 minutes**	**Step 4, Lesson 1 The Role of Decomposers 30 minutes**
6	**Observation time for students can be added into any 10-minute period of the day.**	**Step 4, Lesson 2 Creating Food Webs 60 minutes**
7	Step 5, Lesson 1 Developing Evidence-based Explanations 45 minutes	Step 6, Lesson 1 Waste and Recycling 20 minutes
8	Step 6, Lesson 1 Reducing Waste 60 minutes	Finish student team presentations

Unit Advance Preparation

Preparing Columns

Before beginning this unit, the teacher prepares demonstration Decomposition Columns for student observation and Terraqua Columns to grow radishes for a producer investigation. The Terraqua Columns will provide a means for students to study plant growth through a class investigation in Step 1.

The Terraqua Columns will be assembled by the teacher in a demonstration that takes place in Step 1, Lesson 1, so they require only materials preparation at this time. The following sections provide detailed descriptions of how to prepare the materials for the Terraqua Column and to construct the Decomposition Columns.

Decomposition Columns will be used later in this unit, beginning in Step 3, but require two weeks to begin the decomposition process. As written in this unit, the demonstration Decomposition Columns are completely assembled by the teacher at least one week in advance of beginning Step 1.

Terraqua Column Preparations

Before beginning Step 1 with the class, the teacher needs to prepare the materials for the four Terraqua Columns students will use. All materials must be prepared so that they are ready to be assembled with the students during the experiment set-up. You should complete Steps 1–3 on The Terraqua Column Construction Sheet ahead of time. Removing the label, cutting the bottles, and drilling the hole in the lid can all be completed without your students. This will save more instructional time for designing the investigation and assembling the columns.

Materials

- Column Construction Worksheet
- Four 2-liter bottles with caps
- Tools: ruler, utility knife, scissors, awl, or nail

Decomposition Column Preparation

Decomposition Columns are used twice in this Immersion Unit. The first time they are introduced to the students, they have been constructed by the teacher ahead of time and the contents are already decomposing. These demonstration columns are constructed by the teacher in advance and used in Step 3, Lesson 1 when students make initial decomposition column observations. The second time Decomposition Columns are used in this unit, students design and construct their own columns to gather evidence about what effects decomposition.

One of the first things to do in preparation for this unit is construct the four demonstration Decomposition Columns that will be used in Step 3, Lesson 1. For best results, the columns should sit for at least two weeks before this lesson. Usually, Steps 1 and 2 take about 2 weeks, so before starting Step 1 of the unit, these demonstration columns need to be constructed. As written in this unit, the teacher constructs the demonstration columns outside of class and introduces them to students two weeks later. You could demonstrate the column construction with your students if you want to use that opportunity to teach how to construct a Decomposition Column.

Students will observe these demonstration Decomposition bottles and use them to generate their own investigation questions. Students then construct their own columns to use for their decomposition investigation in Step 3, Lesson 3. Students should start collecting bottles 4–6 weeks in advance to ensure that there are plenty of bottles to work with. You will need to make sure that you have a few extra bottles available for student groups that encounter a problem with constructing their bottles and need to start over.

The demonstration Decomposition Columns will be used to generate excitement and discussion, so they should be as interesting as possible. 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 your 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.

Decomposition Column Preparation (continued)

Once the demonstration columns are assembled, the teacher can set them out in the classroom to initiate student interest. Preferably, all columns should be placed 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. The contents of the columns should be kept moist to aid the process of decomposition. Check your bottles every few days and add a small amount of water as needed.

This unit provides Decomposition Column Construction guidelines for using 16 oz. bottles. Refer to the student direction sheet for instructions on the construction of the bottles found in Step 3. If you would prefer to use larger 2-liter bottles, please refer to www.bottlebiology.org for more information on construction with 2-liter bottles.

Materials for the Four Demonstration Decomposition Columns

- Eight, 0.5L (16 oz.) bottles of the same brand, with caps
- Tools: ruler, utility knife, push pin, and hairdryer (optional)

Suggested ingredients for each column:

- 1 cup soil
- ¼ cup water
- 1 apple core
- a penny
- a twig
- 2–3 green leaves
- 2–4 isopods (pillbugs)
- 1 handful of grass
- 1 banana peel
- 2–3 packing peanuts
- a small piece of Styrofoam
- a paperclip
- 2 brown leaves (dead)
- a healthy dose of sunlight (put them near a window)

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 should remain in the same groups for the duration of Step 3, Step 4, and Step 5.

Science Notebooks

Throughout this unit students will be asked to use a science notebook. They will record their observations of the Terraqua Columns, six sets of observations on their Decomposition Columns, notes on readings, questions that come to mind, and responses to questions.

A spiral notebook without scoring for tearing out pages works well for a science notebook because it encourages students to make entries in chronological order and keeps everything together for the duration of the unit. If a spiral notebook is used, loose pages and handouts should be taped into the notebook on chronologically appropriate pages. Pocket folders with prongs for loose-leaf paper also work well. Students can record their work on single sheets of paper, add these to their folders, and put the worksheets in the pockets. They can also three-hole punch their worksheets and add them to the notebook.

Science notebooks are not static. As students acquire new information and develop new questions, they need to begin new pages in their notebooks. Try not to think of them as something that students need to "fill up." The purpose of a science notebook is not only to keep all of the work in a central location, but also to encourage students to look at past data and compare it with new data. Refer to the previous section on *Scientific Observations* for a more detailed description of the protocol for recording observations. Suggestions for what students should record in their science notebooks are provided in the individual lessons of this unit.

STEP 1

Overview

This step will provide 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 will 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 will then be reinforced by a short reading on the important role producers have in an ecological system.

Lesson 1

Terraqua Column Investigation (60 min)

Producers require sunlight for growth and development.

Lesson 2

The Role of Producers (45 min)

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

Lesson Overview

Using Terraqua Columns, students participate in a class experiment to investigate the role that sunlight plays in the growth of producers. Students collect data and record their observations of this initial investigation.

Lesson Title

Terraqua Column Investigation

Key Concept

Producers require sunlight for growth and development.

Time Needed

60 minutes

Materials

For the Class Demo

- Prepared Terraqua Column Materials (cleaned cut bottles and lids with holes)
- Column Construction Worksheet

For Each Column

- 2 cups Soil
- 1 cup Water
- 10 Radish Seeds
- Column Labels

Each Student

- *Terraqua Column Observation* Worksheet
- Science Notebook
- Rulers

Key Words

Experiment, Investigation, Control, Variable, Observation, Data, Producer, Energy, Ecological System

Step 1, Lesson 1

Lesson Snapshot

1. Generate a class discussion about the needs that plants have for growth and development. Have students brainstorm ideas and compile a class list on the board. Indicate to students that they will be focusing on one factor: Sunlight.
2. Develop questions about the role that sunlight plays in the growth of plants and model how to form the kind of question you can investigate with an experiment.
3. Introduce students to the structure and function of the Terraqua Columns. Explain how they can be used as a physical model of an ecological system.
4. As a class, design an experiment to answer your question, Do radishes grown in a Terraqua Column need sunlight to grow and develop into a healthy radish plant?
5. Have students record their predictions for what they think will happen to the seeds and plants that will receive light and those that will not. Be sure students explain their prediction.
6. Assemble the Terraqua Columns and demonstrate proper set-up procedures for your experimental design. "Think aloud" so that students hear why the procedure is designed to control as many factors as possible.
7. Have the students record their initial observations on the "Observation" worksheet. This can then go into their Science Notebook. Over the next week, students should make at least three more observations of the columns.

REAP Questions

R – What do plants need for growth and survival? *Sunlight, Air, Water and Soil.*

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

A – What kinds of plants or parts of plants do you eat? *Corn, potatoes, lettuce (Help students think about what part of the plant the foods they list are.)*

P – What do you think will happen to the radishes grown without sunlight? Why? *Responses should include a logical explanation for the prediction.*

Background Information

Terraqua Columns

Terraqua Columns are used as physical models that represent an ecological system. The model 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. Water added to the terrestrial section on top will move down through the soil and drain into the aquatic section.

The top unit of the Terraqua Column should be filled with soil collected from outside or potting soil bought from a store. The lower unit should be filled with tap water or water from a pond, lake, puddle or fish tank. Soil and water that are collected from a natural environment will most likely contain organisms such as algae, bacteria and insect larvae. Make sure that the soil and water used are the same for each Terraqua Column.

Radish seeds work well in the Terraqua Columns. Radish is a fast-germinating and fast-growing plant that will provide many opportunities for observations.

Advance Preparations

Materials Preparation

Before the beginning of this lesson, the teacher must prepare the materials for the columns. Refer to the Terraqua Column Construction Sheet. You should complete Steps 1–3 ahead of time. Removing the label, cutting the bottles, and drilling the hole in the lid can all be completed without your students. This will save more student learning time for constructing the columns.

Steps 4–6 on the Terraqua Column Construction Sheet provide directions on how to construct the bottles with your students.

Experimental Design for the Terraqua Columns

The Terraqua Column provides you with a model to explore the interactions in an ecological system. The model has four basic components: soil, water, air and plants. By varying the treatment of just one of these components, you can explore how one thing can affect the whole system. A well-designed investigation allows students to examine one difference between the columns. Observable differences can then be attributed to just one factor instead of many.

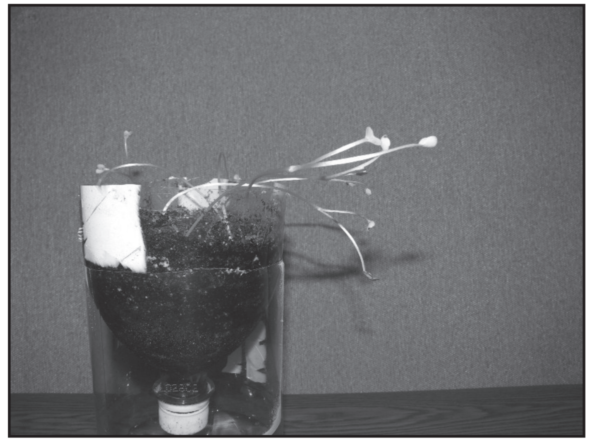
In this investigation, students will examine the effects of sunlight on plant growth and development. The varied factor will be the amount of sunlight the columns receive. Therefore, all other components including amount and type of soil, water, radish seeds, and temperature need to be controlled. This means that these components should not vary between the different columns.

Students should look for indicators or changes within the Terraqua Columns that are in response to the varied physical factor (amount of sunlight). Possible plant indicators that can be observed include percentage of seeds that germinate; plant height and weight; leaf and stem size, shape and color. Choose characteristics that will help to answer the investigation question.

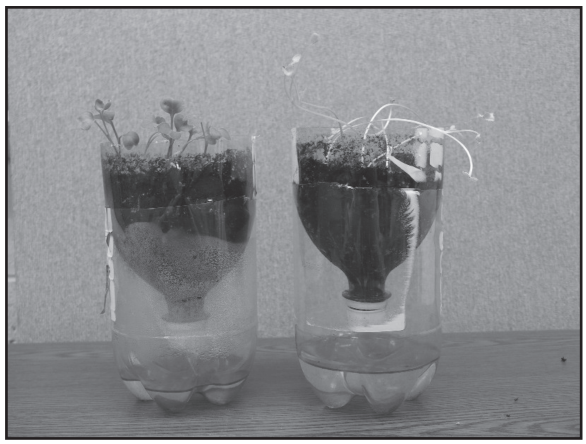
Remember that radish seeds in the Terraqua Column without sunlight will still grow; in fact these seedlings will most likely be taller than the seedlings with sunlight. The seedlings without sunlight, however, will have an abnormal appearance including pale color, thin shape, and small leaf size.

The following examples include radish seedlings 7 days after planting:

Terraqua Column with Sunlight



Terraqua Column without Sunlight



Remember that well-designed investigations are those that change only one part of the system at a time. A good scientist keeps the investigation very simple. In this way, it is possible to identify more clearly, which observations resulted from the one varied factor. This makes it easier to form explanations that will answer your investigation question. It is critical for students to have a solid understanding of this process.

Scientific Observations

Refer to the section on observations in the *Immersion Inquiry Background Information*. If this is the students' first experience with recording scientific observations, spend a few minutes discussing a protocol for recording observations before students observe the columns. Students should try to use as many descriptive terms as possible. Describing color, texture, height, smell, and using analogies are all great note-taking strategies. Good notes will help students assess their own progress and draw conclusions in the end. Encourage students to ask many questions about the columns and record all of those questions in their notebooks.

Teacher Preparation

It will work best to begin this lesson at the end of a week, on a Thursday or Friday. This will give the seeds time to begin germination over the weekend and leave more time for students to make observations and collect data during the following week. Radish seeds will sprout in approximately 4 days.

Scientific Illustration

Sometimes students have a hard time drawing for scientific purposes. It is important that students realize that there is a difference between artistic and scientific drawings. They should draw only what they see, using colors, descriptive text and labels to identify the parts of their drawing.

Implementation Guide

1. Encourage students to think about what plants need in order to live and grow. Where do plants get the energy they need for growth and development? If students have trouble with the concept of energy, ask them how they get energy to live and grow. Have them think about what they eat and then relate this to what plants need to "eat." Do plants "eat" food like us to get their energy? Give students a few minutes to freely brainstorm ideas as to what plants need and where they get their energy for survival. Write student responses on the board and compile a list. You may have to prompt students to think about additional factors. For example, if they forget air tell students to hold their breath for several seconds and then ask them if they can think of anything else a plant might need.

   Students may think of many different things that plants need for survival such as habitat requirements or tender loving care. Guide the discussion to include discussion about the basic needs, including water, soil, air and sunlight. Tell students that the class is going to investigate one of these factors: sunlight. This means that they are going help you design an experiment to investigate how sunlight affects the growth and development of radish plants.

2. Explain to students that a very important step in designing an investigation is to develop a good scientific question that they will be able to answer during their investigation. You may want to review the "Asking Questions" topic in the *Immersion Inquiry Background Information* (found in the Unit Information chapter of this guide) to carefully model for students how to develop a scientifically testable question. Give students several minutes to brainstorm possible questions about the role that sunlight plays in the growth and development of plants. Allow students to share their questions with the class.

3. Explain that in this activity, you have chosen a question that the class will investigate. Talk aloud and model how you are going to set-up an experiment to investigate the question "Does sunlight affect how radishes grow and develop?" This may or may not be one of their questions. Have students write down the question in their science notebook so they can easily refer to as you demonstrate the investigation. Point out why this question is testable—because it is specific to a type of plant that you can investigate and can be tested by changing only one variable—sunlight.

4. Introduce students to the Terraqua Columns. Begin by showing them the materials that are used to construct the columns, and demonstrate how they can be put together. Draw a picture of a Terraqua Column on the board and point out the different parts of the column and contents. Explain to students that the Terraqua Column is a physical model of an ecological system—a "mini" ecosystem. An ecological system is made up of living (biotic) and nonliving (abiotic) components that form complex interactions and relationships. Ask students to identify some of the living and non-living components that interact in the Terraqua Columns.

Living Components	***Non-Living Components***
• Plants	• Air
• Bacteria	• Soil
• Algae	• Water
• Fungi	
• Fish	

   Draw students' attention to the Terraqua Columns as a tool for their investigation. Terraqua Columns provide a wonderful environment to grow and experiment with plants.

5. Explain to students that the next important step is to design an investigation that will answer the question, *Does sunlight affect how radishes grow and develop?* Review the background information for designing an investigation using Terraqua Columns. Talk aloud to the students as you walk them through this experimental planning process. In order to design an investigation that will answer your class question, there should be only one thing that changes throughout the investigation: amount of sunlight. It is very important that all other things remain the same—otherwise you will not know which factor caused the changes that you will observe.

   Emphasize how to design a controlled experiment by working with the class to list on the board all the factors that are involved in growing radishes in the Terraqua Column. This should include the following: soil, light, air, bottle, temperature, and water. Next, highlight that *light* is the factor that your experimental set-up will allow you to change, while everything else will stay the same. "Think aloud" as you demonstrate how to develop an experimental procedure that will generate evidence to explain your question, *Does sunlight affect how radishes grow and develop?*

   Explain and share the procedure for the experimental set-up with the students while you write it out or draw the steps on the board. This should include the directions for constructing the Terraqua Columns (see Terraqua Column Construction worksheet) as well as the specific directions to follow during the investigation. Explain how you will assemble the materials to make the Terraqua Columns, including the specific amount of soil, water and number of radish seeds. Remind students that these factors need to be the same for all four columns. Emphasize that light is the only factor that is different. Two of the columns will be placed in sunlight while the other two will be placed in the dark (without sunlight).

6. Using the materials that you prepared in advance, construct two columns as a demonstration; talk aloud as you are doing it to emphasize how in a scientific experiment you pay careful attention to the procedures so that only one variable is tested. Make your thinking visible to students by being explicit about the thought processes you want students to use when they later design and conduct their own investigations. Remind students that you were careful about measuring materials when you constructed the columns because the columns need to have the same amounts of soil, water, and seeds. Once the columns are constructed, bring out the second set of columns that you made in advance, and explain that you used the same procedure to build them. Label each one with a number. Choose two to be placed in the dark and two to be placed in the sun.

7. Ask the students, "Now that we have these columns, what do you predict will happen to the seeds and plants in light and those in the dark?" Have students individually record their prediction and reasoning in their science notebooks so they can refer back to it later. Circulate among students to be sure they write both a prediction and explanation for the prediction. Having students each think about and record a prediction increases individual buy-in and heightens curiosity.

8. Ask the students, "How will you collect data from the columns to determine if light is effecting plant growth and development?" Allow students a few minutes to brainstorm some characteristics they might look for in their Terraqua Columns. Characteristics are things to measure and observe that indicate how sunlight is affecting the growth and development of the plants in the Terraqua Columns. 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.

   Suggested characteristics are included in the background section on experimental design. Characteristics such as height, weight and number of seedlings can be measured and easily recorded numerically. Characteristics such as color and texture can be recorded as an observation but are not directly measurable and are therefore difficult to record in a consistent way. One option for color is to use a set of crayons. The students can try to match the plants color to a crayon color. This also works with a color wheel or paint sample cards from hardware stores.

   Hand out one "Terraqua Column Observation" worksheet to each student. Have students write in the characteristics (one for each table) that they will be collecting data on over the next 2 weeks. They should also record the numbers of the bottles that are in sunlight and the numbers of the bottles that are in the dark (from the column labels). Instruct students that it is very important to keep track of the date that they make each observation. Have them put today's date in the first box in each table. Demonstrate how they should record their observations in the adjacent boxes. Explain to students that when they make observations it is important to look very carefully in order to notice small changes. Students want to make sure their data is as accurate as possible.

   Make your first set of observations of the columns as a class. Break the class up 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. Working together, ask the students to offer observations that you can use to model a good record. Once students have completed their observations, place the columns in a safe place (two in sunlight, two in dark).

9. Over the next week, have students make at least three more observations of the columns and record the data on their Observation Worksheets. Observations can be done as a whole class or you can break students into two groups, giving each group one bottle that has been in sunlight and one bottle that has not been in sunlight. Each group should observe the same bottles each time. Observations should take approximately 10 minutes. The columns without sunlight should not be kept out in the light for long periods of time; this could effect the results of the investigation. Remind students to collect their data from these columns carefully but quickly, and then return them to the dark.

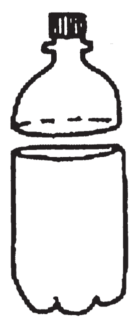
Terraqua Column Construction

Materials

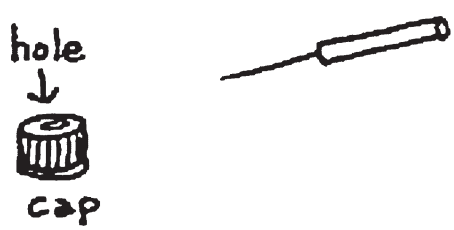
- 2-liter bottles with caps
- Wicking material—fabric interfacing or cotton string
- Soil, Water, Radish seeds
- Ruler
- Utility knife
- Scissors
- Awl, Darning needle or Nail

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).

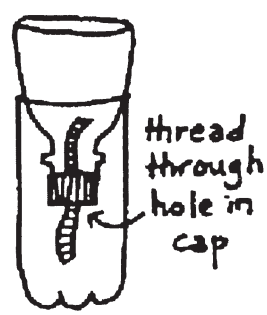


3. Using a nail or an awl, puncture a 1 cm hole into the bottle cap.



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. The wick should reach the bottom of the reservoir and thread loosely through the cap.



6. Fill the bottom reservoir with water. Add soil and seeds to the top chamber. To be effective, wick should run up into the soil, not along the side of the bottle.

Name: ____________________________________

Date: _________________

Terraqua Column Observation Worksheet

Characteristic ____________________________

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

Characteristic ______________________________

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

Lesson Overview

Students develop evidence-based explanations for their column observations and read a short article on the important role producers have in an ecological system.

Lesson Title

The Role of Producers

Key Concept

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

Time Needed

45 minutes

Materials

Each Student

- Completed *Terraqua Column Observation* Worksheet
- Science Notebook
- *Producer Power* reading

Key Words

Evidence, Explanation, Producer, Consumer, Organism

Lesson Snapshot

1. As a class, encourage students to review the data and observations they have collected about the Terraqua Columns. What do their observations tell them about the role of sunlight in plant growth?
2. Instruct students to read the short article on producers.
3. After reading the article, assist the students with developing explanations supported by evidence. Students should use both their observations from the investigation and their own background knowledge to form explanations about sunlight and plants.

REAP Questions

R – What differences have you observed between the four Terraqua Columns? *Those in light should be described as different than those in the dark.*

E – When you look at your data do you see any patterns or trends? *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 you think other organisms get the energy they need to live? *From producers or other consumers.*

Background Information

Photosynthesis

In this lesson, it is important for students to understand that producers use the energy from sunlight, 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 when conditions are poor for growth.

Although this lesson focuses on the importance of sunlight in providing energy for this process, there are several other important ingredients that producers need 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 to grow and reproduce. 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 you think 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 of carnivorous plants. Carnivorous plants are still considered producers since they must produce their own food through photosynthesis. The insects they digest only supplement nutrients that they do not receive from the poor soil they grow in. They do not provide a source of food for the plants.

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 the columns. If left to grow long enough (approximately 4 weeks) students should 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.

Implementation Guide

1. Have students take out and review their observation worksheets. Provide each group with a Terraqua Column for observation. When you look at your data, do you see any patterns or trends? What differences do you see between the columns that were kept in sunlight and columns that did not get sunlight?
2. Use your preferred reading strategy to lead the class through a reading of the short article on producers. It is recommended that students underline, circle, or highlight the vocabulary words in the article. Students should then make a word list in their science notebook. Instruct students to copy the vocabulary words onto their word list and write a definition for each term in their own words. This list should be kept in a safe place so students can add words to this list throughout the unit.
3. Explain to students how scientists use both data and their own background information to form explanations that are supported by evidence. Ask the students to look at their observation worksheet and remind students that these are the data they have collected for their Terraqua Column investigation. Do you see any patterns or trends in your data? Can you summarize your data into words? In general, what happened to the first characteristic you observed? In general, what happened to the second characteristic you observed? After students share some responses, write out a sentence or two (for each characteristic) on the board that summarizes the data. Have students write this evidence in their science notebook. What do your data tell you about the role of sunlight in plant growth and development? Explain how their evidence can now help them form an explanation about sunlight and plant growth and development. Students should be reminded that they could also use their reading as background information to help them form an explanation for their investigation. Where do plants get the energy they need to live and grow? How do you know that sunlight gives plants the energy they need for growth and development? Ask students to share their explanations. As a class, write out a general explanation for the class and have students write this in their science notebooks.

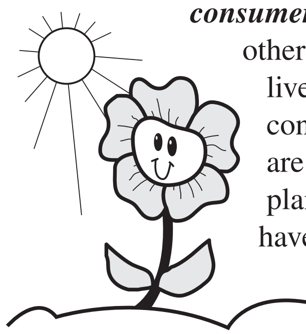
Producer Power

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 sunshine 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 sunshine or air!

STEP 2

Overview

The students will engage in a thought provoking activity tying their own eating habits to those of other organisms. The students will work on building an understanding of food chains and the flow of matter and energy in an ecosystem. They will also deepen their understanding of consumer niches through a reading.

Lesson 1

Food Chains (45 min)

Organisms need matter to live and grow.

Energy is transferred from the sun to producers and from producers to consumers.

Lesson 2

The Role of Consumers (20 min)

Consumers get energy by eating producers or other consumers.

Lesson Overview

Students engage in small-group discussions about what humans get from eating food, and then work in pairs to construct food chains based on the organisms related to an example breakfast.

Lesson Title

Food Chains

Key Concepts

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

Time Needed

45 minutes

Materials

For the Class

- Breakfast Pictures
- Source Organism Pictures

Per Pair of Students

- Organism card sheets
- Food chain worksheet
- Red crayon
- Pair of scissors
- Science notebooks

Key Words

Producer, Consumer, Organism, Energy, Matter

Lesson Snapshot

1. Pose the question "Why do we eat?" Allow student groups to discuss their ideas, develop their own answers, and record their ideas in their science notebooks. Repeat the process with a second question "What do we get from the food we eat?"
2. As a class, review student ideas for the first question. Discuss if their ideas hold true for producers and other consumers. For the second question, list the student responses to those questions and group into categories of those that have to do with gaining matter, and those that have to do with gaining energy.
3. As a class, develop a food chain that contains some of their breakfast ingredients. Begin the model with the sun and draw the arrows in the correct direction.
4. Students work in pairs rearranging cards to create additional food chains. Each student records their food chains on their own Food Chain worksheet.
5. Use one of the student's food chains to review the steps to create a food chain. Discuss that an organism needs more than just energy to survive. Matter, as well as energy, is being passed up the food chain.
6. Conduct the REAP Questions.

REAP Questions

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? How does it help their body? *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.*

Background Information

Food Chains: Transferring Energy and Matter

All living things depend upon energy and matter to live. This energy and matter flows 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 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 tell you that the chicken eats the corn, so when they add an arrow to their 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 who. They often start their sentence by saying the consumer and end with the producer. So, if they follow their statement they would start their arrow at the "chicken" and end it at the "corn"— backwards from how it should be. Try encouraging them to say things like "the corn is eaten by the chicken" or "the corn goes into the chicken's mouth" instead.

You can also employ a "talking it through" strategy each time a student draws an arrow. Model how to talk through drawing an arrow and encourage them to do the same. For example, "The energy from the sun (start your 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 you draw an arrow.

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?"

Implementation Guide

1. Group students into teams of four and make sure they have their science notebooks. Within the group of four, plan for students to have a partner with whom they will work as pairs later in the lesson. You will be asking the students a series of questions they need to reflect on as a team, before developing individual answers. Have students record their thoughts in their science notebooks.

   Introduce the first question "***Why do we eat?***" and allow two or three minutes for the groups to discuss their ideas. Stop the discussion and give students a minute or two to write down their answers and ideas.

   Pose the next question, *"**What do we get from the food we eat?**"* As you walk among student groups, prompt them to move their discussions from being opinion-based to evidence-based. Ask them how they know their answers are true. Did they read it somewhere? Do they have a personal experience that makes them believe that? For example, a student might say that we get energy from our food, and if asked to explain how they know, they might cite feeling weak and tired when going without food for long periods of time. Stop the discussion after just 3–4 minutes of discussion time, and have individuals take one or two minutes to write down their thoughts.

2. Conduct a class discussion about student ideas on these two questions. **Why do we eat?** Because we're hungry. Because it's time for a meal. Because it tastes good. Ask the students if they think that other organisms eat for the same reasons. What about producers? Do they "eat"? *No, they don't have to eat. They make their food from the sun's energy, water, and carbon dioxide.* Can we make our food? What about other animals, can they make their own food? *No, animals are consumers. They have to consume things.* Review the definitions of producers and consumers found in the "Producer Power" reading.

   Now, ask the second question—***What do we get from the food we eat?*** Write down student answers on the board. Make two unlabeled groups. In the first group, write anything that has to do with matter. The second group deals with energy. For example,

What do we get from what we eat?	
Column 1	**Column 2**
get bigger	have more energy to play
grow taller	feel less sleepy
feel full	do better on tests
stop feeling hungry	be nicer
a bigger stomach	think better

   Column 1 pertains to the big category of **Matter**. Eating takes in physical substances into our bodies. Substance, or matter, is the stuff that takes up space inside of us and forms our bodies. It allows us to grow and makes us feel full.

   Column 2 pertains to the big category of **Energy**. We get energy from breaking down our food into very small pieces. When we do this we can use the energy that is contained in the food to breathe, walk, play, talk, and move. It also makes us "feel" more alert, focused, and can improve the way that our brain functions. Explain that this is why you are always telling your students to eat breakfast before they come to school—so they can think better and do better in school.

3. Explain to your students that you want them to imagine they ate a big healthy breakfast this morning like you are always telling them they should. They are going to have warm corn tortillas, eggs, sweet apple slices, and ice cold milk. As you describe each food item, tape its 8x11 picture on the board. Where did these breakfast items—corn, eggs, apples, and milk—come from? Below each ingredient, tape the Source Organism picture.

Breakfast Ingredient	Tortillas	Eggs	Apples	Milk
Source Organism	Corn	Chicken	Apple Tree	Cow

Now remove the first row of breakfast ingredients. From now on, they will be working with organisms only. As a class, work to label each organism as either a producer or consumer. Which of these organisms are producers? *Corn and Apple Trees.* Write the word producer on the blank line below the picture of the corn and the apple tree. The chicken and the cow are not producers. They have to eat something to get their energy, so what are they called? *Consumers*. Write the word consumer on the blank line below the picture of the cow and chicken.

Explain that you want the students to think about the corn plant that provides the corn flour for the tortillas. Where does it get its energy? If they struggle with this, ask them where the radishes that they grew earlier got their energy. Write "sun" on the board before corn. Draw an arrow that indicates how the sun's energy moves into the corn. Talk them through it explicitly. "The energy from the sun (start your pencil at the sun) goes (pull the pencil over toward the corn) INTO (make the arrow point) the corn." Talk them through it again.

Ask them if it would make any sense to draw the energy arrow going the other way. What would that tell them? *That the energy was going from the corn into the sun.* Would that arrow make any sense? Does corn give energy to the sun? Explain that drawing it while talking themselves through it is a strategy to make sure the arrow is going in the correct direction. It is also a strategy to ask themselves after drawing the arrow, "Does this arrow make sense? Is that the way the energy goes?"

Sun ⟶ Corn

Now have them look at the other organisms listed on the board. Which of those organisms would get its energy from corn? Either the chicken or the cow. Repeat the process of drawing the arrow from the corn to the animal of the students' choice.

Sun ⟶ Corn ⟶ Cow

Explain 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 then from the producer to a consumer. Ask the students to think of another organism that they could add on to their food chain. In our breakfast example, who ate something from a cow? Humans. Have a student come to the board, label the human picture as a consumer, and model talking through drawing the arrow in the correct direction from the cow to the consumer. Have the student ask the class, "Does how I drew this arrow make sense? Is that the way the energy goes?" Allow other students to agree or disagree with the arrow's direction.

Sun ⟶ Corn ⟶ Cow ⟶ Human

Hand out the Food Chain Worksheet and use this model food chain to demonstrate how student should fill in the table. Instruct them to leave the top row of the table blank as these will be used to label the columns. After students have filled in the first food chain and correctly drawn in the arrows, ask them to label each column. *The first column should be labeled primary energy source (Sun), the second column should always contain examples of producers, and the third* *and fourth columns will be consumers. Have students differentiate these consumers by labeling the third column 1st consumers and the fourth column 2nd consumers. They will further differentiate the various consumers in Step 2, Lesson 2.*

4. Explain that they will work with a partner to develop additional food chains from the organisms that provided their breakfast—corn, cows, apple tree, and chickens. They should make as many food chains as possible. If they need to add an additional organism, they should make a card for it. They will have to write its name on one of their blank cards and whether or not it is a producer or consumer. Designate partners, and hand out one copy of the *Organism Card Sheet* to each pair. Have the students write whether each organism is a producer or consumer on the blank line below the organism's name.

   Then, students will need to cut out the pictures and use them to create some of their own food chains. Once they have developed a food chain using the pictures, have the students write their food chain down on the Food Chain Worksheet. They should then rearrange their cards and make another.

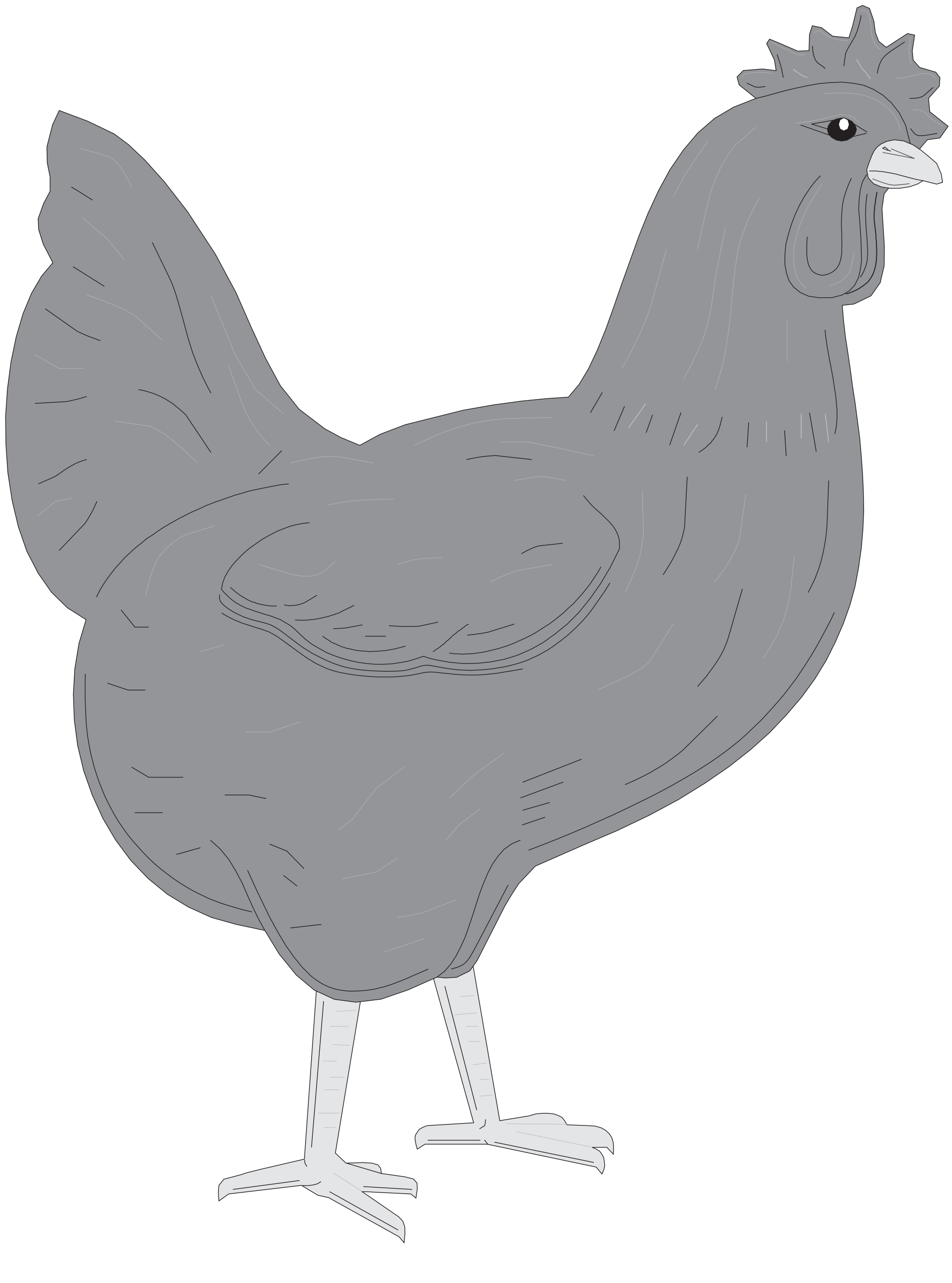
   As you travel around the room:

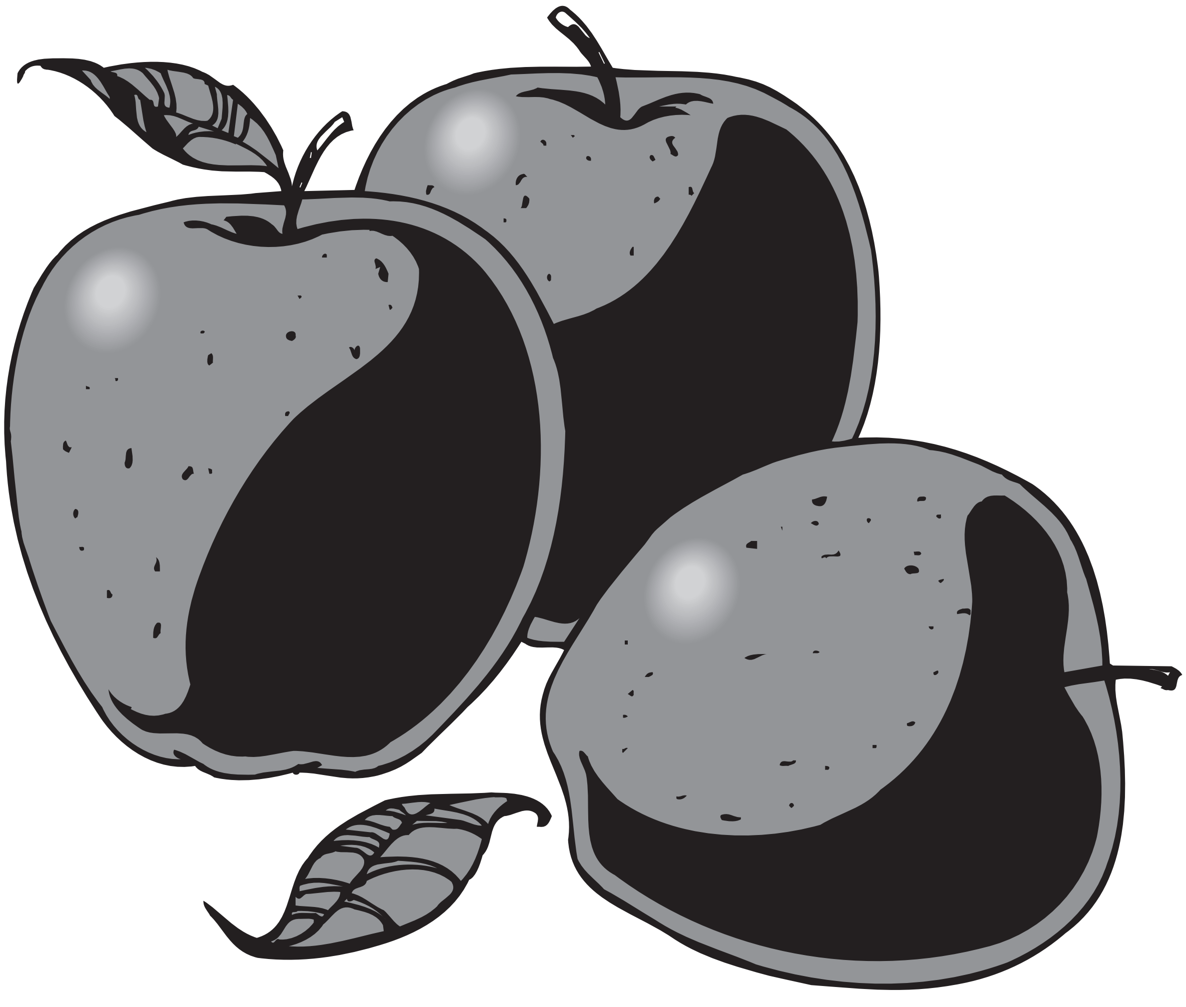
   - Remind them to use the blank cards when they need to create additional organisms for their food chains.
   - Challenge them to make more food chains or to make their chains longer by adding another organism.
   - Model talking through drawing arrows and asking if the direction they drew it makes sense.

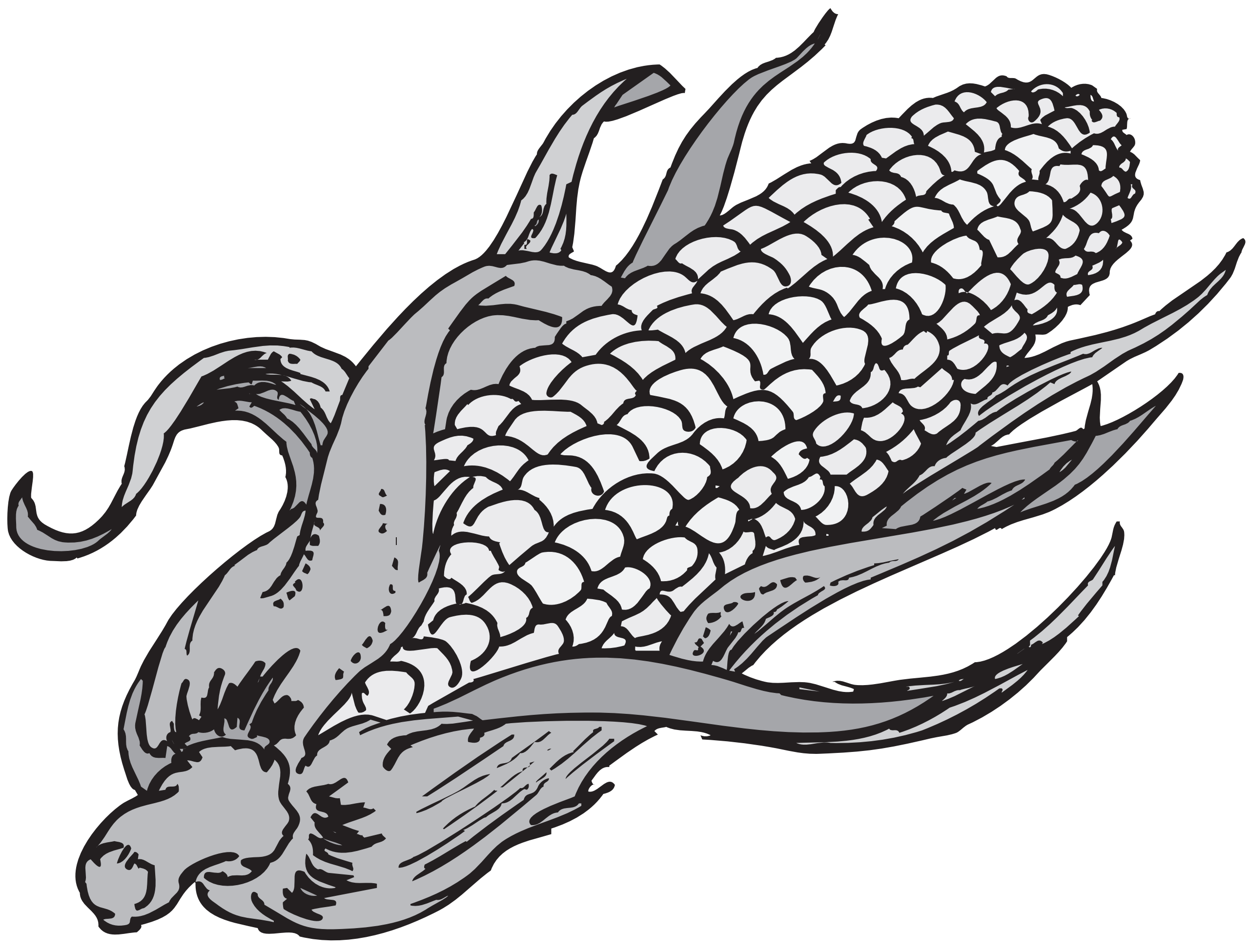
   When you discover a group with an incorrect food chain, ask them questions to get them to identify their error and figure out the solution. *In their effort to explain, it usually becomes clear to them that they do not have it quite right.* Try statements like this:

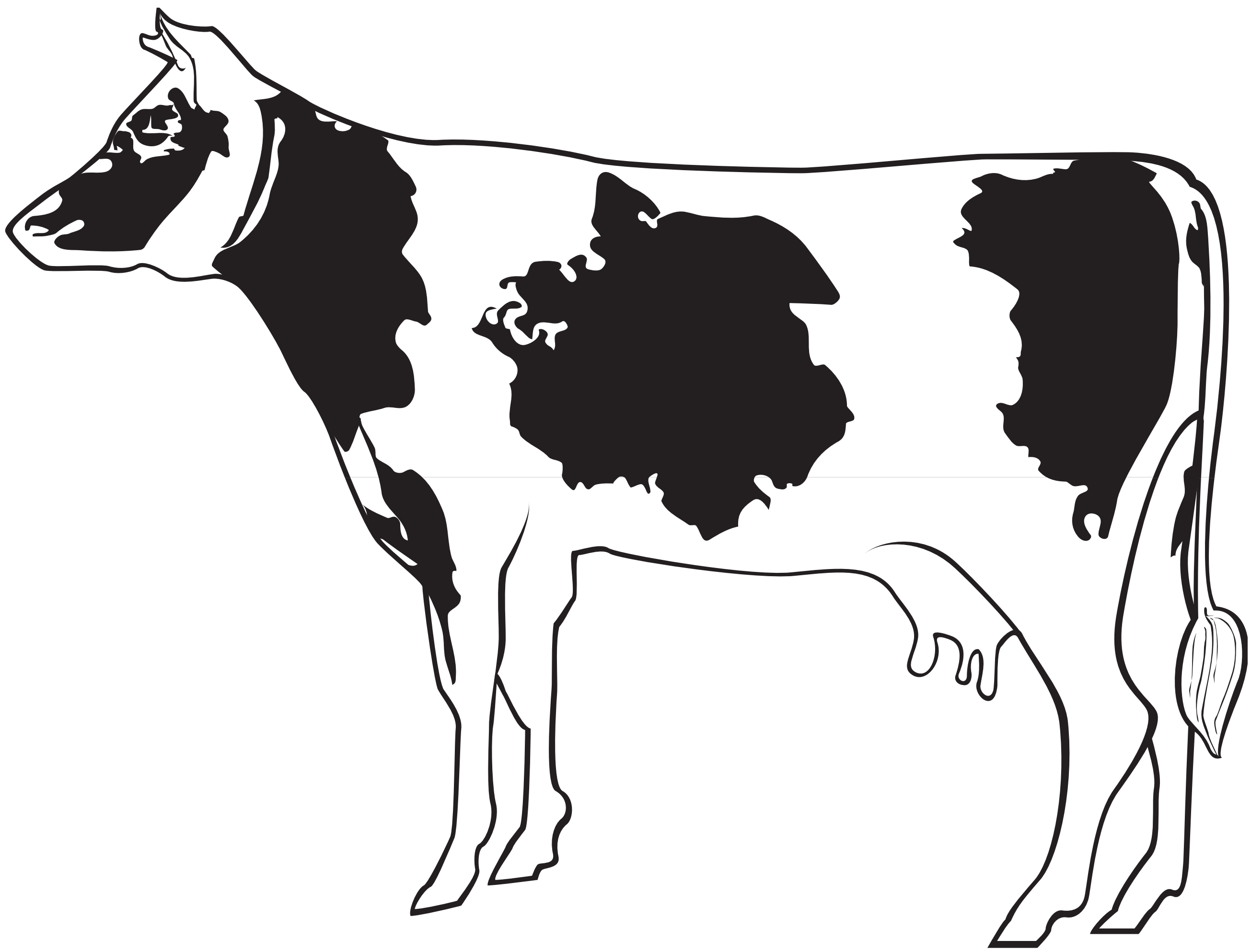
   - Your diagram tells me that that the corn's energy flows into the sun. Can you explain how that works?
   - Your diagram tells me that that the sun's energy flows into the chicken and then into the human. I see how the chicken gets into the human, but can you explain to me how the chicken gets energy from the sun?

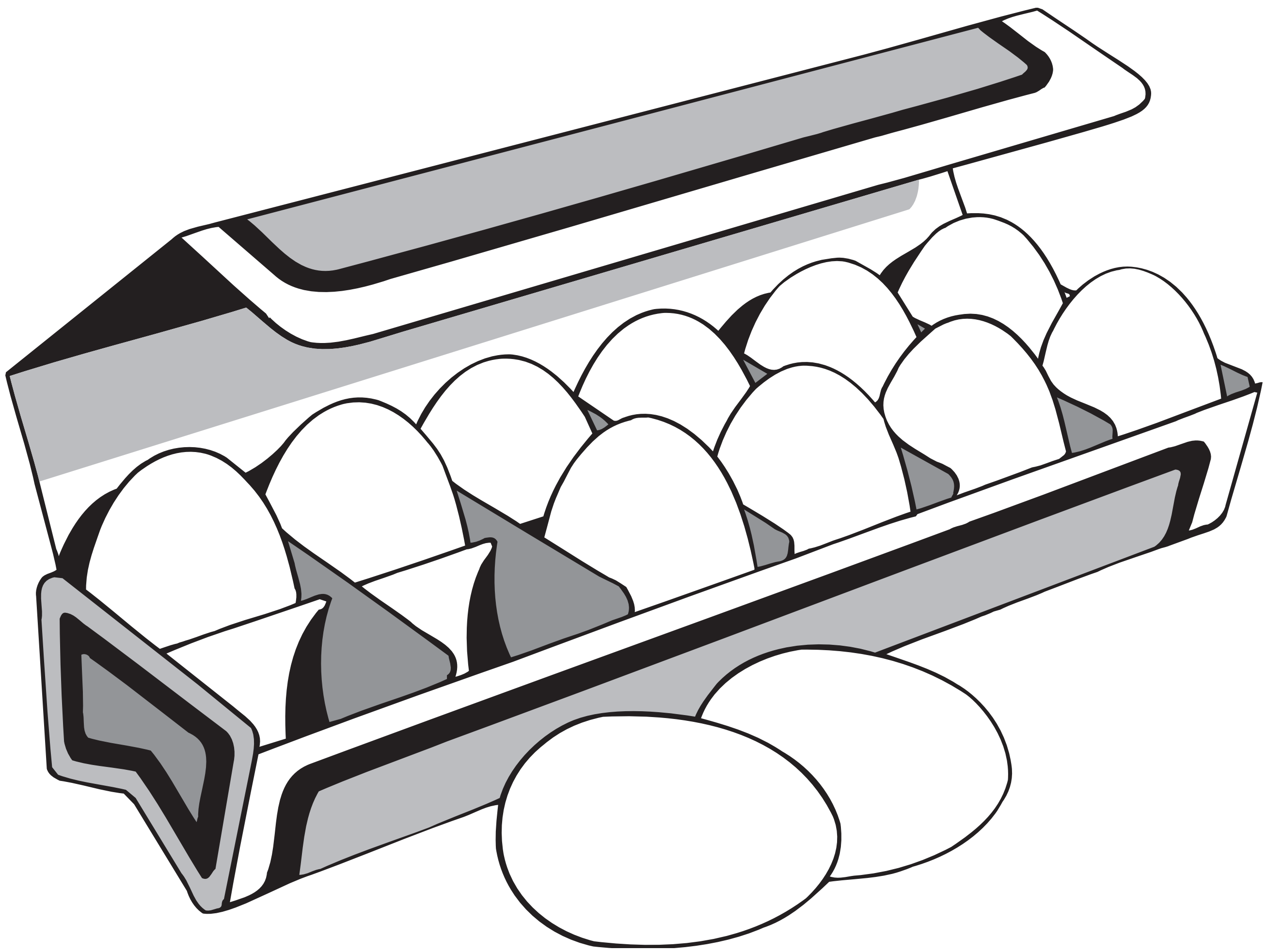
5. Use one student example to review the steps for creating food chains—arrow direction and transfer of energy from the sun to producers, producers to consumers, and consumer to other consumers. Also, review the concept that organisms require more than just energy to survive. They also need substance, or matter, to build their cells and grow larger. Ask the students to suggest what additional matter the producer in this food chain needs to take into its body to survive and grow. *They need water, minerals and nutrients from the soil, and carbon dioxide.* What other matter does the consumer need to take into its body to grow? *They need oxygen, water, vitamins, and minerals.*
6. Conduct the REAP Questions.

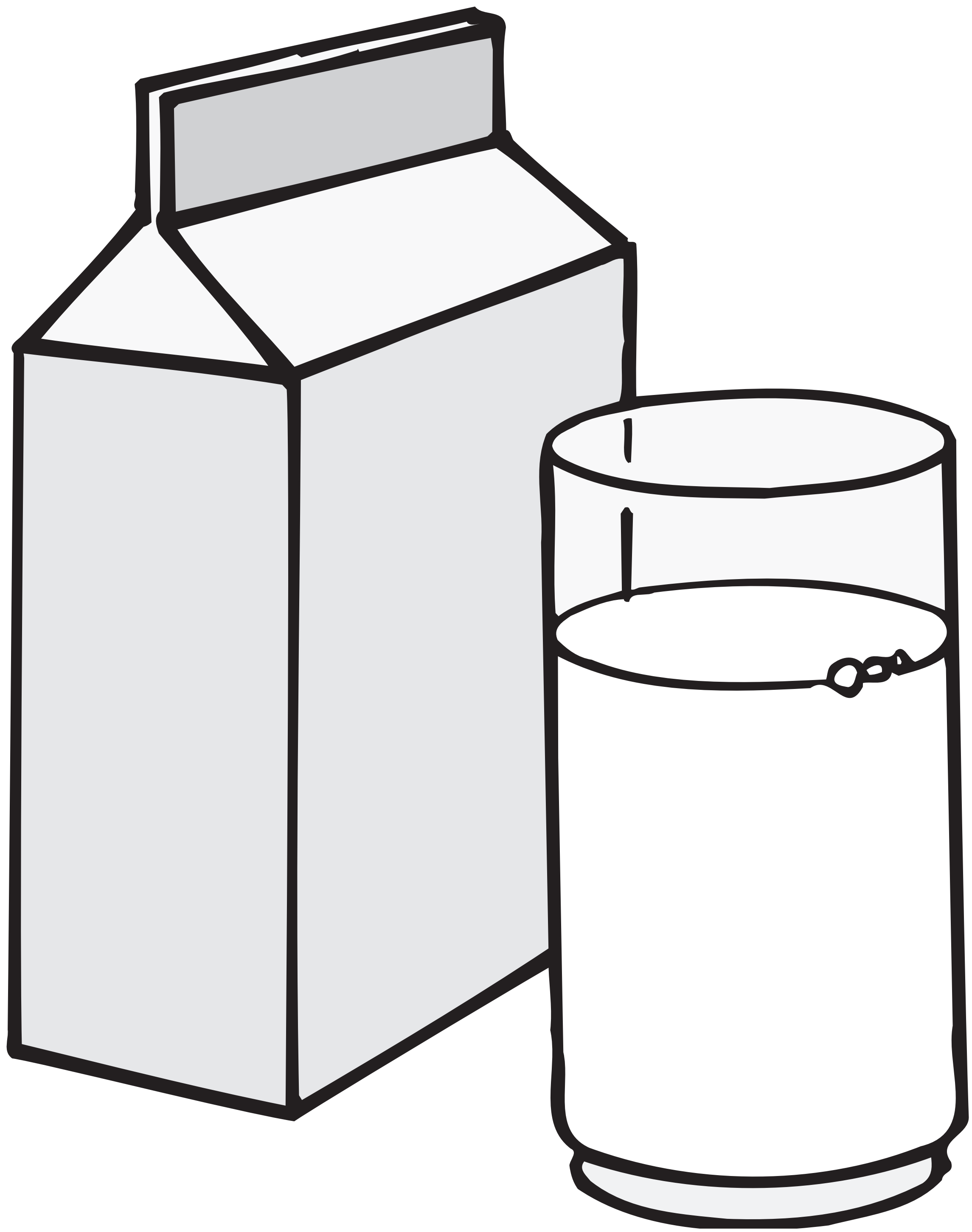


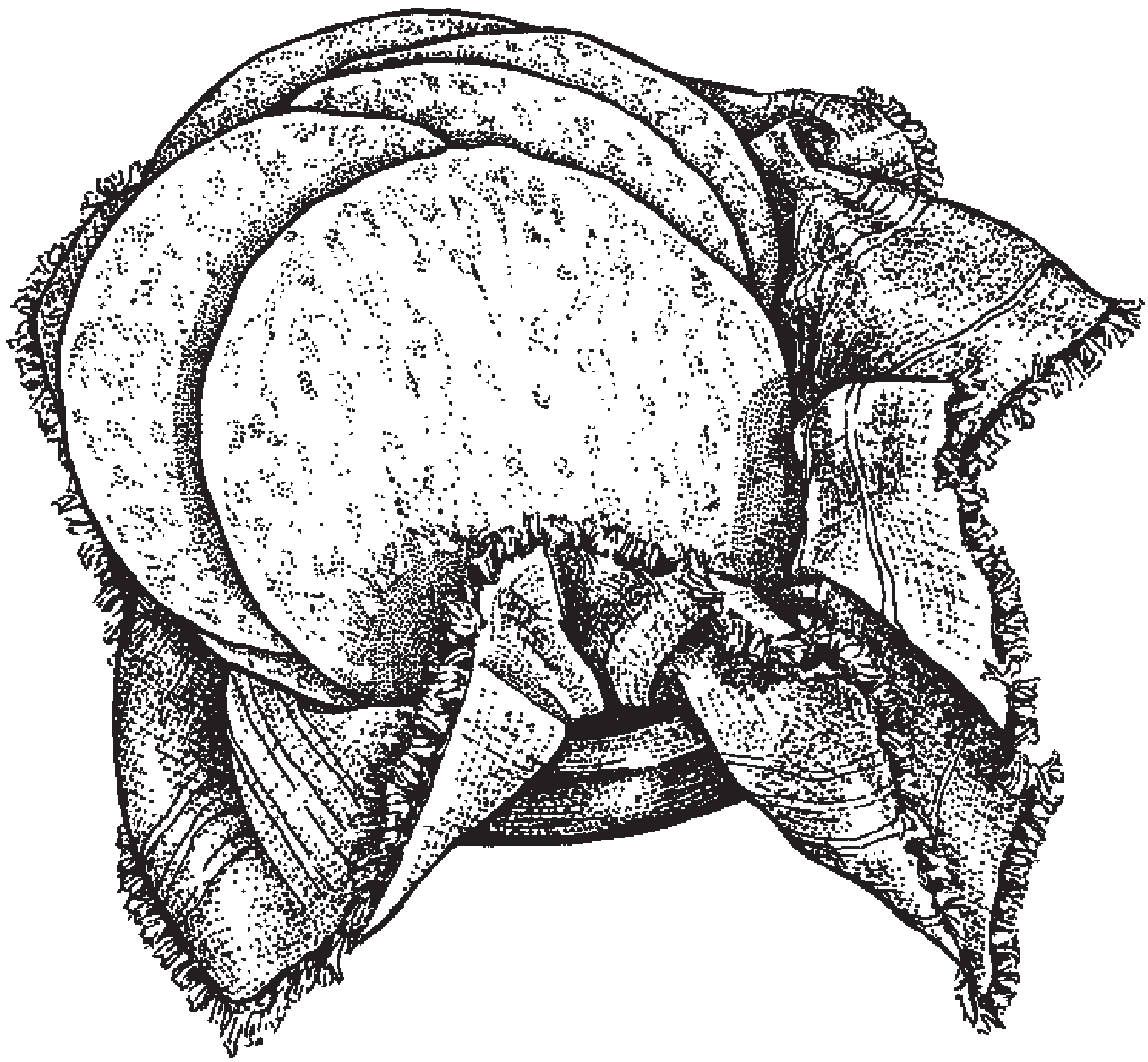




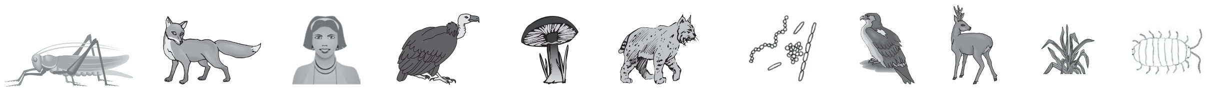








Food Chain Chart



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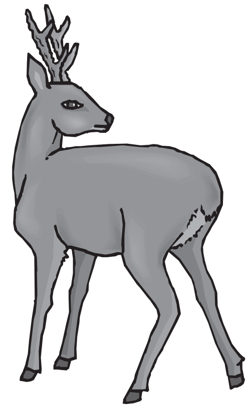
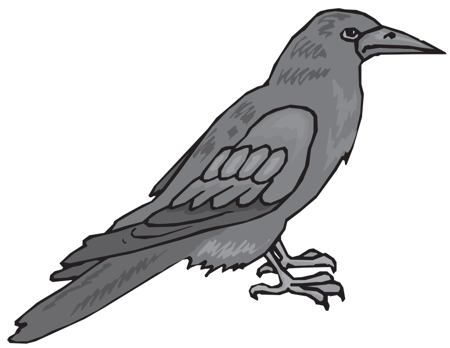
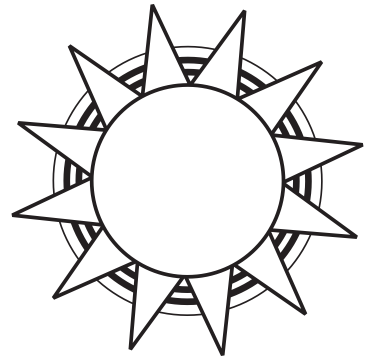
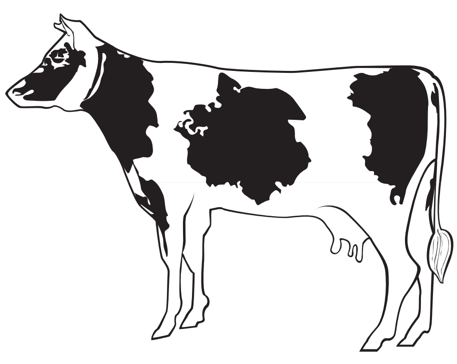
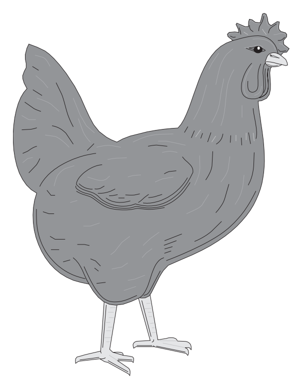










Lesson Overview

Students expand their understanding of consumers through a reading. The content of the reading will help students focus their broad understanding of consumers on each niche within this group.

Lesson Title

The Role of Consumers

Key Concept

Consumers get their energy from eating producers or other consumers.

Time Needed

20 minutes

Materials

Each student

- *What Do You Consume?* reading
- Science Notebook

Key Words

Consumer, herbivore, omnivore, carnivore

Lesson Snapshot

1. Using a classroom reading strategy, have the students read the article entitled, *What Do You Consume?* Have students individually write down what herbivores, omnivores, and carnivores they know of.
2. Ask the students to work in groups to brainstorm a large list of consumers. Ask each group to share one organism from each category. As a class, discuss what things each organism might eat.
3. Discuss whether they think humans are herbivores, omnivores, or carnivores. Have students write their ideas in their science notebook.

REAP Questions

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 – Do you have any consumers in your decomposition bottles? How do you know? *Decomposers are a type of consumer—they consume waste materials and/or dead organisms.*

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 would happen if there weren't any consumers? *Producers would not be eaten, and when they died, there would be no decomposers to recycle the nutrients.*

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. You should be sensitive to 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. Provide students with the article *What Do You Consume?* Read the first paragraph and discuss where the students think that animals get their energy and matter. Ask each student to define consumer in their own words in their science notebook.

   Continue through paragraphs 2 and 3. Stop to allow students to write down any herbivores that they can think of in their science notebooks. Read paragraph 4 and pause to have students add a few omnivores to their list. Read the next paragraph and pause to have students add a few carnivores to their list.

2. Gather the students in groups to discuss their ideas about herbivores, omnivores, and carnivores. have them create a large list of herbivores by combining their individual ideas. As they look at the list, do they see any animals that may not really be herbivores? Do any animals need to be reclassified? Repeat the process with omnivores and carnivores. Ask each group to share one organism from each category. Encourage groups to share the animal that they are the least sure about having in the correct group. As a class, discuss what things each organism might eat and if they have it classified correctly.

3. Now, ask each group to discuss the final question of the article. Are humans herbivores, omnivores, or carnivores? Students should have evidence for whatever idea they decide on.

What Do You Consume?

How do you get energy? You get energy from the food that you eat. Now, think about your class radish experiment. Where did those plants get their energy? Plants can get energy from sunshine. You cannot eat sunshine! Only ***producers*** can get their energy from sunshine. People eat foods like hamburgers, tacos, and vegetables. One thing we get from our food is energy.

Do we only eat food to get energy? No. We also 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 you eat. You might eat cereal for breakfast. You might eat chicken for lunch. And for dinner, you 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.

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. How do you think that these three types of consumers are different?

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. Can you think of an animal that eats only plants? One example is a cow. A cow eats grass, corn, and grains. A cow is a herbivore.

Herbivores can become food themselves. Other consumers may eat herbivores. As an example, many humans eat cows. Hamburgers are cow meat. If you eat a hamburger, you are a consumer eating a herbivore. And what do you get if you eat a hamburger? You 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. Can you think of a consumer that is a carnivore? They are good hunters. Often they are large animals. Mountain lions and sharks are carnivores. Mountain lions eat rabbits and deer. Sharks eat fish and seals. Neither mountain lions nor sharks eat plants. They get their matter and energy from the other consumers they eat.

Now you know some special names for types of organisms. First, you 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

Students design an investigation around a question that they pose about decomposition. They begin with observations of mature columns and progress to asking their own investigative questions. They construct columns and set them up to support their investigation. Students collect quantitative data and qualitative observations about their columns.

Lesson 1

Observing Decomposition Columns (45 min)

Ecosystems can be characterized by their living (biotic) and nonliving (abiotic) components.

Lesson 2

Designing a Decomposition Investigation (60 min)

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

Lesson 3

Decomposition Column Construction (75 min)

Scientists collect quantitative and qualitative data to support explanations.

Lesson 4

Decomposition Data Collection (30 min)

Scientists take measurements and make observations in order to formulate and justify explanations to their key questions.

Lesson Overview

Student teams are given a two-week-old Decomposition Column to investigate. Students make observations, draw, identify the contents in the column, and generate questions about what they observe.

Lesson Title

Observing Decomposition Columns.

Key Concept

Ecosystems can be characterized by their living (biotic) and nonliving (abiotic) components.

Time Needed

45 minutes

Materials

Each Student

- Science Notebook
- "Observing Decomposition" worksheet

Each Group

- Four Decomposition Columns
- Hand Lenses
- Rulers
- Thermometers
- Balances (optional)
- Colored pencils or markers

Key Words

Abiotic, Biotic, Record, Decomposition

Lesson Snapshot

1. Review observations skills used in Step 1. Discuss the term 'decomposition'.
2. Give each group one column to investigate for ten minutes.
3. Ask students to complete the "Observing Decomposition" worksheet and draw a picture of the column in their science notebooks. Provide tools like rulers, thermometers, and hand lenses.
4. List student observations on the board.
5. As a class, classify the observations into categories and record each category of observations on its own piece of chart paper.
6. Ask students to record questions and thoughts about the columns in their science notebooks.

REAP Questions

R – What types of things do scientists call *abiotic*? *Soil, water, air* What types of things do scientists call biotic? *Animals, plants, living organisms*

E – What types of observations can you make when looking at the decomposition columns that would be useful for a science notebook? *Size, shape, color, texture, odor and any other descriptive words.*

A – Where in your everyday life have you observed something that reminded you of what you observed in the decomposition columns? *Refrigerator, compost pile, garbage can…*

P – How do you think these columns have changed in the last two weeks? *Answers should include reference to specific, observed evidence.*

Background Information

What is decomposition?

Decomposition involves a whole community of large and small organisms that serve as food for each other, cleanup each other's debris, compete for nutrients, and convert materials to forms that other organisms use. The bacteria and fungi initiate the recycling process by feeding on dead matter and, in turn, becoming food for other organisms. The 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 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 bacteria or 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 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?

You can think of the Decomposition Column 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.

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. Explain to the students that today they will be observing another type of bottle. Review the scientific observation skills that the students used in Step 1 to observe their radish seeds. Which of their senses do they expect to use the most? The sense of sight is by far the most useful in this unit. However, smell comes in a close second. What features did they observe with their sense of sight when they studied the radish seeds? For instance, size, height, color, shape, texture, and moisture of materials in the bottle. How easy was it to observe all the aspects of the radish seeds? What did they have to do to make sure they noticed the details? Explain that these bottles are called Decomposition Columns. Begin a discussion on the word decomposition so that all students know what the term means. What does the word decomposition make you think of? Ask students to think about their own experiences with decomposition or "rotting." Ask them about the banana that was left on the counter too long or what happens to a carved pumpkin after a few weeks? They will most likely be familiar with the effects of decomposition on the appearance of things. If the things inside the bottles were rotting, what would they expect them to be like? Moldy, slimy, smelly, etc.

Teacher Preparation

Demonstration Columns

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

Material Tips

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. This should be a class policy however and discussed before the experience.

If small samples are going to be removed, the students should do this 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. Students should work slowly and intentionally and do their best not to disrupt the rest of the sample. 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.

2. Put students into groups of 3–5 students. Provide each group with a two-week old decomposition bottle to observe. Establish rules for working with the bottles. Decide if you are going to allow students to open the bottles. Be sure to review that the students will be responsible for keeping them intact. They should always keep them over the tables and focus on the task at hand. Travel around the room and ask guiding questions to get the students to notice finer details or to guide them to an aspect of the bottle they may have not noticed.

   - What senses have you used to observe your bottle? Can you think of another sense or tool that you could use?
   - What have you noticed about the bottle? How did you discover that?
   - Do the decomposing items in the bottle look how you expected them to? Is everything decomposing in the same way?
   - How would you tell another person about your bottle? What descriptive words would you use?
   - What do you wonder about the bottle?

3. When the students are finished with their initial observations, explain that they are going to start recording these observations on a data sheet. Hand out the *Observing Decomposition* sheet. Review the terms that are used on the worksheet, as needed. Students will most likely have made many of these observations already. Be sure that they take the time to record all of their initial observations and to make additional ones that they may have overlooked. Students may wish to describe their bottles with words that they do not know how to spell. To prevent this concern from limiting their science observations, start a word bank somewhere in the room where you can write down words that students use to describe their bottles. Travel around the room to help students with words and completing the worksheet. When they are finished, ask them to make a scientific drawing in their science notebooks. Remind them of the guidelines of scientific illustration—scientists draw what they see. They use the appropriate colors and include as much detail as they can. Scientists always include their name, date, and bottle number, and then label their drawings as carefully as possible. You do not have to be an artist to be a scientific illustrator, you just have to draw what you see. The goal is to record what is in the bottle so that later you can use it a reference to help you remember what is looked like. Ask guiding questions to keep student illustrations realistic.

   - Is your leaf really that green? What color could you choose that is closer to the leaf that is actually in your bottle?
   - You recorded that the sides of your bottle are wet, is that part of your drawing?

   Provide the students with some simple tools to allow them to make observations that are more detailed. 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 bottles or the temperature inside the bottles. If you allow them to do so, they can remove an item from the bottle and inspect it closely.

   Allow about 10 minutes for observations. As you collect the bottles, ask the groups to identify three notable things that they would like to share with the class.

4. Conduct a class discussion to gather student observations and record them on the board. It is perfectly acceptable to share something that another group also observed about their bottles. It validates the student's observations to know that someone else also observed that feature. However, encourage the students to share things that not everyone may have seen. Is there anything that you observed that has not been recorded on the list yet? If your students are repeating many of the same observations, try giving them a challenge like:
   - What is the weirdest thing you observed?
   - What is the smallest/largest thing you observed?
   - What is the wettest/driest thing you observed?
   - What is the smelliest thing you observed?

Example Class Observation List

- The plastic bottle had water drops on it.
- The rock had nothing growing on it.
- The wet leaves had holes in them. The dry leaves didn't.
- The soil in the bottle was wet.
- The plastic pen was half in the soil and half out.
- There was a flying "bug" in the top of the bottle.
- The leaves were covered in white stuff.
- One end of the stick was slimy and wet, and one end was dry.

5. As a class identify ways to classify the observations. What similarities do they notice in their observation? How could they divide them up into similar categories? What criteria will they use? Strive for 2–3 categories of observations, but you can work well with up to 4. There are many different ways to classify the same set of class observations. The example below has three different solutions for classifying the same set of observations.

   A common theme is that some things inside the bottles are rotting and other things are not. Biotic things, things that came from living organisms, decompose quickly under the right conditions. Abiotic things, things that are non-living and did not come from living things, (like rocks, foam cups, and plastic straws) do not decompose quickly, if at all. Students may observe that the abiotic materials do not seem to have changed. They may not know the terms biotic and abiotic, but they will likely be able to make the distinction based on the things that are decomposing and the things that are not. If they make categories like this, lead them into a discussion of the definitions of biotic and abiotic. Another common theme is the amount of humidity or water in the bottles. Extremely dry bottles do not decompose quickly.

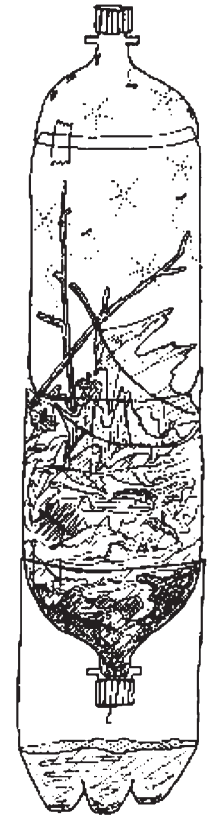
   Once the students agree on a way to organize their observations, record the tile of each category on a blank piece of chart paper. Have students identify which observations belong to that category.

Example Classified Observation Lists

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.	

6. Ask the students to think about these observations and others they made. What do they wonder about these things? Have them record their questions and ideas in their science notebooks. Review that science notebook entries always need a name and date.

Observing Decomposition



Name: ______________________________

Date: ______________________________

Bottle #: ______________________________

Describe the environment inside of the bottle.

Colors: ______________________________

____

Smell: ______________________________

____

Textures: ______________________________

____

What do you think has changed in the bottle over the past two weeks?

____

____

____

I wonder if: ______________________________

____

____

Draw and label the contents of the bottle:

Lesson Overview

Student teams design an investigation using decomposition columns. The investigations will be based on a student-generated question about decomposition.

Lesson Title

Designing a Decomposition Investigation

Key Concept

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

Time Needed

60 minutes

Materials

Each Student

- Completed "Observing Decomposition" worksheet
- "Design an Investigation" worksheet
- Science Notebook

Each Group

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

Key Words

Cause, Effect, Observation, Prediction, Investigation

Lesson Snapshot

1. Review the last lesson's notebook entries. How well did they record what they saw? How could they improve their recording? Review the procedure for recording notebook entries and add any other ideas that students come up with to help them organize their entries.
2. Refer to the observations recorded in the last lesson. Ask the students to report on anything that they wondered about the bottles. Connect these wonderings to the appropriate observation category.
3. Ask each team to regroup and record any additional questions that they have in each category. Instruct the team to choose one question that they think could be answered through an investigation with the Decomposition Columns and record that question in their science notebooks.
4. Provide students the *Design an Investigation* sheet. Discuss what predictions are and how to ask a good question. Have the students in each group record their investigation set-up, including what they think each bottle will contain. Brainstorm ways to measure decomposition in their bottles.
5. Have a short conference with each group to ensure that they have developed a good question to investigate and have access to the supplies they need.

REAP Questions

R – What kind of observations will you make? *Weight, color, texture, smell, etc.*

E – How are your observations going to help you 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 – How is your experimental design going to help you answer your investigation question? *By keeping all conditions in the experiment the same for both columns in the investigation, any differences in decomposition will likely be caused by the one factor that was varied. That factor ought to have been chosen because it is related to the question being asked.*

P – What do you expect will have changed the most in your columns the next time you observe them? Why? *Answers should include reference to specific, observed evidence.*

Background Information

Experimental Design

In this decomposition unit, there are two main types of investigations that students often think of designing. One type of investigation will vary the conditions that the two bottles are exposed to, examining environmental effects on decomposition. The second type would vary the contents within the two bottles, examining the relative rate of decomposition between two objects. A well-designed investigation will allow students (investigators) to study one difference between their bottles and thus be able to attribute a difference in results to just one factor, instead of many.

To test the effects of an environmental condition on decomposition a student would put the same items in two bottles, for example, the same amounts of soil, leaves, fruits, etc. and 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 positioned so that one of the bottles was in the light and the other in the dark. For a well-designed investigation, all other factors that the bottles were exposed to (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

Teacher Preparation

Question Development

Guide students to ask a question that is genuinely interesting and feasible in your classroom. As described in the previous section, the investigations should test only one factor of decomposition. When helping students develop questions, refer back to their original observations of the model Decomposition Column and associated questions. It may also be helpful to have a class discussion and list the questions that each student has. Group the questions together based on content. Try to narrow the field of questions through this exercise and then ask each group to choose one question to investigate. Refer to the description of experimental design for an explanation of a "fair test."

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. Students should 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.

Bottle 1. Then, in Bottle 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. The bottles should then be placed next to one another, so that each is exposed to nearly identical environmental conditions.

A good scientist tries to minimize variability in their experiments. If they are testing the effects of light on decomposition, there should not be anything else different about the columns. If everything else 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 water that is causing 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 your 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 bottles decompose, are you really going to know what caused it, or could it be multiple things?

Tips and Hints for Investigations

Keep it Simple

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

What Can Be Tested?

***The effects of biotic factors on decomposition*:** The types, amounts, and ratios of plant matter (dead leaves, grass clippings, fruit peels, etc.). Remember, depending on the source, the soil will likely contain such life as fungi, insects, and countless microorganisms, so they could vary the type of the soil, too. Small animals can also be added to study the direct effects of macro invertebrates 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.

***The effects of abiotic 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 be change as decomposition occurs in a Decomposition Column 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***.

Measuring Tools*:* 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*: The temperature of the column can be taken at intervals throughout the investigation. The temperature should be taken at approximately the same time every day and in the same way (e.g., the thermometer should be in the same location in the bottle).
- *Ruler*: A ruler can be used to measure the depth of the contents of the bottle. This could be the average depth of the material or the highest part. Either way, the students should be consistent about how they measure it.
- *Balance*: The students might be interested in the weight of the materials over time. They could weigh the bottle 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 could weigh the bottles and their contents each time they weigh them, 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 2–3 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 will collect will be in the form of visual observations, 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, 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 tell you a lot about the materials in your 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. If you use food scraps, mix in 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

Students recording in their Science Notebooks all their observations and reflective writing about those observations will find it easier to look for patterns in their data from throughout the experiment. Encourage students to be consistent with writing their notebook entries, marking them with the date and using data tables wherever possible. Guide students to focus their observations on two or three items that they write about in each entry. Additional information can be included in the entries, but by watching a few specific items decompose, students will be more likely to notice the subtle changes and recognize patterns.

How Long Will It Take?

You will begin to see mold and other evidence of decomposition within the first few days after filling your 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 your classroom. Some take hundreds or millions of years, and some may never decompose!

Implementation Guide

1. Begin by asking students to review their science notebook entries from the last lesson. How well did they record what they observed last time? Is there anything else that they wish they would have written down or drawn? Do they remember things that they did not record? Review the procedure for recording notebook entries and add any other ideas that students come up with to help them organize their entries.
2. Gather student attention to the observation charts that you created during the last lesson. You are going to connect what students wonder about their bottles to the observation category that is most closely related to their question.

   Following is an example of how this process might play out. Your students' observations and their observation groups will most likely be different, as will their questions. Often their initial questions focus on figuring out what you originally put into the bottles to help them figure out how they have changed.

Observation Groups	I Wonder
Natural Stuff	***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.	1. What is that stuff on the leaf? 2. Everything is wet and slimy. How much water did you put in these bottles? 3. Why does this one bottle stink so bad and the others don't? 4. How come the rock doesn't have any mold on it? 5. What happened to the middle of the apple or did you just put the skin of the apple in there? 6. Did you put the same amount of stuff 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	***Man-made things***
The plastic bottle had water drops on it. The plastic pen was half in the soil and half out.	7. Would a wood pencil change or stay the same? 8. 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?

3. Ask students to gather into their groups and record any other observations and questions they might have into each observation group. What other observations did your group make about natural things or man-made things? What other things did you wonder about each group of observations?

   Instruct the teams to choose one question they have that they think could be answered with an investigation of the columns. If they are having trouble doing this, ask them to put all of their questions into two groups, one group of questions that could be answered easily by looking up the answers in a book and the other group of questions that can possibly be answered through experimentation. Work with them to transform their wonderings into a question that they can test with their bottles. Notice how the Investigation Questions are more focused than the wonderings and that they involve keeping track of some aspect of the bottle over time to figure out the answer. They also involve supplies to which the students have access. Have every individual student record their investigation questions in their science notebooks.

Observation Groups	Wonderings	Investigation Questions
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*** 1. What is that stuff on the leaf? 2. Everything is wet and slimy. How much water did you put in these bottles? 3. Why does this one bottle stink so bad and the others don't? 4. How come the rock doesn't have any mold on it? 5. What happened to the middle of the apple or did you just put the skin of the apple in there? 6. Did you put the same amount of stuff in all the bottles or is one rotting faster? Some have a short stack of stuff and others have a tall one.	***Natural Stuff*** 1. Does that stuff grow on green leaves or just dead brown ones? 2. What would happen if we didn't put so much water in the bottles? Would they rot as fast? 3. Is it the banana peel rotting that makes that bottle smell worse; or is it the apple? 4. What does mold grow on the fastest—rocks, sticks, leaves, or lettuce? 5. Do the insides of fruit decompose faster than the skins? 6. Does the amount of stuff you put in the column change how fast it rots?
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*** 7. Would a wood pencil change or stay the same? 8. 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?	***Man-made things*** 7. Which decomposes faster—a wood pencil, a stick of the same size, or an empty paper Pixie Stick? 8. Does the part that's under the soil rot faster than the parts out of the soil?

4. Provide students the *Design an Investigation* sheet. Students should record their investigation question on this worksheet. Discuss what predictions are. Scientists predict explanations for natural phenomena that they are interested in studying before they know the answer. A prediction is their idea about the explanation and a reason why that idea might be accurate. Their experimental results will provide them with evidence that may or may not support their prediction.

   Remind the students that predictions are not judged or graded by whether or not they are right. Rather, it is the students' explanation for whether the prediction is likely accurate or not in light of their experimental results that is important. Have each student answer questions 1 and 2. Each group will be investigating the same question, but individual students may have different predictions. Their predictions will be based on their prior knowledge of decomposition and the observations they made in Step 3, Lesson 1. By having the students make and record their predictions individually, each student will have a stake in the results, and you will be able to informally assess their prior knowledge by reading the predictions. As they learn more about decomposition, they will be able to evaluate whether or not their prediction was accurate.

   Have the students design and record their investigation set-up. This should look like a written set of directions that includes what they think each column will contain, where they will keep the bottles and any other special instructions. For example, Bottle 1 will have 2 handfuls of soil, 1 slice of apple, and no water. Bottle 2 will have 2 handfuls of soil, 1 slice of apple, and X amount of water.

   Conduct a class discussion about measuring. Have the students brainstorm ways to measure changing conditions in their bottles. Make a class list of ideas on the board. Now have groups discuss which of those ideas (or others that they come up with) would work to help them investigate their question. For example, the group that is trying to determine if a rotting apple is smellier than a rotting banana might need to come up with a "stink-o-meter" to help them qualify the smells coming out of their bottles. The group investigating what effects water has on decomposition rates, may decide to measure the height of their dry bottle and their wet bottle to see which changes volume more quickly.

   Be sure that the students plan carefully how they are going to take these measurements. Will they need rulers, measuring cups, thermometers, or scales, or will they need to create a tool like a color wheel or stink-o-meter?

5. Have students record what supplies they will need to fill their bottles with and any measuring tools they will need. If they need something that you don't have available, they will either need to bring it in themselves or change their investigation a little to make use of the supplies that you have.

   Travel around the room as the students complete their sheets. 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 supplies.

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: ______________________________

____

____

____

Lesson Overview

Student teams work together to construct bottle columns. Students collect data and record their observations.

Lesson Title

Decomposition Column Construction and Data Collection

Key Concept

Scientists collect quantitative and qualitative data to support explanations.

Time Needed

75 minutes

Materials

Each Student

- “Decomposition Column Construction” worksheet
- “Decomposition Column Data Chart” worksheet
- “Decomposition Column Observation” worksheet
- Science Notebook

Teacher

- Cutting blade, utility knife, or Exacto knife (see teacher preparation section)

Each Group

- Demonstration Columns
- Bottle Construction Tool Kit: scissors, pushpin
- Four–eight 16 oz. bottles—Each pair of bottles should be of the same brand
- Measuring Tools
- Materials to fill columns (soil, leaves etc…)

Key Words

Environment, Record, Investigation

Lesson Snapshot

1. Ask each group to review their investigative design.
2. Hand out the Decomposition Column Construction worksheet. Talk the students through this sheet and hand out necessary supplies. Instruct students to construct their columns.
3. Hand out and explain the Decomposition Column Data Chart and the Decomposition Column Observation worksheets to each student. Ask each student to complete the necessary data on both sheets.
4. Instruct students to complete the bottle construction by filling their bottles. They should record the contents added and the quantity of each item.
5. Ask each team to work together to record their first set of data and observations. Each student should complete their own sheets, but the whole group should have the same data on their data charts.

REAP Questions

R – What items will you need to construct your 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 that you could grow radish seed in these bottles like we did with the Terraqua Columns? Why? *Answer should 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.*

Material Tips

Column Construction

- Constructing a column in advance is the best preparation for this segment of the unit as you will then be able to use your own experiences to help guide the students with their own columns.
- The demonstration columns should be set out during the work time so that students have a reference.
- When making the initial cut on each bottle it is easiest 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. When you run out of bottle rotate the bottle so you are continually cutting downwards in front of you 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 between 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.

Teacher Preparation

Students should cut and assemble all of the bottle columns. To speed up the process and to increase safety, the bottles can be prepped for cutting ahead of time. Using a box cutter or a utility knife, insert the tip of the knife into the bottle to create a 1-inch slit. When students construct the columns, they can insert scissors into the pre-cut slit and eliminate the need for them to use box cutters or utility knives.

Implementation Guide

1. Have students review their science notebook entries from the previous lesson. Ask them to focus on their responses to the *Design an Investigation* sheet. How did they decide that their bottles should be created? What materials did they decide to use? How much of each? How will they measure that?
2. As students review their notebooks, distribute the *Decomposition Column Construction* sheet. Talk the students through all of the directions. Instruct each team to determine how many bottles they will construct. It is recommended that each student construct a column. Even if they only need 2 columns for their investigation, they can build as many columns as there are students in the group. For example, if a group is only comparing two columns (e.g., Which will decompose faster, a bottle without water or a bottle with X amount of water?) but the group contains four students, that group can make 2 of each type of bottle. This way they have multiple trials of the same experiment, and will likely have better results. Alternately, groups may be investigating which grows mold the fastest, green leaves, brown leaves, lettuce, or apples. In this case, they would make 4 bottles with the same amount of soil and water and then add a test item to each one.

   Have all the students participate in the column construction tasks. They should build all of 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 your classroom.

3. Provide students with the *Decomposition Column Data Chart*. Explain to the students how they will need to complete it. They can use this sheet for measurable characteristics (quantitative data) like height or weight. They can also use it for qualitative characteristics like smell or color, if they came up with some standard way of measuring those things (e.g., a "stick-o-meter, or have paint chips or a hand colored color wheel to compare their bottle colors to). Students will need to keep this sheet in their science notebooks and add to it each time they make observations of their bottles. Groups may need multiple copies of this data sheet depending on how many characteristics they investigate and how often you have them making observations.

   Provide students with the *Decomposition Column Observation Sheet*. Explain that this sheet should also be completed each time they make observations. They should include drawings. Review that scientific illustrations are realistic sketches of what the students see. They are not creative artwork. These sheets also have a few blank lines for students to record more qualitative observations of their bottles or other things that they are not measuring on a regular basis. For example,

   - I see white stuff growing underneath the banana peel.
   - This is the first day our column really stunk.
   - The slime mold is a lot bigger than it was last time.

4. Have students take out their science notebooks and record what they add to the bottles and the amount. They can use standard or non-standard measurements (i.e., 1 cup of soil or 2 handfuls). They should add as much detail as possible about what they added. For example, they should not just write that they added a stick. They should write down that they added a stick as big around as their finger, 6 inches long, with rough dry bark. The more detail they have on what they added, the easier it will be to determine how the things have changed.

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

Decomposition Column Construction

Materials

Two .5L bottles

Utility Knife

Scissors

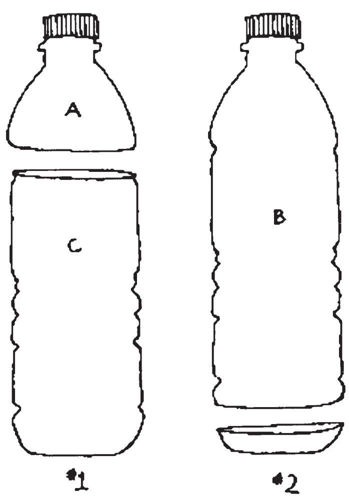
Push Pin

Tape

Materials for Decomposition Investigation

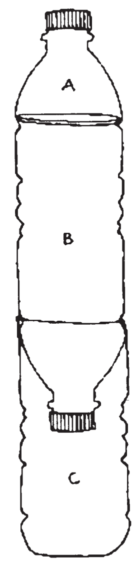
1. Remove the labels from each bottle.

2. Cut top off bottle #1, just above the label, so that the top cylinder has straight sides. Remove the two bottle caps and use a push pin to poke 10 holes in each cap. Put the caps back on.



3. Cut bottom off bottle #2, just above the base. The bottom piece should be very shallow (about 1cm deep).

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 your ingredients.

Decomposition Column Data Chart

Name: ______________________________

Date: ______________________________

Characteristic: ______________________________

Date	Bottle #:	Bottle #:	Bottle #:	Bottle #:	Bottle #:	Bottle #:

Decomposition Column Observation

Name: ______________________________

Date: ______________________________

Location: ______________________________

Lesson Overview

Students use simple tools to take measurements and make observations. They record their observations and data about the progress of their Decomposition Columns.

Lesson Title

Decomposition Data Collection

Key Concept

Scientists take measurements and make observations to formulate and justify explanations to their key questions.

Time Needed

30 minutes

Materials

Each Student

- "Decomposition Column Data Chart" worksheet
- "Decomposition Column Observation" worksheet
- Science Notebook

Each Group

- Decomposition Columns
- Measuring tools
- Colored Pencils or markers
- Hand lenses

Key Words

Measure, Observation, Record

Lesson Snapshot

1. Talk the students through a complete observation entry. Encourage the students to help define the attributes of a complete observation.
2. Have student teams record a set of observations on their Bottle Data and "Observation" worksheets. Provide additional copies as needed. Travel around the room and make sure students are recording what they observe and being as descriptive as possible.
3. Conduct REAP Questions.

REAP Questions

R – What observable changes have you seen in your bottles? *Smell, color, shapes of materials, texture, weight, depth of materials*

E – Which observable changes that you have seen in your bottles 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 when you observed decomposition columns 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 student's explanation for what they think constitutes decomposition. The explanation should include reference to specific, observed evidence.*

Background Information

Over the course of the unit, students should make at least 6 sets of observations of their Decomposition Columns. They made their first set in Step 3, Lesson 3. This lesson is the students' second opportunity to collect data on their columns. In Step 4, they will make their 4 remaining sets of observations. They should make 2 sets of observations per week in Step 4. Each set of observations will take about 10–15 minutes. After 6 sets of observations, you can have them complete Step 5, Lesson 1 or you can make a few more sets of observations and then move on to Step 5, Lesson 1.

You are also encouraged to keep the bottles in your classroom after the investigations are complete so that students can observe the long term effects of decomposition.

Teacher Preparation

Read over the Scientific Observations section of this unit.

Encourage the students to open the bottles and remove a small sample occasionally. The sample can be analyzed with a hand lens or a microscope. If the sample is returned to the column within the class period, it should not affect the investigation.

If time is tight for science in your classroom, you do not need to set aside specific timeslots for these observation sessions. You can make use of transition times. Possibilities include, students incorporating observations into their morning arrival routines or making their observations right after lunch as they get settled.

Implementation Guide

1. Choose an object from your classroom, such as a rock, an apple or something else that is large enough to be seen from a few feet away. Hold up the object and ask the students to describe it. Tell them that you are going to record their observations in the form of a notebook entry, just like the entries that they will record about their Decomposition Columns. Begin by writing your name on the top of the board, along with the date and your location, the classroom.

   Ask students to tell you what you should include in your entry. Ask them what information they think is important when recording an observation. Make a list of their suggestions. Next, ask the students to describe the object that you have selected. Create a sample observation on the board, record the descriptions using proper notebook entry attributes based on the students' suggestions. Guide students to include, among other things, the following: color, size, and smells using descriptive words and labels.

2. Ask students to find their *Decomposition Column Data Chart* in their science notebooks. Have the groups study their Decomposition Columns and record their data. Remind them to make careful measurements with their tools (rulers, hand lenses, scales, color wheels, "stink-o-meters", etc.). Be sure the data they are entering corresponds to the number on the bottle. It is easy for students to mistakenly add data from Bottle 1 to Bottle 2's column, etc. thus confusing the results. You may need to provide additional copies of the data sheet if students have several characteristics that they are looking at, or if they have made many sets of observations. Provide students with a *Decomposition Column Observation* sheet. Remind them that their drawings should be scientific—not creative artwork. They should use this sheet to take detailed notes on other things they see and smell in their columns. Students should tape, clip or staple their Observation sheets and Data Charts into their science notebooks.

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

   - Is that the closest pencil color you could find to color your leaf with? It doesn't seem like it's green anymore.
   - What do you notice about this piece of data? Does it seem to make sense with the other data you've collected? Are you sure that you recorded it on the right line?
   - How could the height of Bottle 1 have dropped so much and the height of Bottle 3 gained so much? Is there any chance you've made an error recording your data? How could you be sure which s right? *Measure it again.*
   - I noticed in your description of the bottle that you said that the bottle was wetter than last time. Did they really get wetter since you looked at it last? Did you add any water to your bottle? How could you explain why it looks wetter, even through you didn't add any water?

3. Conduct the REAP Questions.

Decomposition Column Data Chart

Name: ______________________

Date: ______________________

Characteristic: ______________________

Date	Bottle #:	Bottle #:	Bottle #:	Bottle #:	Bottle #:	Bottle #:

Name: ______________________________

Decomposition Column Observation

Date: ______________________________

Location: ______________________________

STEP 4

Overview

Students study the role of decomposers in food webs and nature. They connect this knowledge back to the smaller food web occurring in their bottles.

Lesson 1

The Role of Decomposers (30 min)

Decomposers are consumers that recycle matter from plants and animals.

Lesson 2

Creating Food Webs (60 min)

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

Lesson Overview

Students read an article on decomposers and their role in decomposition. Then they record their Decomposition Column data and observations.

Lesson Title

The Role of Decomposers

Key Concept

Decomposers are consumers that recycle matter from plants and animals.

Time Needed

30 minutes

Materials

Each Student

- "Rotten Work" article
- "Decomposition Column Data Chart" worksheets
- "Decomposition Column Observation" worksheets
- Science Notebooks

Each Group

- Decomposition Columns

Key Words

Beneficial, Matter, Microorganism, Organism, Recycle, Fungi

Lesson Snapshot

1. Read an article about specific decomposers. Throughout the reading, have students examine their columns for evidence of the decomposers mentioned in the article.
2. Create a class list of all the decomposers in the article. Supplement it with additional decomposers students found in their column that were not mentioned. Discuss the differences in the contents of the bottles that had many observable decomposers vs. those that did not.
3. Allow students 10 minutes to record data and observations for their ongoing decomposition investigation.

REAP Questions

R – What decomposers did you observe in your 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 will be on the surface.*

A – Why don't you think all the bottles had the same decomposers in them? *This depends on the materials originally placed in the bottles.*

P – Do you think that you will see more or less decomposers in the bottles next week? Why? *Answers should include reference to specific, observed evidence.*

Teacher Preparation

Reading Strategies

As you progress through the reading, be sure to use appropriate reading strategies to support students' understanding of new vocabulary words and to connect the reading back to their prior knowledge. Also, make it clear that the students need to connect the content from the article to their decomposition bottles.

Recycling

When the idea of recycling comes up in the reading, discuss the items your 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. Sixty years ago, you simply returned the milk bottles to the milkman. They were washed, sterilized, and refilled. If one was broken, it was just thrown out. Back then they "reused" the bottles. Today, we reuse the glass that the bottles are made of, but not the bottles themselves. The glass in your recycling bin is crushed into little pieces, melted, and re-formed 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.

Tally Sheets

The class list of decomposers is a resource that can be used in several ways. They can use it to expand their bottle observations by creating a tally sheet of sightings. To do this they should 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 every observation period by marking an X next to each organism that they saw. After taking the data on each organism, they should 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 *Teachers Guide to Decomposition Critters* for more information on the types of decomposers that might be present in the columns. It is most important for students to accurately describe the critters that they see, not for them to know the names of

Teacher Preparation (continued)

each critter. However, students are often excited to learn the names of different organisms and to connect this knowledge with other experiences.

Math Connections

- You can make a connection to math by using the tally sheet to create a bar graph of sightings. Have the students construct a graph that has the name of each organism on the X-axis and the number of sightings they have made of the organism on the Y-axis.
- Ask the class to figure out how many bottles in the whole class that had a particular organism in it. Then, figure out what percentage of the bottles contained that organism. You can repeat the process for several organisms to figure out which was the most common.

Implementation Guide

1. Provide each student with one of their team's decomposition bottles and the article "Rotten Work." Assign silent or oral reading of the article using an appropriate reading strategy to support comprehension. Break the reading into sections of one to three paragraphs so that after reading each section, students can pause to examine the bottle in front of them. Ask, do they see any evidence of the decomposers that from the article? Have them record in their science notebooks any decomposers described in the reading that they observe in their bottle. Next, have students mark with a check in the article any organisms that they observed in their bottle. Not all bottles will have all the types of decomposers in them. Repeat this process for each reading section. At the end of the reading, ask students to observe their bottles and write down any other decomposers that they see.
2. Have the students reference their notebook entries to develop a class list of decomposers. Encourage students to add additional organisms that they have observed in their bottles. Not all decomposing organisms are mentioned in the article. Discuss the characteristics of each organism and record two or three descriptive terms after each organism. For example, instead of just recording "mold," try differentiating the different types of molds with descriptive words. "Mold" turns into "white, fuzzy, soft mold," "yellow, flaky mold," and "greenish, powdery mold."

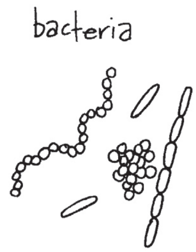
   Some students may have been observing bottles where they saw few or no decomposers at work. This may be disappointing for them, as they were not able to share many sightings with the class. Be sure to discuss the bottles that did not have observable evidence of decomposition. Ask the students whose bottles did not contain many observable decomposers to describe what was in their bottles. Do they have a lot of fruit, plastic, leaves, vegetables, paper, etc.? Contrast their bottle's content to the contents of bottles that did have many decomposer sightings, and encourage students to look for patterns. There may be sufficient data in your class that students will observe that the bottles with fruit or vegetable pieces are more likely to contain the more obvious decomposers.
3. Have students get into their teams with the decomposition bottles and make another round of observations to gather evidence that may explain a possible answer to their investigation question. Provide them with additional copies of the *Decomposition Column Data Chart* and the *Decomposition Column Observation* sheet as needed. Be sure that they are recording as many details as possible in their science notebooks and on their worksheets. This should take about 10–15 minutes.

Teacher's Guide to Decomposition Critters

One of the challenges of viewing some of the critters of decomposition is their size. All organisms are not the same size nor even relatively close in size. This unit introduces students to some organisms that are very important to the process of decomposition. Many of these creatures cannot be seen by the student without the aid of tools. Therefore, the pictures in this guide are not of actual size but rather a representation of what some of these organisms look like when magnified. The sizes listed here are averages since there is great variation in size among some of these organisms. Students can use hand lenses and microscopes, if available, to view many of these organisms in their decomposition columns.

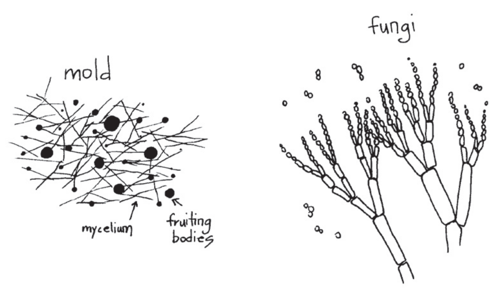
Microorganisms: Seen only by microscope

Bacteria—Colonies may be visible with the naked eye. They will appear as round spots, ranging from brown, to white, to cream in color. The colonies are made up of thousands, or more, of single individual bacteria. While colonies can be viewed with the naked eye or a hand lens, individual bacteria will need a microscope to be seen.



Approximate size: 5µm
400 per pinhead

Fungi—Is commonly referred to as mold. Very fine, thread-like structures make up the body of fungi. It will appear fuzzy, like a blanket of color (black, green, gray, and others) that covers rotting matter. Fungi can have a great range in size from microscopic individuals to large mushrooms.

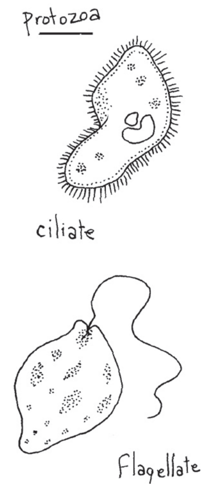


Approximate size: 10µm
200 per pinhead

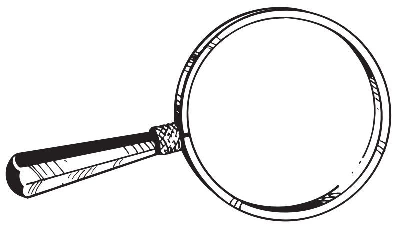
Algae—Is a single or multi-celled photosynthetic organism. It appears green in color because of photosynthetic pigments. While single-cells require a microscope to view, algae colonies can be seen with the naked eye or with a hand lens. Algae live in both aquatic and terrestrial environments; however, land-living algae require a moist environment to survive.

Approximate size: 50 µm
40 per pinhead

Protozoa—Are single-celled organisms such as amoeba and paramecium. Protozoa live in both aquatic and terrestrial environments. They move in a variety of ways such as with cilia (hairs) or flagella (tail-like). Since they are single-celled, these organisms can be viewed only with a microscope.



Approximate size: 250µm
8 per pinhead

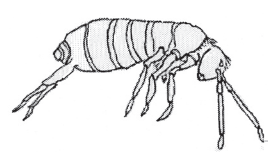


Barely Visible: Seen with hand lens

Nematodes—These are multicellular organisms. They appear as tiny, narrow roundworms and are commonly found in soil. A handful of soil will contain thousands of these worms. Nematodes are approximately the width of a thread and can be seen with a hand lens.

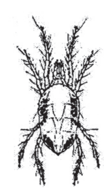
Approximate size: 5mm
Larger than pinhead

Collembola—Are also called springtails. This name hints at their means of locomotion, jumping. They are a primitive, wingless insect, pale-brown to cream in color. Collembola prefer a damp soil environment. They can be viewed using a hand lens and appear to jump or hop away when disturbed.



Approximate size: 5mm
Larger than pinhead

Mites—Belong to a group of insects related to ticks and spiders. Mites can inhabit both aquatic and terrestrial environments. They are very small in size, barely visible to the eye, and can be best seen with a hand lens.



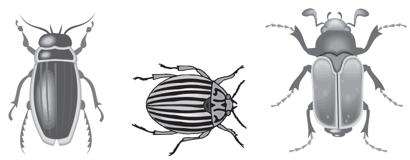
Approximate size: 5mm
Larger than pinhead

Visible: Seen with naked eye

Ants—Are a common terrestrial insect. They are social organisms that live in colonies or groups. Depending on the type of ant, they can range in color from black and brown, to red. They have a typical life span of one to two months. Although they range in size, they are all visible with the naked eye.

Approximate size: 10mm
Larger than pinhead

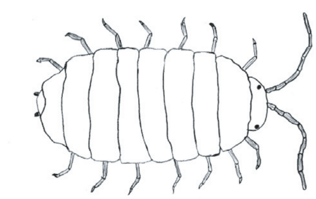
Beetles—Are a common insect. There are thousands of different types of beetles such as the ladybug (lady bird beetle), tiger beetles, and lightning bugs. They live in both aquatic and terrestrial environments. Beetle larvae are called grubs and usually look like fat worms or caterpillars. Both adult beetles and larvae are large enough to be seen with the naked eye.



Approximate size: 20mm
Larger than pinhead

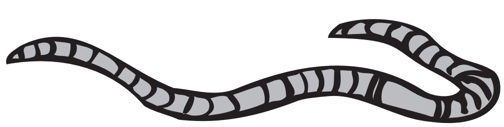
Slime molds—Are not true molds. They live in colonies that are usually brightly colored with the appearance and consistency of pudding. One part of their life cycle is animal-like in that they can move. The reproductive part of their life cycle however, is more plant-like because their fruiting bodies resemble tiny mushrooms. Slime molds can be seen with the naked eye and with use of a hand lens Approximate size: 100mm. Larger than pinhead.

Isopods—Are insects such as Pillbugs or Sowbugs. They have antennae, seven pairs of legs and vary in color from dark gray to white. Isopods are both aquatic and terrestrial organisms. Terrestrial Isopods live in moist, shady areas such as under leaf litter, logs or rocks. When disturbed, some species roll up into balls. Both adult and juvenile isopods are large enough to be seen with the naked eye.



Approximate size: 5mm
Larger than pinhead

Earthworms—Are segmented, terrestrial worms. They have a long thin body and can vary in color ranging from dark brown, purple, red and blue. These organisms eat their way through soil allowing air to penetrate into the soil more easily, thus enriching the soil through a process called aeration. Earthworms are large enough to be seen with the naked eye.



Approximate size: 100mm
Larger than pinhead

Rotten Work

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

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 that looks fuzzy? This is probably mold. Algae might show up too. Algae will look like a soft green carpet.

Do you see any decomposers 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.

They may live in a slimy and stinky environment, but the decomposers have an important job. What would happen without them? We would be up to our noses in dead organisms, with no room (or fresh soil) for new growth! Most decomposers help humans. They help other organisms, too, by helping clear things away. Next time you see a decomposer, thank it for cleaning up!

Lesson Overview

Building off the food chains and reading, *What Do You Consume?* from Step 2, Lesson 1, students create their own food webs. They apply their understanding of the cycling of matter and transfer of energy to the construction of a food.

Lesson Title

Creating Food Webs

Key Concept

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

Time Needed

60 minutes

Materials

Each Student

- Food Web Cards
- Science Notebooks

Each Pair of Students

- One piece of chart paper
- Glue or tape
- Markers or colored pencils

Key Words

Producer, Consumer, Herbivore, Omnivore, Carnivore, Decomposer, Energy, Food Chain, Food Web

Lesson Snapshot

1. Review the food chains that the students created in Step 2 and the terms *producer* and *consumer*.
2. Review and discuss the terms *herbivore*, *omnivore*, *carnivore* and *decomposer*. Label each consumer on their food web cards with their proper niche.
3. Introduce combining two food chains to make a simple food web. Allow student pairs to create their own food webs with their organism cards.
4. Allow students 10 minutes to record data and observations for their ongoing decomposition investigation.

REAP Questions

R – What determines if an organism is called a producer, consumers, herbivores, 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 – What would the food web drawing look like for your bottle? *Webs will vary but could be Sun ➔ Plant ➔ decomposer*

P – If you took the contents of your bottle outside and dumped them under a bush, what might change about your food web? Would there be more or less organisms involved? *Depending on where the contents were dumped, the moisture level would likely change considerably, and if it dried out, it might not continue decomposing very quickly. There would be more organisms involved, probably, because the environment in the bottle is much more confined.*

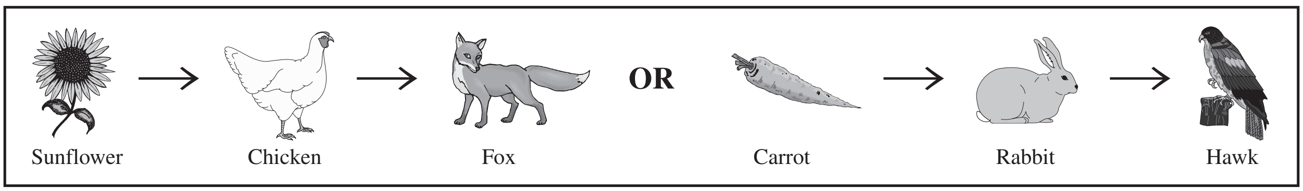
Background Information

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:

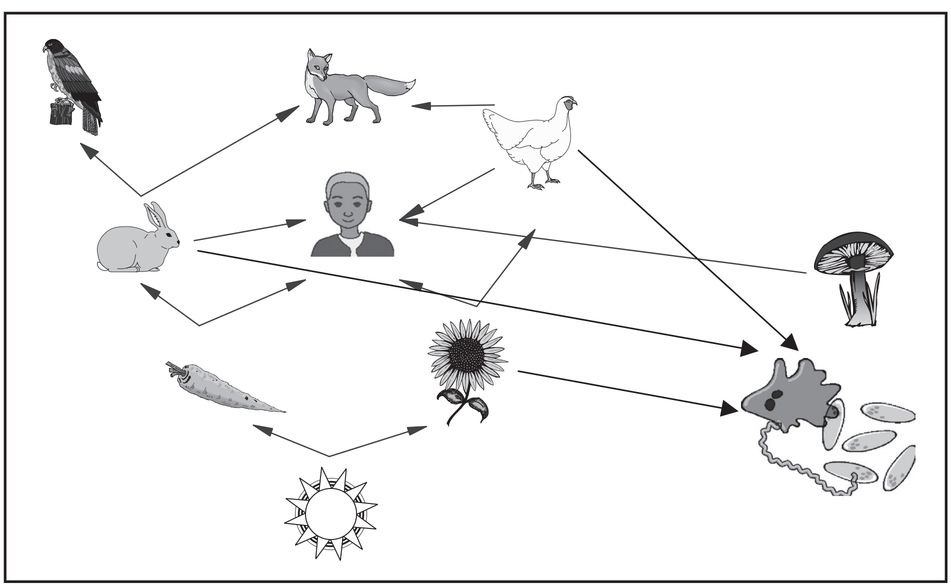


In most ecosystems, however, energy does not flow in simple, straight paths. Very few organisms eat only one thing and rarely is one organism only eaten by one other. Ecological systems are comprised of many interdependent organisms. A food web includes interconnected food chains and shows the competition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

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 to grow in. Producers get their energy for growth from the sun, but they also need carbon dioxide, water, and nutrients to grow. Decomposers help to ensure that these nutrients are available to producers. They help to provide some of the matter that producers need to grow.

Example food web that includes decomposers:



Movement of Energy in an Ecological System

Remind students of the way arrows were used 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. Have the students find in their science notebooks their food chain worksheet (completed in Step 2). Ask a volunteer to share a food chain that includes at least 2 consumers.

   Sun ⟶ Corn ⟶ Cow ⟶ Human

   Have the student draw or talk you through drawing the food chain on the board. Ask the whole class questions along the way to check for understanding.

   - What begins this food chain? Does the sun provide the starting energy for every food chain?
   - What do we call the kind of organism that gets energy from the sun?
   - Which way should the arrow point to show the transfer of energy?
   - Which of these things are producers?
   - What does it mean to be a producer?
   - Do food chains always have to have a producer?
   - Which are consumers?
   - What does it mean to be a consumer?
   - What are the different names for different types of consumers?

Sun	⟶	Corn Producer	⟶	Cow Consumer	⟶	Human Consumer

   Hand out the food web cards and ask each pair to label them as either a producer or consumer.

2. Ask the students to name some of the consumers that they used in their food chains. Create a list of all the consumers that students used in their food chains on the board. Ask the students to recall the special names scientists use to further group consumers according to what they eat. Having students think on their own to recall the names, then share their list of names with a partner, and finally share and generate a single class list will likely result in a complete list, including herbivores, omnivores, carnivores, and decomposers.

   Work as a whole-class group to first define where each of the different consumers get their matter and energy. Refer students back to the reading, *What Do You Consume?* from Step 2 if they have difficulty. Once each consumer classification is defined, have students work in pairs to decide which consumer group they would assign to each consumer in the list. Ask pairs to share their decisions and discuss any discrepancies.

   Refer back to the food chain you drew on the board at the beginning of this lesson. What different types of consumers are in this food chain? Label appropriately the herbivore, omnivore, carnivore or decomposer.

Sun	⟶	Corn	⟶	Cow	⟶	Human
		Producer		Consumer		Consumer
				Herbivore		Omnivore

   Ask the student pairs to gather all their consumer cards together. They should work with their partners to label each consumer card with the appropriate consumer group name. Is this consumer a herbivore, omnivore, carnivore or decomposer?

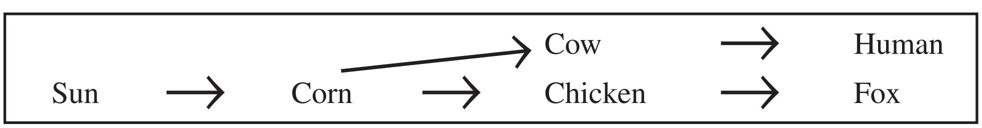
3. Gather student attention back to the board. Write another student food chain on the board below the first one.

Sun	⟶	Corn	⟶	Cow	⟶	Human
Sun	⟶	Corn	⟶	Chicken	⟶	Fox

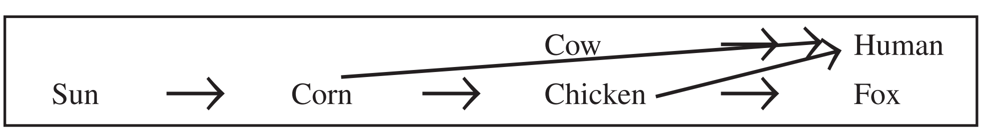
   Does this food chain have any of the same members? Ask the students to think of another way they could show these relationships without having to write the same thing on the board twice. Erase the extra Sun and Corn.

				Cow	⟶	Human
Sun	⟶	Corn	⟶	Chicken	⟶	Fox

   What arrows do they need to add to make this work? *Draw another arrow from the Corn into the Cow.*



   Are there any other arrows that we could draw on this diagram? Does anything eat anything else on the diagram that is not shown with the arrows? *Yes, humans eat corn and chickens. How could we show this on our diagram? Draw an arrow from the corn into the human and another from the chicken into the human.*



Explain that this kind of diagram is called a ***food web***. Ask students if they think this type of diagram is more realistic than a food chains. *In nature, consumers usually eat more than one thing. Many consumers may eat the same producer.*

Explain that they are going to have the opportunity to rearrange their food chains to make food webs. They are going to use the same animals as before, and they will get several new cards as well as some blank cards to work with. The blank cards will be used if another organism is needed for their food webs.

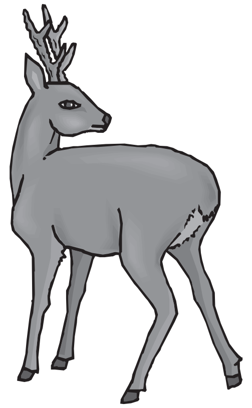
Hand out a large, chart-sized piece of paper to each pair of students. Draw a square the size of the students' paper on the board so that you can explain the key steps for making a food web. Model how to begin by drawing a sun in the center of the page. Next, ask the students to arrange the organism cards on the paper in a way that shows the energy transfer between the organisms. The web should include all of the organisms on the cards. Make sure they include at least a few decomposers wherever appropriate.

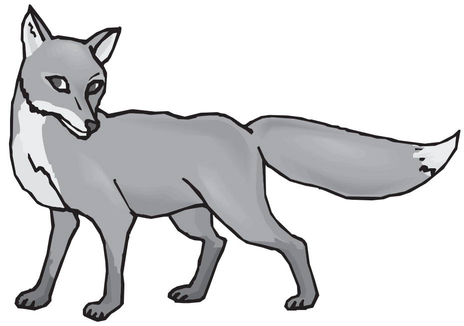
When they are finished, have each group explain the relationships they have drawn.

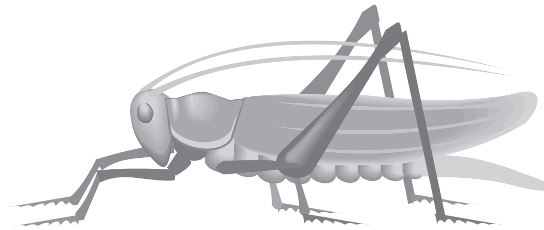
If their diagram makes sense, ask them to tape down the cards. Next, ask students, *How will you draw arrows to show how energy is transferred in this web?* Check for understanding before directing students to add arrows. They may want to begin drawing their arrows with a pencil. If the group agrees that it is going in the correct direction, they can color it with a colored pencil or marker.

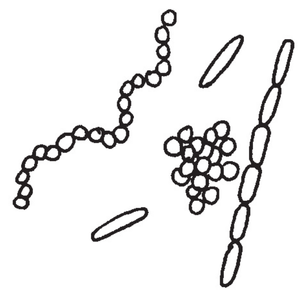
4. When the food webs are completed, provide time for students to spend five minutes writing reflections on their food webs in their science notebook. Direct students to explain where they included the decomposers in their food web, and why. Ask students to cite at least one example decomposer from the food web in their explanation.

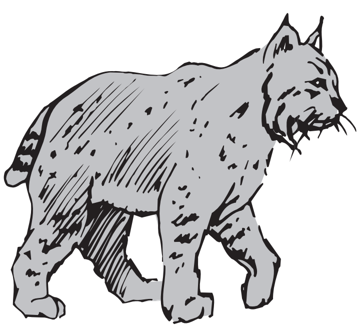
5. Have students get into their teams with the decomposition bottles and make another round of observations to gather experimental evidence. Provide them with additional copies of the *Decomposition Column Data Chart* and the *Decomposition Column Observation* Sheet as needed. Be sure that they are recording as many details as possible in their science notebooks and on their worksheets. This should take about 10 minutes.

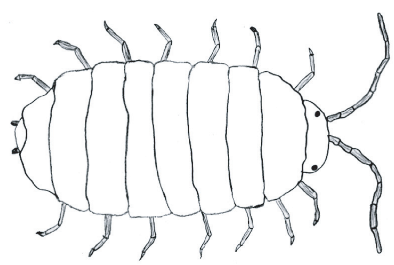


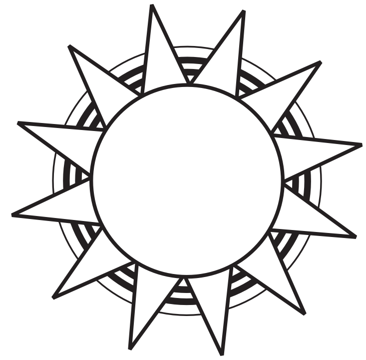


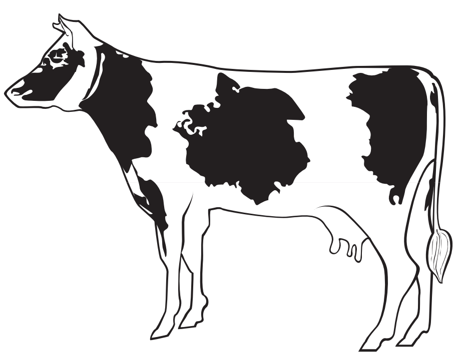


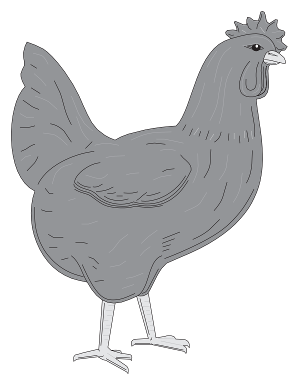












STEP 5

Overview

In this step, students will use their data collected from the Decomposition Columns to form explanations about the process of decomposition. Students will draw on background information from the previous step and their column observations as a foundation to support their explanations about the process of decomposition. These explanations will likely lead students to ask other questions about decomposition, continuing the scientific process.

Lesson 1

Developing Evidence-based Explanations (45 min)

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

Lesson Overview

Students use their prior knowledge, recorded data and observations to develop explanations about decomposition and to develop new questions about the decomposition process.

Lesson Title

Developing Evidence-based Explanations

Key Concept

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

Time Needed

60 minutes

Materials

Each Student

- Complete "Analyzing Data" worksheet
- All completed "Decomposition Column Observation" Worksheets
- Science Notebooks

Each Group

- Decomposition Columns

Key Words

Evidence, Cause and Effect, Conclusion, Opinion, Result, Explanation

Lesson Snapshot

1. Gather investigation teams together with their columns and science notebooks. Students should review their initial investigation question, their predictions, and their data and observations.
2. As students review their work, hand out the Analyzing Data worksheet. Students should complete the worksheet using all their collected data. Guide students to carefully study their data and look for patterns. Next, ask students to use logic and reasoning to link evidence from their data to claims that appear to be accurate about decomposition in their columns. Instruct students to use their Analyzing Data worksheet as evidence to develop their explanation for a possible answer to their question.
3. Have each group prepare and present a short talk to the class about their question, their explanation, and what data they have to present that will support their ideas.

REAP Questions

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

E – Do you see a pattern 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, explain what happens in the process of decomposition? *Students should 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? *Answers should include reference to specific, observed evidence.*

Implementation Guide

1. Have students gather into their Decomposition Column investigation teams. Allow them a few minutes to get their materials organized. Instruct teams to look through their science notebooks and review their initial investigation question and prediction for their Decomposition Column investigation. With their teams, students need to review the data they have collected from their columns, including both their data table and notebook entries.

2. As students review their collection of data sheets, notebook entries, and handouts, distribute the *Analyzing Data* worksheet. Then, go through the worksheet to make sure that everyone understands exactly what each question is asking and how to complete it. Remind them that when they are asked to describe something to use some of the descriptive words that they have been using to make their observations. Remind them of any rules for writing sentences that your class has (e.g., need to be complete sentences, check spelling, use correct punctuation, etc.).

   Once students have analyzed their data, ask them to move on to the *Developing an Explanation* portion of the worksheet. Ask them to complete the first two items—their initial question and their prediction. They should write their prediction just as it was when they made it. It should not be changed based on new information.

   Now, ask them to complete the explanation part of their worksheet. Explain that you will be evaluating how they analyze their initial prediction, not on whether their results support it. If the columns produced evidence that did not support their prediction, that data gives valuable information, too. Either way they learned something about decomposition.

   You will likely need to model this process of linking evidence and claims and developing explanations, and that can be done using an example from the radish experiment. Remind students that one pattern in the observations was that the plants in the dark did not grow straight up like those in the light. A logical claim, after looking at the data, would be that radish seedlings need to be in full light to grow straight. The evidence to support the claim would be that the radishes grown in the dark did not grow straight while those in the light did. A logical explanation for a possible answer to the question, *Do radishes need light to grow and develop in a Terraqua column* could be: Yes, radishes growing in Terraqua columns need light to grow and develop into healthy plants because those grown experimentally without light were unable to grow straight, had pale green leaves, and later fell over. The plants grown in light grew straight and developed dark green leaves.

   Circulate among groups as they develop explanations to be certain they use evidence (from experiments, other steps in this unit, and the readings) to support their ideas about a scientific answer to their question.

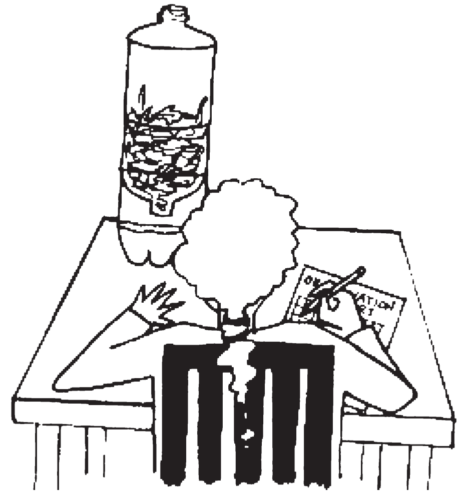
3. Work with the class to develop some expectations for their class presentations. Decide in advance how much time you will allow each presentation. We recommend limiting the time to three to five minutes. The following is a sample discussion that might occur in class to establish a presentation criteria.

   What do you think should be part of the talk you give to the class? *We should show them our bottles and tell them what we did.* What do you need to tell them first? *Who was in our group, what question we investigated, and what we thought would happen—our prediction.* What should you tell them next? *What we put in the bottles and what happened to the stuff after we put it in.* How will they know how you figured out what happened to the stuff? What did you do to figure out what was happening to the stuff? *We will have to tell them what we measured.* Is there anything else you should so? *Tell them the answer to our question.* How should we end our talks? *Say thank you. Ask them if they have any questions about our investigation.*

Write on the board the components to be included and the criteria for a strong presentation so that all groups are clear about the expectations. Provide time for each group to prepare according to the guidelines established. As groups work, travel around the room and remind the students that all explanations must be supported with evidence, so they should carefully choose which data they will present to support their ideas. A good explanation is supported with evidence collected from their Decomposition Column investigation, unit readings, and any outside sources used.

After each presentation, give students a few minutes to reflect on the findings of their classmates. Ask each student to write any questions they have about another groups' investigation or explanation in their science notebook. Explain to students that by asking questions at the end of an investigation they are continuing the scientific process. Explain that from these questions, they could generate another set of decomposition investigations. To take it a step further, you could even have them design their own personal investigation without completing it or have them complete it for a science fair project.

Analyzing Data



Name: ____________________________________

Date: ____________________________________

My investigation question was:

____

____

____

____

My investigation prediction was:

____

____

____

____

Write your data in your own words. ______________________________

____

____

Do you see any patterns in your data? ____________________________

____

____

What has changed in your columns? ______________________________

____

____

____

STEP 6

Overview

In this step, students relate the process of decomposition to issues of trash and waste created by humans, as well as other animals. Students are challenged to think about how decomposers may or may not be able to help solve our trash problems. This step provides an opportunity for students to recognize the important practical applications of scientific research by connecting their research to the world around them.

Lesson 1

Waste and Recycling (20 min)

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

Lesson 2

Reducing Waste (60 min)

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

Lesson Overview

Students read an article on the garbage produced by humans and other animals and the role that decomposers play in reducing this waste.

Lesson Title

Waste and Recycling

Key Concept

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

Time Needed

20 minutes

Materials

Each Student

- Reading, *"The Decomposition Times"*
- Science Notebooks

Key Words

Environment, Resources, Landfill, Recycle, Waste

Lesson Snapshot

1. Read the first three paragraphs of "The Decomposition Times" article. Then stop and make a food chain/web with the sun, oak tree, squirrel, fox, and decomposers.
2. Read the next three paragraphs of the article. As a class, list the kinds of trash the class throws away every day. Circle all the items that will take <u>over hundreds of years or never</u> decompose. Students should use the knowledge gained from their investigations as evidence to predict what decomposes and what does not.
3. Read the final two paragraphs. Develop ideas for dealing with each item that they determined would NOT be broken down by decomposers.

REAP Questions

R – What do the arrows show in a food chain/web drawing? *Transfer of energy*

E – Where do decomposers get their 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.*

Implementation Guide

1. Provide each student with the article "The Decomposition Times." Work through the article with your students using an appropriate reading strategy. After the first three paragraphs, stop and use the information in the article to make a food chain. You can have students do this as a class or individually.
   - What is the producer in our food chain? *The oak tree.*
   - Where does it get its energy? *The sun.*
   - How should I draw the arrow? *From the sun to the tree.*
   - What comes next? Look at the article. *The squirrel.*
   - How should I draw the arrow? *From the tree to the squirrel.*
   - What eats the squirrel? *The fox. Draw the arrow to the fox.*
   - What else was eaten in the article? *The acorn shells and the squirrel's fur.*
   - Who ate them and how do I draw them into the food chain? *Put a decomposer above the Oak Tree with an arrow going into it from the tree. Put one above the squirrel, because it eats the fur. Put one above the fox, because eventually it is going to die and the decomposers will eat it.*
2. Continue reading the next three paragraphs of the article. Then, stop and, as a class, list the kinds of trash the class makes. After you have a large list, ask the students to think about which items will decompose and which will not. They should use the knowledge they gained through this unit as evidence for their explanations. They may not have experimented with or read about the exact item, but they can predict that the plastic toy would either not decompose or decompose very slowly based on the fact that the plastic pen in their column did not decompose during their investigation time. Circle all the items that will either decompose extremely slowly or not decompose.

Teacher Preparation

As you progress through the reading, 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 bottles and previous articles.

3. Read the final three paragraphs. Return to the list of items they created earlier. Have them focus on the items that they said would not decompose. Start with the first item on the list and question whether or not each item was really needed in the first place. If it was not, how could they make a better decision next time they decide to buy something? Work with them to determine some criteria they can use for deciding whether or not they should buy that new toy. How long will they have to play with before it is worth it. What solution do they have for getting rid of it when they are done? What about the extra food that they throw out—the "eyes bigger than your stomach syndrome"? Can they figure out a way to remind themselves to take smaller portions so that they have less waste if they do not like it?

   If the item they listed was one that they really needed, like bigger clothes, shoes or a bottle of water when they were thirsty, try to figure an alternative to sending it to the landfill. What else could you have done with this item besides throw it out? *Give to somebody else that might want it, like a neighbor, friend, or cousin. Donate it to a charity. Sell it at* *a rummage sale. Trade it for something somebody else has that they do not want. Put the leftovers in the fridge and eat them for a snack later. Put it in the recycling bin. Write on the back of the piece of paper and then recycle it.*

You may want to teach your students the three Rs—Reduce, Reuse, then Recycle.

It is often difficult to think of how to dispose of some items, apart from throwing them away. This is a global issue. There are many items that scientists continue to research, looking for new disposal methods. In some cases, the only alternatives for a material are to put it in a landfill or stop using it altogether.

Classroom Extensions

The topic of trash and recycling provides good extension opportunities for students to conduct individual research. Students can:

- plot landfills on a map of California.
- research the condition of local landfills—discovering what problems they are having managing waste, what effects they have on the communities where they are located, and what is being down to solve the landfills problems. You may even be able to arrange a speaker from the landfill to come to your classroom.
- explore waste reduction tactics in their community, school, and their own homes and develop strategies for improving them.
- keep a waste log—by weighing the amount of trash produced by their classroom each day. Together the class can brainstorm ways to reduce classroom trash and set a goal for a lower weight. As a class, you can implement those strategies and continue to monitor their progress towards a lower trash weight.

The Decomposition Times

What happens to the waste that plants and animals in the wild leave behind? Think about what squirrels leave as waste when they eat acorns. An oak tree produces acorns. A squirrel finds those acorns and has a tasty meal. The squirrel eats the tender acorn meat inside and leaves the shells. What do you think will happen to those shells?

Decomposers will munch their way through those shells in a few months. Imagine if a fox later eats the squirrel. 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. Decomposers eat dead plants and animals. They use some of the matter and energy from their food to survive. 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.

Decomposers take care of nature's waste, such as squirrel fur and acorn shells. What would happen without decomposers? The waste would pile up. Now think about the kinds of trash people create. Consider the bags and cans of trash that your neighbors put out on the curb where you live. 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.

Decomposers can only eat a small amount of the matter in a landfill. Even things that usually decompose quickly can stay in landfills for years before the decomposers get to them. There is just too much for them to eat. In addition, there are many things that we use every day *that will not decompose. Glass jars take a million years to decompose. Most plastic bottles never decompose. What did you throw away today that will not decompose?

Some of those things that will not decompose can be recycled instead of going to the landfill. Plastic bottles, glass containers, paper, and metal cans are often recycled. Factories break them up into very small pieces. Then, the small pieces are processed and made into new things. Recycling keeps human waste from piling up. That is important since decomposers cannot handle much of our trash.

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

Lesson Overview

To connect their classroom investigations to their own community, students write an informational article about the environmental problems concerning waste

Lesson Title

Reducing Waste

Key Concept

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

Time Needed

60 minutes

Materials

Each Student

- All completed worksheets
- Blank paper

Each Group

- Internet access (optional)
- Newspapers (optional)

Key Words

Review all key words

Lesson Snapshot

1. Introduce the project on trash problems and solutions. Remind students to include all of the information the editors are looking for. Encourage them to use their data and explanations from their investigations as evidence in their article.
2. Once students are finished writing their articles, have them share their articles with their investigation teams.

REAP Questions

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? *Answers should include reference to reducing, reusing, and recycling waste.*

Background Information

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. Introduce the project on trash problems and solutions. Share the following scenario with the class:

   The editors of the local newspaper heard that our class is doing research on decomposition and waste. They would like you to submit an article that discusses the relationship between decomposition and trash problems that humans have created. They would like you to share what you have learned through your own research. Use this opportunity to tell others how your investigation has made you think about trash differently and ideas that you have about reducing trash.

   The article must include the following:
   - Describe the results of your investigation.
   - Describe how the results of your investigation can inform how you think about trash problems.
   - Describe one thing your class could do to help reduce how much stuff you use or how much stuff you send to the landfill.

   Instruct students to independently write a short newspaper article. This should be a reflective writing that explores their understandings and ideas regarding trash problems and solutions. Encourage students to use their data and explanations as evidence and rationale in their article. Remind students to include all of the information the editors are looking for.

2. Gather students into their investigation teams and ask students to share their articles with their investigation teams. they can read their articles to their team or exchange with a partner and read each other's articles.

3. Finish the lesson with a whole-class discussion about what students have learned in this unit that they did not know before and what questions they still have. You may encourage students to continue observing their decomposition columns and bringing information to class about trash and recycling as they encounter it in newspapers, magazines, or television.