K–3 Module

Unit 3
Vermicomposting

Lesson 1
The Basics of Vermicomposting

Lesson 2
Getting to Know Red Worms

Lesson 3
Cycles in Nature and Red Worm Development

Lesson 4
The Effects Worms Have on Soil

Lesson 5
Using Compost and Promoting Vermicomposting

This unit had exciting activities that made the concepts clear. The students and I enjoyed this unit every step of the way.

— Donna Flores, third-grade teacher, Nightingale Elementary School, Stockton Unified School District

It was fun! We learned a lot about worms, their needs, life cycles, nutrient cycles, and composting.

— Sharon Janulaw, kindergarten teacher, Marguerite Hahn Elementary School, Cotati–Rohnert Park Unified School District

The students were fascinated by the concepts presented and the activities. The "What I Know/What I Want to Know" and "What I Found Out" format was effective. The book Squirmy Wormy Composters *is a must!*

— Gayle MacDonald-Gura, third-grade teacher, Lower Lake Elementary School, Konocti Unified School District

K–3 MODULE

Unit 3: Vermicomposting
Overview

Note: Approximately one month before beginning Lesson 3 in Unit 3, complete "Preparing the Decomposition Experiment" on page 106.

UNIT 3'S CONCEPT

Through vermicomposting, food waste is recycled and the compost can be used to enhance soil.

The five lessons in this unit are:

LESSON 1: THE BASICS OF VERMICOMPOSTING

Lesson's concept: Food scraps can be recycled through vermicomposting.

In Lesson 1 students will:

- Brainstorm what they know and what they would like to know about worms.
- Set up a vermicomposting bin.
- Classify those items that can be fed to red worms and those that cannot be fed to red worms and write a poem about it.
- Design a chart with pictures of what to feed and what not to feed red worms.
- Record the weight and type of worm food and where it was placed in the worm composting bin.
- Select questions about red worms that they can research in books, on the computer, through videos, and through personal observations.

LESSON 2: GETTING TO KNOW RED WORMS

Lesson's concept: Red worms, like all other living things, "take in nutrients, give off wastes, grow, reproduce, and respond to stimuli from their environments." (*Science Framework*, p. 116)

In Lesson 2 students will:

- List the ways to humanely observe and handle a red worm, and using the list, they will then write a song or sing a song that is already written.
- Observe a red worm by using a magnifying lens and record their observations.
- Conduct humane experiments to determine whether red worms prefer light or dark.
- Practice measuring on gummy worms and then measure live red worms, chart these measurements, and develop a graph to compare the length of 20 red worms.
- Draw pictures or write stories about red worms.

LESSON 3: CYCLES IN NATURE AND RED WORM DEVELOPMENT

Lesson's concepts:

- All living things create waste. In natural systems, waste is broken down by chemical and physical means and can be used by other living things. ("Conceptual Matrix for Integrated Waste Management Education")
- In the cycles that occur in nature, materials, such as nutrients, are recycled. Worms play an important role in recycling nutrients.

In Lesson 3 students will:

- Examine the stages of decomposition of the items they buried at the beginning of this unit.
- Design a game to model the water cycle and identify a water cycle in the worm bin.
- Illustrate the stages of growth of a red worm.

- Determine the role red worms play in the nutrient cycle.
- Make a mural of cycles in a well-functioning vermicomposting bin.

LESSON 4: THE EFFECTS WORMS HAVE ON SOIL

Lesson's concepts:

- Red worms turn food waste into compost that can be used to improve soil.
- People and other living things depend on soil.

In Lesson 4 students will:

- Observe, touch, and describe soil.
- Examine and describe worm castings and compare them to soil.
- Discuss the effect worms have on soil and how their actions may benefit other organisms.
- Sing a song about the importance of worms and soil to people.
- Design collages showing ways people use soil.

LESSON 5: USING COMPOST AND PROMOTING VERMICOMPOSTING

Lesson's concepts:

- Red worms turn food and paper waste into compost that can be used to enrich soil.
- People can participate in actions that enhance their environment.

In Lesson 5 students will:

- Harvest the vermicompost from the worm bin.
- Conduct an experiment to test whether worm compost affects plant growth.
- Read or listen to *Miss Rumphius* by Barbara Cooney and *Johnny Appleseed* by Eva Moore and discuss the special things each character did to improve the environment.
- Make a red worm mascot, puppet, or clay model, and use these to share what they know about red worms and vermicom-posting.
- Write poems, songs, and stories or design murals, illustrations, and posters to teach others about the importance of vermi-composting.

Required Books to Implement Unit 3

- **For Lesson 1:**

  Kalman, Bobbie, and Janine Schaub. *Squirmy Wormy Composters.* Primary Ecology series. New York: Crabtree Publishing Company, 1992.

- **For Lesson 5:**
  - Cooney, Barbara. *Miss Rumphius*. New York: Viking, 1982.
  - Moore, Eva. *Johnny Appleseed*. Illustrated by Beatrice Darwin. New York: Scholastic, Inc., 1970.

PROJECTS

Projects provide hands-on experiences for students. Some lessons in this unit are project-based and encourage students to apply what they have learned in the classroom. Some project-based lessons are service-learning oriented, and in these lessons students participate in improving the environment in their school and community.

The following describe five projects that address this unit on vermicomposting. Examples are given of schools that participate in vermicomposting. Teachers are encouraged to select one of these projects with their students or to have their students develop one of their own. If students develop an applicable project, they and their teachers are encouraged to send a description of the project to the California Integrated Waste Management Board, Office of Integrated Education, MS-14A, 1001 I Street, P.O. Box 4025, Sacramento CA 95812-4025.

- **Project 1:** Students compile a class booklet, complete with illustrations, describing the first time they saw a red worm. The booklet could include the name of each student in the class, followed by a description written or dictated by the named student. For example, "The first time Charles saw a worm . . ." ; "the first time Marina touched a worm . . ." (Lesson 2).
- **Project 2:** Students plant flowers in planters on the school grounds (Lesson 4), plant shrubs and trees to beautify their school grounds (Lesson 5), or develop a school garden (Lesson 4).
- **Project 3:** Students put together information about red worms and vermicomposting in a script for a puppet show. Arrange for your

students to go to other classes to present their puppet show about red worms and vermicomposting. This show can also be presented during a school assembly and at the school's open house (Lesson 5).

- **Project 4:** Students package the vermicompost and sell it to parents or other community members. Students could also include information in the packages about the benefits of vermicomposting or how to build and maintain a worm bin (Lesson 5).
- **Project 5:** Students organize and conduct an annual worm festival. They could develop stations for students from other classes to visit. A demonstration on how to vermicompost can also be included (Lesson 5).

- **Other Projects**

Lesson 1 of Unit 3 is project-based, focusing on vermicomposting as the class project.

Marguerite Hahn Elementary School, Cotati–Rohnert Park Unified School District[1]

Sharon Janulaw's kindergarten class at Marguerite Hahn Elementary School prepared a vermicomposting bin to be used to process food waste from students' snacks. It is one foot deep by two feet wide by three feet long with a lid. Students take turns caring for the worms, making certain that the worm bin is not too hot or too dry. This bin will be displayed at open house, and the students will explain to their parents how to set up and care for the worm bin and show how food waste can be changed by the worms into a soil amendment.

The schools described below have classroom or school-wide vermicomposting bins and could be contacted for more information. The information on the schools from the San Francisco Unified School District was provided by Natasha Stillman, School Education Coordinator**,** Solid Waste Management Program, City and County of San Francisco. She oversees the San Francisco Recycling Program.

Bret Hart Elementary School, San Francisco Unified School District

Bret Hart Elementary School has a garden that is used by students to study science, social science, mathematics, and language arts. The garden was recently replanted, providing an opportunity for the integration of worm composting. The San Francisco Recycling Program provided outdoor worm bins and introductory classes both to teachers and to students. Currently, two bins are being used several times a week when the students collect food waste from the cafeteria.

Cesar Chavez Elementary School, San Francisco Unified School District

In 1996 a composting program at Cesar Chavez Elementary School was initiated by three teachers as an addition to the garden that was already in place. In 1997 an Americorps volunteer associated with the school took over the project. The school now has seven worm bins, five of which were cut down to accommodate the smaller children. An average of 5–10 pounds of compostable food is collected every week. The worm castings are used as fertilizer in the school's garden.

Dr. Charles R. Drew Elementary School, San Francisco Unified School District

At Dr. Charles R. Drew Elementary School, two worm boxes are kept in a courtyard adjacent to the cafeteria. Two buckets for collection are kept in the teachers' lounge, along with a scale for weighing the amount being composted and newspaper for the worm bins. Students from Kathy Harriman's third-grade class take turns collecting the compostable food waste from the cafeteria and place it in the worm bins on a daily basis.

John Muir Elementary School, San Francisco Unified School District

Initiated by the school's garden coordinator in 1996, with help from the San Francisco Recycling Program, John Muir Elementary School now has the beginnings of a worm composting program in the school's garden, located a half-block away from the school. A fifteen-student "Worm Patrol" team collects food waste from one of the lunch periods. The food is then distributed between a worm bin and a basic bin. The worm castings and compost from the basic bin are used as fertilizer and soil amendment in the school's garden. The garden is used each week by the garden coordinator for lessons on gardening and composting.

Lawton Elementary School, San Francisco Unified School District

The composting program at Lawton Elementary School includes two 4- by 4-foot vermicomposting bins and two basic composting bins. The program consists of teams of six students in grades three through eight that rotate over a two-week period to monitor the process, collect food, and place food in the worm bins. In the 1996–97 school year, an average of 49 pounds of material was composted every week. The compost is used in the school's garden and in the landscaped areas of the school.

[1]Submitted by Sharon Janulaw, kindergarten teacher and field tester for *Closing the Loop,* Marguerite Hahn Elementary School, Cotati–Rohnert Park Unified School District.

Rooftop Elementary School, San Francisco Unified School District

Having a well-established garden at Rooftop Elementary School allowed both worm and basic composting to be integrated easily. The school now has three 4- by 4- by 2-foot worm bins for fruit and vegetable scraps and several basic composting bins for garden trimmings. The students eat in the school garden, making collection easy. An average of 15–20 pounds of food waste is collected each week. The worm castings and basic compost are used in the garden.

Weaverville Elementary School, Weaverville Elementary School District[2]

Sue Odell's third-grade class and a fourth-grade class at Weaverville Elementary School have been involved in a vermiculture project for several years. The students separate lunch products into what the worms could eat and what we need to "throw away." They included the entire school in the project. "We found that our primary children had two to three times the waste material of the older students. We talked about ways to reduce the waste. With more school participation, including buy-in from cafeteria workers, we could lower our throw always even more."

[2]Submitted by Sue Odell, third- and fourth-grade teacher and field tester for *Closing the Loop*, Weaverville Elementary School, Weaverville Elementary School District.

Laytonville Elementary School, Laytonville Unified School District[3]

Putting worms to work has made vermicomposting (composting with worms) successful at the Laytonville Unified School District in Mendocino County. Students from the district's elementary and middle school separate their lunch waste into nonprotein "worm food" (i.e., no meat or dairy products), paper bags, aluminum cans, glass, milk cartons, and garbage. Both the worm food and paper bags (after being shredded) are taken to the worm bins located in the school garden. Under adult supervision, middle school students monitor the bins and record the worms' activities. Students also built four 32-square foot worm bins last spring out of redwood and plywood. A chart showing the amount of compost produced is posted in the cafeteria; the compost and recycling program has reduced school garbage by 60-80 percent.

[3] "Laytonville Composts," *Reusable School News*. Sacramento: Integrated Waste Management Board (spring 1993).

Vermicomposting bins at Rooftop Elementary School, San Francisco Unified School District.

RECOMMENDED TIME LINE AND ACTIVITIES FOR UNIT 3: VERMICOMPOSTING

Day 1	Buy bin and send for worms.[1] Buy or send for required books for the unit.
Day 2 (and at least one month before doing Lesson 3)	Do "Preparing the Decomposition Experiment" to prepare for Lesson 3.
Before doing Lesson 1	Teach students about the needs of living things in order for them to live.[2] Collect newspapers or other paper for the worm bin.
When you get the worms (within two days after receiving the worms)	Do Lesson 1.
Within two weeks of Lesson 1	Do Lesson 2.
Approximately one month after doing "Preparing the Decomposition Experiment"	Do Lesson 3.
Any time after Lesson 3	Do Lesson 4.
Throughout the next two to three months	Do parts of Lesson 5.
When compost is ready	Complete Lesson 5.

[1] When ordering the worms, find out how long it will take for you to get them.

[2] Because this unit focuses on vermicomposting and in order to keep this unit relatively short, we have not included certain lessons that already exist in most science programs. These include the needs of living things. Before beginning Lesson 1, you will need to select and implement an activity to teach students what living things need in order to live.

Note: This is a time line for doing the activities in Unit 3, but you should consider using the worm bin throughout the year. If you do not want to continue to maintain the worm bin, please give it to another teacher or to a responsible student to care for. Another alternative is to release the red worms in a compost pile.

PREPARING THE DECOMPOSITION EXPERIMENT

Note: Do the following approximately one month before you begin Lesson 3 of Unit 3 on cycles.

MATERIALS

___ Dampened bread (Use bread that does not contain preservatives.)
___ Resealable plastic sandwich bag
___ Samples of the following pieces of trash (should be approximately the same size):
  ___ Plastic
  ___ Aluminum
  ___ Cardboard
  ___ Fruit or vegetable
  ___ Yard waste like leaves
  ___ Classroom paper (copy paper, binder paper, or construction paper)
___ Approximately ten to twelve cups of garden soil (Do not use sterilized potting soil.)
___ A container for the soil (e.g., a one gallon milk or water jug)
___ Piece of butcher paper on which to record students' predictions

PROCEDURE

A. Place a piece of dampened bread in a resealable plastic sandwich bag and have students look at it each day as it decomposes. They can record their observations on a piece of paper set up next to the bread in the bag.

B. Show samples of the following pieces of trash and write the names on a piece of butcher paper:

- Plastic
- Aluminum
- Cardboard
- Fruit or vegetable
- Yard waste, such as leaves and grass clippings
- Classroom paper

C. Ask students to predict which items will begin to rot (decompose) in a month if buried in soil. List their predictions on the butcher paper. Keep these predictions to refer to in Lesson 3.

D. Ask students to select two items from the list on the butcher paper and to draw how these items look now and how they think they will look in a month. Keep these illustrations to refer to in Lesson 3.

E. Place garden soil in a container. Bury all six pieces of trash in the soil in the container. Plan to have students unbury and observe these items in approximately a month when you implement Lesson 3. Make sure that the soil stays damp (you might need to water the soil regularly).

LESSON 1: The Basics of Vermicomposting

Note: Before implementing this activity, students will need to know what animals need in order to live. You will need to use an existing lesson (most science programs have lessons on this topic) or design one yourself to teach students the needs of animals, which should include food, water, shelter, air, and a place to live (habitat).

LESSON'S CONCEPT

Food scraps can be recycled through vermicomposting.

PURPOSE

Students are introduced to the basics of vermicomposting and learn about the physical requirements of red worms as they set up a worm bin to demonstrate how food waste and paper can be recycled.

OVERVIEW

In this lesson students will:

- Brainstorm what they know and what they would like to know about worms.
- Set up a vermicomposting bin.
- Classify those items that can be fed to red worms and those that cannot be fed to red worms and write a poem about it.
- Design a chart with pictures of what to feed and what not to feed red worms.
- Record the weight and type of worm food and where it was placed in the worm composting bin.
- Select questions about red worms that they can research in books, on the computer, through videos, and through personal observations.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students set up a vermicomposting bin in the classroom and keep a class journal of everything that gets put into the bin.
  - "Plants and animals meet their needs in different ways. As a basis for understanding this concept, students know: plants and animals both need water, animals need food, and plants need light." (*Science Content Standards, Grades K–12*; Grade 1; Life Sciences, Standard 2c)
  - "A lot can be learned about plants and animals by observing them closely, but care must be taken to know the needs of living things and how to provide for them in the classroom." (*Benchmarks for Science Literacy,* page 15)
  - "Students collect information about objects and events in their environment." (*Mathematics Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 3)
  - "To participate effectively in society, students need to: Develop personal skills . . . group interaction skills (and) . . . social and political participation skills." (*History–Social Science Framework,* page 24)
- Older students do research on worms in various sources.
  - "Students identify the basic facts and ideas in what they have read, heard, or viewed." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 2)
  - Students "understand the purposes of various reference materials." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 13)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, classifying, relating, applying

TIME

60 minutes or more (especially if you need to buy the worm bin and worms) to prepare for the lesson; 60 minutes or more to implement the lesson (depending on whether you have younger or older students and their involvement in preparing the worm bin)

VOCABULARY

compost, organic, organisms, red worm, vermicomposting

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Obtain a ready-made container measuring approximately 1 foot deep by 2 feet wide by 3 feet long with a lid. Plastic storage containers can be purchased from most large variety stores. If possible, reuse a previously used container or purchase one made from recycled plastic.

- Drill several 1/4-inch drainage holes through the bottom of the container.
- Place screen on the bottom of the container. (Red worms will usually not crawl out of the drain holes, because they prefer the dark; however, if your bin becomes too dry or too wet, the worms will leave in search of more favorable conditions.)

___ **3.** Make a transparency of the "Sample Vermicomposting Data Sheet" (page 117).

___ **4.** For younger students (in kindergarten and first grade), duplicate "What to Put and Not to Put in a Worm Bin" for each group of students (page 118).

Note: Some people who vermicompost drill 1-inch round holes on each of the four sides of their bins for an additional air supply. These holes are covered with screen, and a glue gun or waterproof tape is used to secure the screens to the container.

MATERIALS

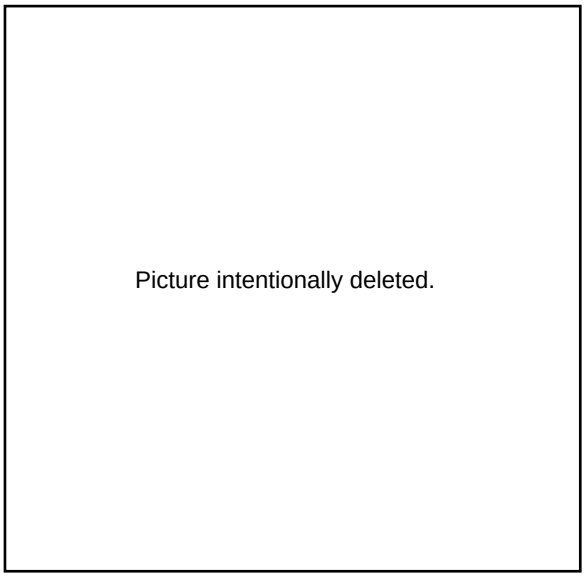
___ Butcher paper on which to write students' responses
___ Vermicomposting container with lid
___ Newspaper (a stack about 6 inches tall) or classroom paper to be used for bedding (Colored paper and paper with crayon drawings can be used. Do not use glossy advertisements and magazines.)
___ A plastic milk jug for measuring water
___ Water (in a watering can)
___ 1 or 2 pounds of red worms, depending on the size of the bin (Red worms can be purchased from bait shops or from worm suppliers. See the list of worm suppliers in the "Appendix.")
___ 4 to 6 cups of garden soil (Do not use sterilized potting soil.)
___ Utility scale (up to 20 pounds) (This scale can be a hanging scale on which students hang a bucket with items to be weighed or a parcel post scale on which students can place a container with items to be weighed.)
___ Large clean plastic bucket or other container (or wheelbarrow) for mixing bedding (Bedding can also be mixed in the vermicomposting bin.)
___ Two boards, or four bricks, or other comparable items to place under the bin so that the bottom will receive sufficient air
___ Sheet of plastic, or large flat garbage bag, or several unfolded newspapers to put under bin in case water leaks through the holes
___ A 2-quart plastic container with lid in which to keep food waste to feed to the worms
___ A class worm journal to keep by the worm bin
___ The book *Squirmy Wormy Composters* by Bobbie Kalman and Janine Schaub
___ Nontoxic permanent marker
___ Six 3- by 5-inch cards
___ The transparency, "Sample Vermicomposting Data Sheet"
___ For younger students, a copy of "What to Put and Not to Put in a Worm Bin" for each group of students

PRE-ACTIVITY QUESTIONS

A. Ask students:

- After you eat lunch, what do you do with your garbage? *Throw some of it away; recycle some of it.*
- What do you throw away? *Some paper, food, plastic.*

- What do you do with the paper from your lunches? *Throw it in the garbage can; recycle it; reuse it; compost.*
- What do you do with cans? *Throw them in the garbage can; recycle them.*
- What do you do with food waste? *Throw it in the garbage can.*
- What else can you do with food waste? *Feed it to animals; bury it; compost it.*
- If we could have a container in our classroom with special animals that are easy to take care of and that could eat our food waste, would we want this container? *Yes.*
- Can you guess what animal might eat our garbage in a container in our classroom? (As students name some animals, you might give them hints, like "it is much smaller than a mouse," until a student identifies the animal as a worm.)
- What do we know about worms? (List what students say on a piece of butcher paper.) *They are slimy. I've used them for fish bait. I have some in my garden. I've seen them after it rains. They don't have any hair.*
- What do you want to find out about worms? (List what students say.) (See answers from Betsy Weiss's class.)



Students in Lynda Mooney's first-grade class at Las Palmas Elementary School compile a list of what they know about worms.

What do you already know about worms?
Worms:

- *Live in the ground, under soil, and compost with centipedes and other bugs*
- *Recycle the dirt*
- *Eat garbage*
- *Dig in soil*
- *Take care of gardens*
- *Wiggle to move*
- *Are long and skinny*

What do you want to find out about worms?

- *What happens if they live in the sun? Will they die?*
- *How do they eat?*
- *Do they have teeth?*
- *What do they eat?*
- *Do they sleep underground?*

Submitted by Betsy Weiss's kindergarten and first-grade class, Paden Elementary School, Alameda City Unified School District.

Note: Keep the lists your students developed to use at the end of the lesson.

- Does anyone know what compost is? Lead students to conclude that compost is a soil enricher that helps plants to grow. Tell students that a special type of worm, called a red worm, can eat garbage, like food scraps (e.g., apple cores, banana peels, bread crust). The worms' droppings, called castings, look like rich soil and contain nutrients to help plants grow. These droppings can be collected and placed in the garden or in flower pots.
- How can red worms help to reduce the waste we throw away? *They can eat our food garbage.*
- If "vermi" means worms, what do you think vermicomposting means? *Composting with worms.*

B. Discuss with students the following:

- If we decide to set up a worm composting bin where worms would live, what will we need to know? *How to do it; what worms need to live; who will take care of them.*
- What do animals need in order to live? *Food, water, shelter, air, and a place to live.*

- What do you think red worms need in order to live? *Food, water, shelter, air, a place to live.*

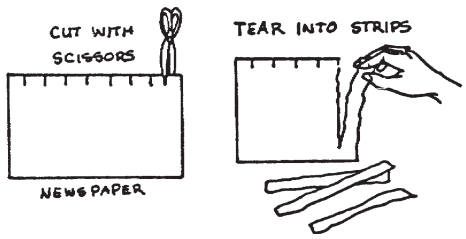
PROCEDURE

Part I, Providing a Habitat for Red Worms

A. Describe the components in a worm bin: bin, lid, paper strips, soil, water, air, red worms, food scraps.

Note: The following could be done in several short sessions by working with one small group at a time, while other groups work on another assignment.

B. Tell students that they will first be making the bedding for the red worms. Provide a stack of paper about 6 inches tall. Have students cut and tear strips of paper. You will need several grocery bags full or approximately 10 to 12 pounds of strips. Newspaper can be easily torn into strips by folding sections and using scissors to snip one inch strips along the fold and then tearing strips starting where the scissors snips began. Adult volunteers can make the snips in the folded paper, and students can tear the strips. Then the strips should be separated from each other so that each strip contains only one layer of paper.



C. Prepare the bedding by completing #1 or #2 below, depending on the grade level of your students (#1 is recommended for students in kindergarten or first grade; and #2, for students in grades two or three).

For younger students

1. The following can be done in the worm bin or in a wheelbarrow or other large waterproof container:

- Place a couple of grocery bags full of paper strips in the mixing container with enough water to dampen the paper, but not so much as to make the paper strips soggy. A watering can works well. To judge how wet the paper should be, think in terms of a squeezed out sponge.
- Add several cups of soil and mix well.
- If mixing is done in a container other than the vermicomposting bin, then place the wet newspaper in the worm bin and distribute the paper evenly.
- Fluff up the paper to provide air.

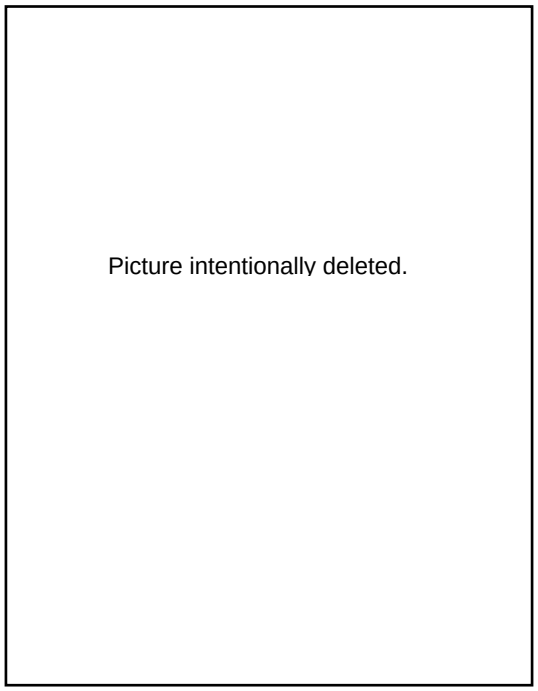
For older students

2. Mathematics problems could be added to this lesson by having students calculate the proper amount of bedding, soil, and water. Have students:

- Weigh 10 to 12 pounds of dry paper strips. They can weigh the paper on a household utility scale.
- Calculate the amount of water needed by multiplying the weight of the paper by three (see the "Note" below). Tell students that a pint of water weighs a pound; therefore, a gallon (8 pints) of water weighs 8 pounds.

Picture intentionally deleted.

Students in Ted Schut's first-grade class at Ripona Elementary School prepare bedding for red worms.



Two students from Sharon Janulaw's kindergarten class at Marguerite Hahn Elementary School prepare a worm bin.

Note: Red worms need an environment that has approximately the same moisture content as their bodies, 75 percent. The environment in the bin can be set up by weighing the shredded paper and adding approximately three times as much water (by weight). Once the bin is established, the food waste usually provides enough moisture, and you will probably not need to add water to the bin.

- Place about half of the paper in the mixing container, add about half of the required amount of water to dampen the paper, and mix.
- Add 4 to 6 cups of garden soil and the rest of the paper and water.
- Mix well, and if a separate mixing container was used, empty the contents into the worm bin and distribute the paper evenly.
- Fluff up the paper to provide air.

Part II, Composing a Poem About Vermicomposting

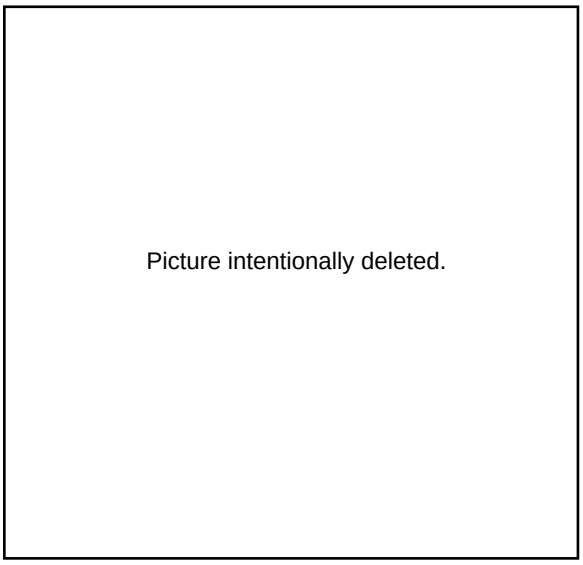
A. In this activity, students will write a poem about what should and should not be placed in the vermicomposting bin.

- Tell students that just about any food waste left over from school lunches can be fed to the worms, including bread, fruit, vegetables, and pasta. Note that these food wastes come from plants.
- Materials not to feed worms are meat, bones, and nonfoods, such as plastic wrap or rubber bands.

Note: Although meat and bones can be com-posted, these materials take a long time to decompose, and their presence in a worm bin may attract rodents (mice and rats) and flies.

B. Ask students to make a chart with pictures and words of what to feed and what not to feed red worms. One way to do this is described below:

- Brainstorm and list items that are common in students' lunches.
- Write the name of each item on a separate scrap of paper, place these scraps in a container, and let students take one.
- Ask students to draw and write the name of the item under each drawing.
- Write the following headings on chart paper: okay to feed to worms/not okay to feed to worms.
- Ask students to glue their drawings under the appropriate category. The placement of the drawings should be agreed upon by a majority of the students.
- Hang the chart paper by the worm bin.



Students in Lynda Mooney's first-grade class at Las Palmas Elementary School develop a chart illustrating "Good Food for Worms" and "Bad Food for Worms."

Note: A chart, "What to Put and Not to Put in a Worm Bin," on page 118 is included in this lesson to use with younger students.

C. Ask students to meet in groups and write a poem about what should and should not be placed in a worm bin.

Note: For younger students, consider writing a poem as a class.

D. If poems were written by groups, have students read the poems to the class.

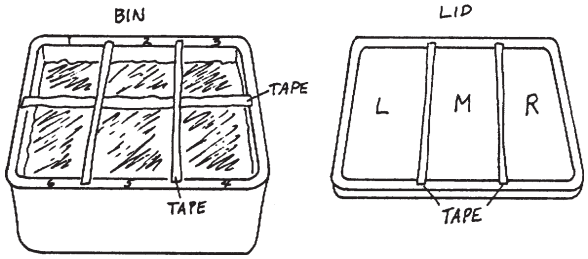
Part III, Adding Worms and Food

Note: Do this before lunch.

A. Show students how to weigh something (e.g., a book). Have students weigh the worms before they place them in the bin, and record the worms' weight on the transparency "Sample Vermicomposting Data Sheet." (There are approximately 1,000 worms in a pound.) Ask a couple of students to gently place the worms on top of the bedding, spreading them out evenly. Keep the bin uncovered; within a few minutes, the worms will move down into the bedding to avoid light.

B. Have students write numbers 1 to 6 on 3- by 5-inch cards. Tape these to the top of the lid. You can also use tape to separate the sections on top of the bin and write the numbers with a marker on the top edges of the bin (see illustration). Students should use this diagram for placing food waste in different sections of the bin. This will enable students to keep track of where and when the food waste was placed. These sections can also be drawn on the back of the class worm journal for reference.

Note: For younger students, separate the worm bin into three parts: a left side (L), a middle section (M), and a right side (R). Students can alternate feeding sides.



C. Before lunch or snack time, separate the class into four teams. Ask each team to bring back to class one piece of food waste approximately the size of an apple core. These food items will be fed to the worms. Examples of food waste that students can bring are: apple core, banana peel, pieces of bread crust. Also see "What to Put or Not to Put in a Worm Bin" or the chart that students developed in "Part II," section "B."

D. Collect the lunch or snack food waste from students and place it in a plastic container with a lid.

- Have students weigh lunch leftovers and record the weight.

Picture intentionally deleted.

Students in Ted Schut's first-grade class at Ripona Elementary School add food scraps to the worm bin.

Picture intentionally deleted.

A student in Mario Chang's second-grade class at Mission Education Center places food into the first corner of the vermicomposting bin.

- Ask one student to add approximately one-half pound of the food waste to the vermicomposting bin. The first pile of food should be placed in the corner for week one (based on the food waste pattern diagram) or on the left side (for younger students).

Note: Students should realize that it is important not to overfeed the worms; otherwise, the bin will have too much food for the worms to process, which will cause the bin to become too moist and acidic for the worms. Students should feed the worms a half-pound of food waste only once a week for the first three weeks until the red worms become established. Also, the worms will eat the paper, so keeping the food waste to a minimum will not hurt the worms. Once the worms are acclimated, they will be able to consume half their weight a day. Food scraps can be kept in a sealed container until it is time to feed the worms.

Note: With the small bin, you will not be able to compost a lot of food. If your class is interested in participating in large scale vermicomposting, see the "Resources" section in this lesson.

E. Project the transparency "Sample Vermicomposting Data Sheet" and have students help you fill in the information.

F. Do #1 or #2 below. (It is recommended that #1 be used with younger students and #2 with older students.)

For younger students

1. Use the transparency to record information when additional food is added to the bin. The information can be transferred from the transparency to a copy of the sheet and kept by the worm bin.

For older students

2. Keep a class worm journal next to the bin. Students can copy the data in their own journals.

- In the class's worm journal, students could record how much food by weight the worms are getting, what type of food was fed, and into what area of the bin the food was placed. The weight of paper added to the bin could also be recorded.
- Practice writing in the class's worm journal as a class and in groups until all students know how to do it.
- Charts can be developed to be included in the class's worm journal, or the "Monthly Vermicomposting Data Sheet" can be used on which to record data.

Note: Directions for harvesting compost from the worm bin are described in Lesson 5 in this unit.

DISCUSSION/QUESTIONS

A. Why is vermicomposting a good idea? *Through vermicomposting, paper and food waste are recycled; therefore, less garbage ends up in our landfills. The compost helps to improve the soil.*

For younger students

B. What are the main ingredients of a vermicomposting system? *A vermicomposting system's components include the following:*

1. *A place where the worms live—the box*
2. *Living things—red worms and bacteria and fungi*
3. *Food*
4. *Moisture*
5. *Air*
6. *Preparing, maintaining, and harvesting the bin: preparing the bedding, adding worms, burying garbage, separating worms and castings, using castings*

APPLICATION

A. Have students look at the questions they listed in "Pre-Activity Questions" about what they wanted to find out about worms. Are there any questions that they now can answer and place on the list, "What do we know about worms?" List students' responses.

B. Do #1 below with younger students and #2 with older students.

For younger students

1. Have groups of students make a collage of "worm food" cut out of magazines and newspapers.

For older students

2. Ask students to add to the list of questions they began in the "Pre-Activity Questions" about red worms and about vermicomposting. Have each student or group of students select a question that they would be willing to research in

books, on the computer, through videos, and through personal observations. (A question can also be selected to be researched by the whole class, and answers can be compiled and compared.)

- Show them the book *Squirmy Wormy Composters* by Bobbie Kalman and Janine Schaub. Encourage students to look through the book and to come up with additional questions about red worms and vermicomposting.
- Keep the list of questions posted in the classroom, and encourage students to post and report facts to the class when they learn new information. Consider having students print the fact they learned on a strip of paper (e.g., 4 inches wide by 6 inches long), and have them tape it under the question they think it relates to.
- Examples of questions that students can research are listed below:
  - How much food did our worms eat in one week or one month? (Students weigh the food as it is added and observe its decomposition.)
  - What foods decomposed faster than others? (Students keep track of the amount of a specific food and compare it to another type of food.)
  - How often should water be added? (Students keep track of how much water they added when they first set up the bin. They record how much water they needed to add through a specific period of time.) Note that with some bins no additional water will be needed, whereas with other bins (especially in dry climates), adding water will be necessary.
  - Where do worms tend to congregate? Do they seem to prefer certain foods to others? (Students survey the bin.)
  - Do smaller pieces of food waste tend to break down faster than larger ones? (Students set up experiments to find out the answer.)
- Ask students whether there are any ideas stated in the "What Do We Know About Worms" (listed on butcher paper at the beginning of this lesson) which need to be changed or deleted because of what they have discovered.

Homework Assignment: Ask students to do a waste audit at home and measure how much food waste the family produces in one day:

Option 1: Students list the type of food that is being thrown away.

Option 2: Students gather food waste in a plastic bag and weigh it on a bathroom scale.

Note: For younger students, ask students to share with their parents what they have learned about vermicomposting. Then they can talk about what their family does with food wastes. Parents could record this or sign a form that indicates that the student did the assignment.

(Use school's letterhead.)

Dear Parent or Guardian,

Please read the following information with your child:

We are studying how red worms can be used to turn food waste into compost. We are calculating how much food waste the students in our class could compost using worms. Would you please help your child do one of the following:

• Option 1: Help your child record the type of food scraps being thrown away and have your child bring this list to school.

• Option 2: Place the food scraps in a plastic bag and use a bathroom scale to weigh them. Please write the weight of the food on a piece of paper and have your child bring the information to school.

Thank you,

C. On the chalkboard write the types of food and the weights that students discovered concerning home food waste. Conduct a discussion on how much trash can be kept from going to a landfill if everyone had a vermicomposting bin at home. A graph could be designed for the data collected.

EXTENSIONS

A. Obtain a copy of the poem "Sarah Cynthia Sylvia Stout" by Shel Silverstein. (See "Resources" in this lesson.)

- Have students identify which garbage items described in the poem are acceptable to put in worm composting bins and which items are not.
- Discuss with students what Sarah should have done with her garbage at the very beginning. *She should have had a vermicomposting bin for garbage that can be fed to red worms and throw the rest of the garbage into a garbage can to be taken to a landfill.*

B. Have students compare a red worm to a night crawler**.**

C. Have students participate in a science fair by conducting humane projects on red worms.

RESOURCES

Video

Wormania! Available from The Let's Get Growing! Company, 1900 Commercial Way, Santa Cruz, CA 95065; 1-800-408-1868; FAX (408) 476-1427 (26 minutes).

Stars Mary Appelhof and songs by Billie B. Explains the natural history of the red worm. Shows a baby worm hatching; explains how worms move and describes how they reproduce. Although designed for students in upper-elementary grades, some parts would be very interesting to younger students.

Audiotapes

Dirt Made My Lunch. Recorded by the Banana Slug Band; includes the song "Decomposition" by Steve Van Zandt. Music for Little People, 1989.

A tape and booklet with the words to this and other songs.

Nature Nuts. Recorded by Mary Miche, 2600 Hillegass Ave., Berkeley, CA 94704; (510) 845-8417.

Includes a song "Recycle Blues" that includes lyrics on composting.

Books

Appelhof, Mary. Illustrated by Mary Frances Fenton. *Worms Eat My Garbage.* Kalamazoo, Mich.: Flower Press, 1997.

Describes how to set up and maintain a composting system in which worms recycle food waste and produce fertilizer that can be used for house plants and garden areas.

Kalman, Bobbie, and Janine Schaub. *Squirmy Wormy Composters.* New York: Crabtree Publishing Company, 1992.

Describes red worms and how to set up a vermicomposting bin. Contains ideas for activities for students to learn more about red worms.

Ross, Michael Elsohn. *Wormology*. Photographs by Brian Grogan and illustrations by Darren Erickson. Minneapolis: Carolrhoda Books, Inc., 1996.

Contains information, colored photographs, and diagrams of earthworms. Describes activities that can be done with worms.

Silverstein, Shel. *Where the Sidewalk Ends*. New York: Harper and Row, 1974.

Contains a selection of poems, including "Sarah Cynthia Sylvia Stout."

Activity Guides

Appelhof, Mary, and others. *Worms Eat Our Garbage*: *Classroom Activities for a Better Environment*. Illustrated by Mary Frances Fenton and Nancy Kostecke. Kalamazoo, Mich.: Flower Press, 1993.

Contains activities for students to learn about red worms.

Composting Across the Curriculum. A Teacher's Guide to Composting. San Rafael, Calif.: Marin County Office of Waste Management, 1993.

Contains activities about composting and vermicomposting.

Do the Rot Thing. A Teacher's Guide to Compost Activities. San Leandro, Calif.: Alameda County Waste Management Authority and Source Reduction and Recycling Board, 1997.

Contains activities about composting and vermicomposting.

Eulo, Anthony. *Worms, Worms, and More Worms: A Guide to Vermicomposting*. Sacramento: California Integrated Waste Management Board, 1996.

Contains background information on how to set up a vermicomposting system and provides ideas for many activities that students could do concerning worms.

Grossman, Shelley C. and Melissa Weitzel. *Recycle with Earthworms: The Red Wiggler Connection.* Illustrated by Lisa Marie Donnabella. Eagle River, Wis.: Shields Publications, 1997.

Describes various types of worms, the anatomy of worms, and methods for composting with red worms.

Newsletter

Worm Digest. Edible City Resource Center, Box 544, Eugene, OR 97440.

A newsletter containing information about teachers using worms in the classroom, activities to learn about worms, workshops, and resources. Back issues are available.

Web sites

www.globalclassroom.org/worms.html

Information regarding a first-grade class that is vermicomposting. Included in this site are comments from the students regarding the activities.

www.interware.net/~levine/worms/

Primarily for classroom work with worm bins. Provides classroom instruction and materials.

www.wormdigest.org/

Worm Digest is a quarterly newsletter that reports about worms and worm composting (vermicomposting) on all levels worldwide. Its aim is to network people, information, and resources concerning the use of worms for organic waste conversion and soil enrichment.

www.wormwoman.com/frameindex.html

The "Worm Woman's" Web page provides an introduction to the methods of vermicom-posting, covering materials and the process.

www.ciwmb.ca.gov

The Web site for the California Integrated Waste Management Board and includes the most current list of worm suppliers.

Additional Web sites are listed in "Appendix F–VI."

Other Resources

Environmental Education Compendium for Integrated Waste Management and Used Oil. Sacramento: California Department of Education and California Integrated Waste Management Board, June, 1999. Copies are available through the California Integrated Waste Management Board.

Contains information about and evaluations of many curricula on waste management (including composting) and used oil.

A small plastic vermicomposting bin suitable to use indoors sits on top of the large wooden outdoor vermicomposting bin at Laytonville Elementary School.

Transparency

SAMPLE VERMICOMPOSTING DATA SHEET

Date bin was set up:

Number of worms (in pounds or actual number of worms):

Kind of bedding used and weight (or amount):

Harvest date(s):

Draw a picture of the worm bin and assign numbered plots to its surface so that you can track the decomposition of food placed in each numbered area.

Month _____

Date	Weight of food	Type of food	Buried in site #	Notes

WHAT TO PUT AND NOT PUT IN A WORM BIN

Put the following in a worm bin:

- Shredded paper products
- Fruit and vegetable trimmings


- Grains, beans, or breads (without butter, margarine, or mayonnaise)

- Egg shells
- Fallen leaves



- Tea bags
- Coffee grounds and filters

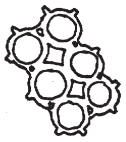
- Lawn clippings and young weeds

Do not place the following in a worm bin:

- Meat products
- Dairy products



- Rocks
- Plastics



- Glass
- Metal products (e.g., aluminum cans)

BACKGROUND INFORMATION FOR THE TEACHER

Vermicomposting is the process of using red worms and microorganisms (like bacteria and fungi) to change organic waste (e.g., food scraps and paper) into useful rich compost, full of nutrients that plants can use for growth. Vermicomposting can help to reduce household and school food waste that goes to a landfill. In 1995 food waste made up about 9 percent and paper made up about 31 percent, by weight, of the household garbage sent to landfills in California.[1]

In order to vermicompost in the classroom, students will need to prepare a bin to hold the red worms and provide bedding and appropriate organic materials to feed the worms. In addition students will need to monitor and control the environment in the worm bin so that it is conducive to worms and composting. This effective composting system can also be set up outdoors. For information on how to set up large-scale outdoor vermicomposting, see "Resources" at the end of the lesson.

Red worms *(eisenia foetida)*, also called manure worms or red wigglers, are the type of worm used in worm composting systems. Red worms naturally live in decaying leaf litter, compost piles, or manure just above the ground's surface. Animals and plants that die and begin decomposing provide food for the worms. In a worm bin, red worms readily consume food scraps and paper, and each red worm can eat half of its body weight every day.

Red worms are ideal for use in vermicomposting, because they can live within whatever space is available, tolerate a wide range of temperatures (especially the warm temperatures found within the average classroom and home), reproduce quickly, and mate throughout the year. (For information about reproduction of worms, see the "Background Information for the Teacher" in "Lesson 3, Cycles in Nature and Red Worm Development.") The population of red worms is limited in the worm bin by the amount of food available and by the amount of free bedding that has not been converted into castings (worm excrement).

Red worms can be purchased from worm suppliers. For the most current listing of worm suppliers, visit the California Integrated Waste Management Board's Web site at www.ciwmb.ca.gov or see "Appendix D."

Worms found in an outdoor compost pile would probably be suitable for indoor vermicom-posting, but there are definitely some worms found in the ground which are not suitable. For example, night crawlers, or *lumbricus terrestris*, are not recommended for the worm bin, because they need large amounts of soil and cannot survive in soil with temperatures above 50° F.

Other organisms (living things) in the vermicomposting bin include bacteria, which break down most organic matter, and fungi, which break down the tougher materials, such as cellulose (found in materials like paper), that bacteria cannot break down.

Red worms have no eyes, but they do have sensory cells on their skin which detect light. They prefer darkness; therefore, keeping worms in a dark container (with a lid) is important.

The bin for red worms should be shallow (8 to 12 inches deep) because red worms tend to be surface feeders. Therefore, a shallow plastic storage container, with drainage holes works best as a worm bin.

The least expensive and easiest bedding to get for red worms is shredded newspaper. The white paper found in schools and offices can also be used for bedding. Avoid glossy advertisements and magazines.

Worms breathe by absorbing oxygen through the wet surfaces of their bodies. Their bodies must be moist in order for the exchange of air to take place. Therefore, the newspaper (or other paper) must be moistened to keep the red worms' habitat in the bin damp. The bedding should be at least six inches deep after moistening. Since paper can be fluffed up, oxygen is provided for the worms. Oxygen is necessary not only for the worms but also for the microorganisms that are breaking down the food waste.

Make certain that the contents of the bin do not get soggy. If their environment is too wet, the red worms become uncomfortable because of the rise in acidity levels. Holes on the bottom of the bin will allow excess water to drain out. This

[1] "Estimated Average 1995 Residential Disposed Waste Stream Composition." California Integrated Waste Management Board.

water, called "compost tea," can be collected and used as a natural concentrated fertilizer for plants.

Worms have gizzards and need a small amount of gritty material to help grind up the food waste. Therefore, several cups of soil should be added to the bin. Before adding the soil, check to make sure that the area that the soil came from was not recently treated with pesticides. An even better source of grit is rock dust, which is ground up rocks. Many nurseries and garden stores sell bags of rock dust. It is rich in minerals and will help balance the acidity of the bin.

Two thousand worms weighing approximately 2.2 pounds (one kilogram) can be fed about 1.1 pounds of food waste each day. Any plant food waste can be put into the bin. Avoid placing animal products in the bin. Meat and cheese attract mice, rats, and other pests and may create an unpleasant odor as they decompose.

It is possible to overload the system by adding too much food waste. Plan to have students keep track of the weight and placement of food buried and check how rapidly the worms are processing the food scraps and paper.

Note: For additional information about maintaining the bin, see "Maintaining a Vermicomposting System" in "Appendix D–II."

Safety Note: If vermicomposting is used at a student's home and cats are present, make certain that students and parents know that cats should not be allowed to use the vermicom-posting bin as a litter box. Cat feces can contain a disease-causing organism called *toxoplasma gondii,* which is harmful to humans, especially pregnant women. Damage to the brain of the fetus can result from contact with this organism.

This sign is posted above each outdoor vermicomposting bin at Cesar Chavez Elementary School, San Francisco Unified School District.

LESSON 2: Getting to Know Red Worms

LESSON'S CONCEPT

Red worms, like all other living things, "take in nutrients, give off wastes, grow, reproduce, and respond to stimuli from their environments." (*Science Framework*, page 116)

PURPOSE

Students learn about red worms through observations and humane experiments.

OVERVIEW

In this lesson students will:

- List the ways to humanely observe and handle a red worm, and using the list, they write a song or sing a song that is already written.
- Observe a red worm by using a magnifying lens and record their observations.
- Conduct humane experiments to determine whether red worms prefer light or dark.
- Practice measuring on gummy worms and then measure live red worms, chart these measurements, and develop a graph to compare the length of 20 red worms.
- Draw pictures or write stories about red worms.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students observe, compare, and properly handle red worms. They graph the various sizes of 20 worms.
  - "Different types of plants and animals inhabit the Earth. As a basis for understanding this concept, students know . . . how to identify major structures of common plants and animals." (*Science Content Standards, Grades K–12*; Kindergarten; Life Science, Standard 2c)
  - Students "should have opportunities, in the context of science, to interact with living things in ways that promote respect." (*Benchmarks for Science Literacy,* page 15)
  - "By the end of the second grade, students should know that there is variation among individuals of one kind within a population. Offspring are very much, but not exactly, like their parents and like one another." (*Benchmarks for Science Literacy,* page 107)
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students will . . . record observations and data with pictures, numbers, and/or written statements." (*Science Content Standards, Grades K–12*; Grade 1; Investigation and Experimentation, Standard 4b)
  - "Simple graphs can help to tell about observations." (*Benchmarks for Science Literacy,* page 211)
  - "Students will construct bar graphs to record data using appropriately labeled axes." (*Science Content Standards, Grades K–12*; Grade 2; Investigation and Experimentation, Standard 4e)
- Students use magnifiers to observe red worms and rulers to measure them.
  - "Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained by just observing things without their help." (*Benchmarks for Science Literacy,* page 10)
- Students draw a worm.
  - "Students create original artworks based on personal experiences or responses." *(Visual and Performing Arts Framework;* Visual Art: Creative Expression Component, Goal 4, page 101)
  - "Students will draw pictures that portray some features of the thing being described." (*Science Content Standards, Grades K–12*; Grade 1; Investigation and Experimentation, Standard 4a)

- "Adaptations in physical structure or behavior may improve an organism's chance for survival. As a basis for understanding this concept, students know plants and animals have structures that serve different functions in growth, survival, and reproduction." (*Science Content Standards, Grades K–12*; Grade 3; Life Sciences, Standard 3a)

- Students write about worms.
  - Students "select a focus when writing." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 8)
  - Students "write brief expository descriptions of a real object, person, place, or event, using sensory details." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 8)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, classifying, relating

TIME

30–45 minutes to prepare for the lesson;
60–90 minutes for two days to implement the lesson

VOCABULARY

red worm (Select one or two additional words from this lesson that students should know.)

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Make a copy of the "Worm Investigation Sheet" for each pair of students (page 130).

___ **3.** Make transparencies of "Handling Our Worms" (page 129); "Do Red Worms Prefer Light or Dark?" (page 132); and "A Red Worm" (page 131).

___ **4.** Make an outline of a large red worm out of butcher paper about 10–15 feet long.

MATERIALS

For "Pre-Activity Questions"

___ The transparency of "Handling Our Worms"

For "Part I, Observing a Worm"

___ Magnifying lens for each pair of students
___ A paper towel for each student
___ One worm for each student
___ Spray bottle with water (to keep the paper towels moist for the worms)
___ The "Worm Investigation Sheet" for each pair of students
___ The transparency of "A Red Worm"

For "Part II, Studying Whether Worms Prefer Light or Dark"

___ The transparency of "Do Red Worms Prefer Light or Dark?"
___ One worm for each group of students
___ A plate or lid to a shoe box for each group of students

For "Part III, Measuring Worms"

___ Gummy worms, one for each student
___ One ruler for each pair of students
___ Strip of paper, 1/2 inch wide and several inches long, for each student
___ Graph paper with 1/2-inch grid for each student
___ Colored markers
___ At least 20 red worms of various sizes

For "Application"

___ Outline of a large (10 to 15 feet long) worm on butcher paper
___ Colored markers

PRE-ACTIVITY QUESTIONS

A. Discuss with students how they can hold a worm in a way that will not injure it. Discuss the humane treatment of worms. This should include:

- Handling the worms very gently

- Avoiding dropping the worms
- Keeping the worms moist (Explain to students that worms "breathe" through their wet skin, and must be kept moist.)
- Keeping the worms away from bright lights (Later in the lesson you can explain that worms have sensory cells, which are concentrated on their skin at the front end of their bodies. These sensory cells detect light. Red worms prefer darkness and will usually avoid light.)

B. Have students help you develop a list of what they should do when studying a red worm outside the bin. This list could be used to develop a poem that students can recite or a song that students can sing; or students can sing "Handling Our Worms" (in this lesson).

PROCEDURE

Part I, Observing a Worm

***Note*:** You might first need to perform worm appreciation exercises for students who have aversions to worms. Many students find organisms like insects, snakes, and worms distasteful, disgusting, or frightening, so it might be helpful to take some time to explain the interconnec-tedness of living things and the important role that these species play. Worms, for example, play an important role in soil productivity by breaking down organic waste and converting it to rich compost that enriches soil for plant growth. (Additional information about this topic will be addressed in lessons 3 and 4.) Also, students should know that worms are very timid creatures and cannot bite (since they have no teeth) or hurt anyone in any way.

A. Distribute to each pair of students a magnifying lens and a piece of dampened paper towel. Allow students to use the magnifying lenses by looking at various objects, including the paper towel. Have them practice focusing by moving the magnifying lens and their eyes farther away from and closer to an object.

1. Remind students of the rules for handling red worms and provide each student with a worm. Ask students to look at a worm through the magnifying lens and without the magnifying lens. During their observations students might need to redampen their paper towels, which can be done with a spray bottle.

2. Ask students to complete the following statements and list their descriptions on the chalkboard:

- Using only my eyes, my worm looks like . . . *it's shiny, 2 centimeters long, spaghetti string, a pink sausage.*
- Using a magnifying lens, my worm looks like . . . *little lines, little spikes, reddish-brown, shiny, slippery, pointed head and tail.*
- Some words that describe my worm are . . . *muscular, band is thick, wiggly, soft, slow.*

- Using only my eyes, my worm looks like:
  - *reddish brown color*
  - *stretches*
  - *a rubber band*
  - *has sections*
- Using a magnifying lens, my worm looks like:
  - *looks bigger and longer*
  - *sticky*
- Some words that describe my worm are:
  - *squirmy*
  - *wet*
  - *reddish brown*
  - *stretchy*
  - *squishes in and out*
  - *pointy nose*

Submitted by Donna Flores's third-grade class, Nightingale Elementary School, Stockton Unified School District.

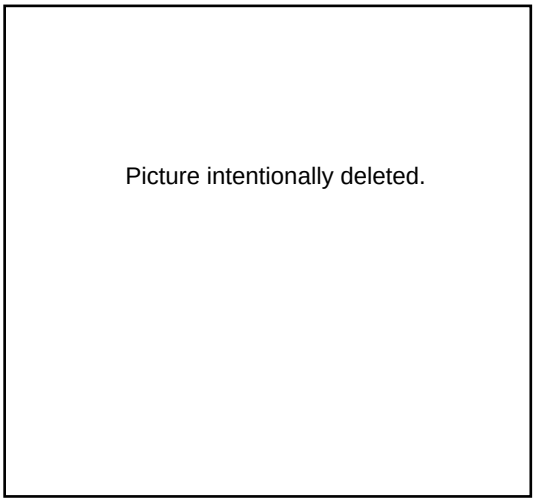
Some words that describe my worm are:

- *pretty (bonito)*
- *fat (gordo)*
- *slimy (resbaloso)*
- *with lines (con lineas)*
- *earth colored (color de tierra)*
- *red (rojo)*

Submitted by Mario Chang's second-grade class, Mission Education Center, San Francisco Unified School District.

B. Provide a copy of the "Worm Investigation Sheet" to each pair of students. For younger students, you might want to do this as a class.

- Ask students to observe the worms and to answer the questions on their sheets.
- Remind students to keep the paper towels damp, so the red worms are kept damp and can breathe.



Students in Gayle MacDonald-Gura's third-grade class at Lower Lake Elementary School observe red worms.

C. When students have finished drawing their red worms, ask them to gently place the worms back into the bin under some bedding.

Note: Some paper towels used in these observations of the red worms can be reused for "Part II" and "Part III." Then the paper towels can be shredded and placed into the worm bin for recycling.

D. Ask students to share their observations. Use the "Worm Investigation Sheet" as a guide for questions.

E. Ask students how they determine which end of a worm is the front. To find out which is the front end of the red worm, students should observe how a worm moves and which end leads the body. When a worm moves, the front (head) end usually goes first. Another distinguishing feature is the clitellum, the swelling or band which is usually lighter in color, that is nearer to the front end. Ask students to find the clitellum on their worms. For more information about the clitellum, see "Background Information for the Teacher" in Lesson 3.

F. Project the transparency of "A Red Worm." Ask students to compare their drawings to the one on the transparency. Have them identify each part of the worm (mouth, head, segments, band, tail), as you write these on the transparency.

Part II, Studying Whether Worms Prefer Light or Dark

A. Ask students how the class can determine whether worms prefer light or dark. Select those suggestions that are the most humane to the worm and help students design and set up the experiments and/or conduct the experiment described in step 2.

Note: If students will be conducting their own experiments to test the preferences of several worms, they should do so under your supervision.

1. Project the transparency "Do Red Worms Prefer Light or Dark?" and have students vote their predictions, as you write them on the chart. Discuss reasons for students' predictions. *Protection, moisture, food*.

2. One way to determine whether worms prefer light or dark is to use a plate or a lid to a shoe box that is partially covered. The bottom of the container should be lined with a wet paper towel.

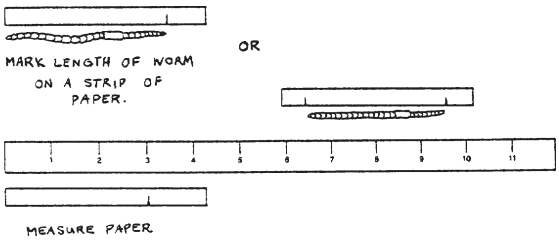
- Ask students to help you record the observations that they make. Perhaps each group can test one worm as the class members observe and record the data.
- The following can be done with several worms:
  - Place a worm in the middle between the light and the dark part on the plate (or a shoe box lid) and see where it goes. (This might take some time.)
  - Place a worm in the light section to see if it moves away from the light.
  - Place a worm in the dark and see if it moves into the light.

B. Discuss with students why red worms tend to prefer dark over light. Have students consider where the worms live naturally. (This instinct to avoid light may have evolved as a protection from the drying rays of sunlight.) How do the worms find their way around? *They have sensory cells which detect light*.

Part III, Measuring Worms

Note: Younger students may have difficulty measuring with rulers, but could compare longer and shorter worms.

A. Provide gummy worms and rulers and allow students to practice measuring. One way to do this is to provide a strip of paper about 1/2 inch wide and several inches long for each pair of students. Have students place a pencil mark on the paper strip to indicate the length of the worm. They can use a ruler to measure the length of the paper strip. The purpose of using the paper strip is that it might be difficult for young students to get an accurate reading on a ruler when a live red worm is moving, whereas a strip of paper can be quickly torn or marked to indicate the length of the worm. Then time can be spent accurately measuring the paper strip with the ruler.



Picture intentionally deleted.

A student in Lynda Mooney's first-grade class at Las Palmas Elementary School measures a gummy worm.

B. Once students have shown you that they know how to measure a worm, and can do so without injuring a live worm, provide a damp paper towel, a live red worm, and a strip of paper for each pair of students. Ask students to:

- Measure the worm when it is extended to its full length.
- Mark the paper strip to indicate the length of the worm.
- Use a ruler to measure the paper strip.
- Record the worm's length.

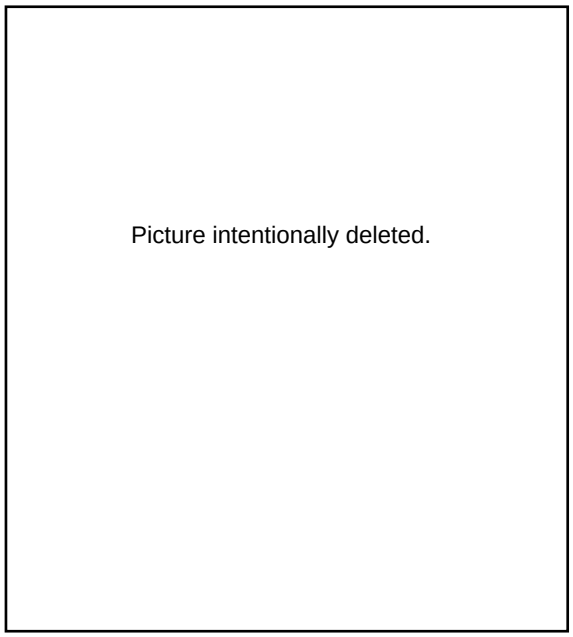
C. Check students' measurements (or have students check each other's measurements), and then have them return their worms to the worm bin. Give pairs who completed measuring one worm another worm to measure, until a class total of 20 worms have been measured.

D. Develop a chart with students to compare the measurements of at least 20 worms. Then have them record the lengths of their worms on the chart.

E. Provide students with graph paper with a 1/2-inch grid. Show students how to graph the results. This can be done by writing the

Picture intentionally deleted.

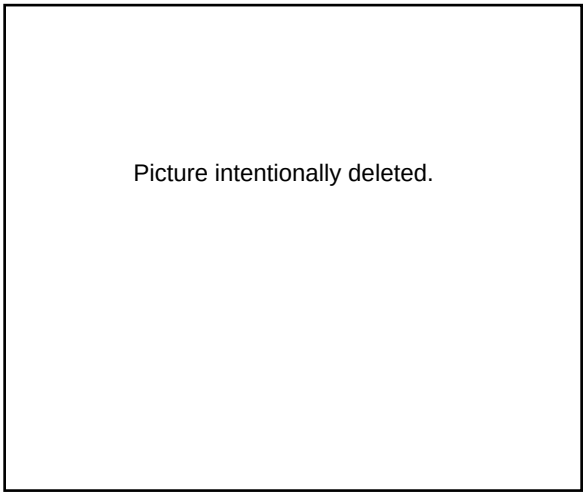
A student in Lynda Mooney's first-grade class at Las Palmas Elementary School measures a red worm.



Students in Mario Chang's second-grade class at Mission Education Center measure red worms and record their lengths.

number of worms on the bottom of the page (horizontally along the X axis) and labeling the length in inches or centimeters going up the page (vertically along the Y). Students can do a bar graph by using colored markers to color spaces for each worm's length.

Note: With younger students, do a simple bar graph on butcher paper as a class.



Students from Lynda Mooney's first-grade class at Las Palmas Elementary School make a graph to show the variations in length of some red worms.

F. Discuss with students:

- Who had the shortest worm? What was its length?
- Who had the longest worm? What was its length?
- How long were most worms?
- Why are the worms different in size? *Some are older; some eat more*.

DISCUSSION/QUESTIONS

A. Ask students, "What do we know about red worms?" *They do not like light; they range in size; they need to be kept damp*. Add students' responses to the chart they developed in Lesson 1. Encourage students to add to the chart throughout this unit.

B. Ask students, "What more do we want to know about red worms?" Add their responses to the list they began in Lesson 1. Encourage students to find the information that the class would like to know about red worms.

APPLICATION

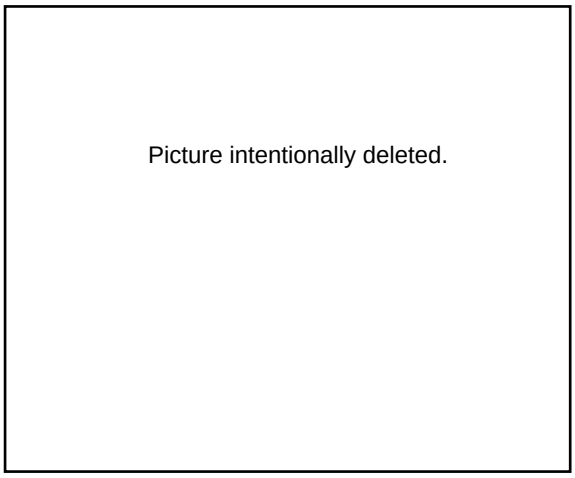
A. Have students make a large worm out of construction or butcher paper to hang in the classroom. Students should individually or in pairs color and label the parts of the large drawing of a red worm which you prepared in "Preparation" step "3."

B. Do the following on the carpet in the classroom or on a lawn area on the school grounds:

- Ask students to move individually as a worm (the act of moving the body can awaken creative thinking); move toward food; move away from light. Then form a giant worm with the class; each student can represent a segment of the worm's body. Allow students to use knees and elbows to simulate the worm's setae.
- Create phrases about movement and compile into a poem or song.

C. Discuss with students this lesson's concept: Red worms, like all other animals, "take in nutrients, give off wastes, grow, reproduce, and respond to stimuli from their environments."

- Ask them to explain what food red worms take in.
- Ask students what they think a worm's wastes might look like.
- Discuss how worms respond to stimuli



Two students from Gayle MacDonald-Gura's third-grade class at Lower Lake Elementary School move like a worm.

from their environment (e.g., they crawl from light to dark).

D. Have students select any one of the ideas listed below or come up with their own ideas for writing in their journals about red worms. If you have access to older students or adult volunteers, they can help the younger students by writing down what the younger students dictate.

1. Write a conversation between two worms in a worm bin. (Younger students might need help with this.)

2. Write a short story about "My Day as a Worm . . ." Students might begin, *When I woke up this morning, I realized that I was a red worm. I . . .*. They can answer any or all of the following questions:

- What do you do all day?
- Where do you go?
- What other animals are your friends?
- What do you eat?
- Why are you important?
- What funny things happen to you?
- In what kind of trouble do you find yourself?

Note: Younger students can illustrate and label the story.

3. Write several things that are true and several things that are false about red worms.

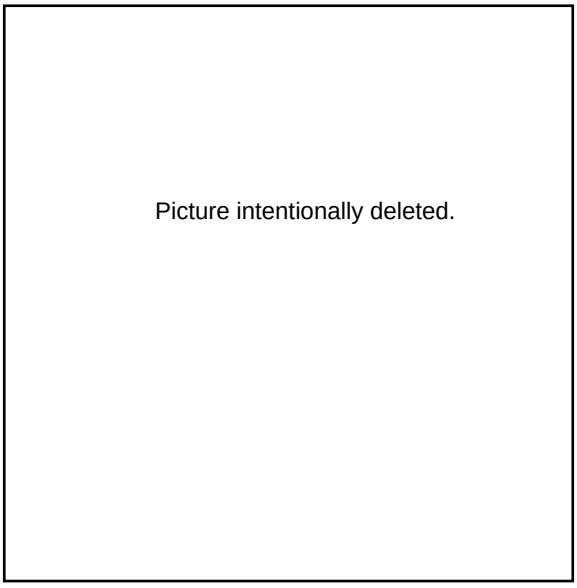
4. Write a poem entitled "I Like Worms" and include the types of worms you like (e.g., little worms, big worms, fast worms, slow worms) and worms that . . . (e.g., move, slither, eat food waste).

5. Complete the following chart:

What I thought I knew:
What I expected to learn:
What I learned:
Next time, I:

6. Have students complete the following:

- The first time I saw a worm, I . . . *did not want to hold it*.
- The first time I touched a worm, . . . *it was slimy, but drier than it looked*.



A student from Gayle MacDonald-Gura's third-grade class at Lower Lake Elementary School writes and illustrates a story about worms.

When I first saw the worms, I thought they were slimey. The first time I touched a worm it was Smooth.

Submitted by Lynda Mooney, first-grade teacher, Las Palmas Elementary School, National School District.

Project Idea: Compile a class booklet, complete with illustrations, about the first time students saw a red worm. The booklet could include the name of each student in the class, followed by a description written or dictated by the named student. (For example, "The first time Charles saw a worm . . ."; "the first time Marina touched a worm . . .")

Note: For the class booklet, older students could work with younger students by recording what the younger students say they observed.

Homework Assignment: Ask students to do one of the following:

- Design a home for a red worm. The home needs to meet all the conditions that a worm needs in order to survive.
- Write a friendship letter or poem to a worm.

E. Ask students to share their homework assignments.

RESOURCES

Video

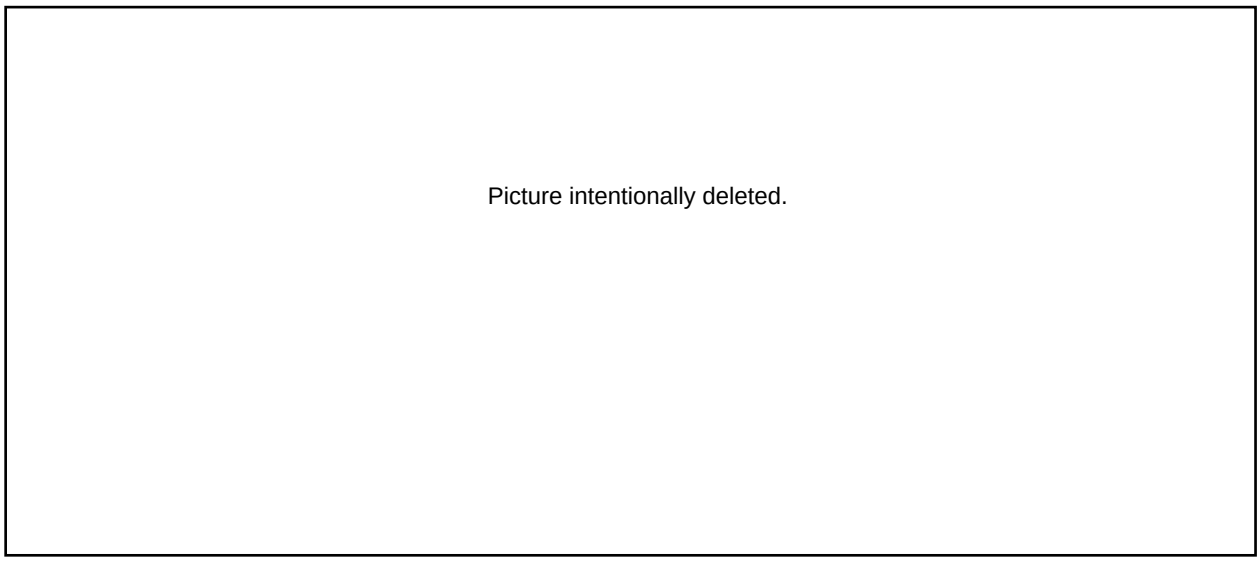
Wormania! Available from The Let's Get Growing! Company, 1900 Commercial Way, Santa Cruz, CA 95065; 1-800-408-1868; FAX (408) 476-1427 (26 minutes).

Stars Mary Appelhof and songs by Billie B. Explains the natural history of the red worm. Shows a baby worm hatching, explains how worms move, and describes how they reproduce. Although designed for students in upper elementary grades, some parts would be very interesting to younger students.

Book

Appelhof, Mary, and others. *Worms Eat Our Garbage*: *Classroom Activities for a Better Environment*. Kalamazoo, Mich.: Flower Press, 1993.

Contains student activities concerning red worms.



Students from Gayle MacDonald-Gura's third-grade class at Lower Lake Elementary School make a worm out of butcher paper.

HANDLING OUR WORMS

Lyrics by Olga Clymire
(Sung to the tune of "Round the Mulberry Bush")

This is the way we lift a worm, lift a worm, lift a worm.
This is the way we lift a worm, early in the morning.

We gently hold it in our palm, in our palm, in our palm.
We gently hold it in our palm, early in the morning.

We never let our red worm fall, red worm fall, red worm fall.
We never let our red worm fall, early in the morning.

We place it on a paper towel, paper towel, paper towel.
We place it on a paper towel, that's been dampened in the morning.

We measure each red worm carefully, carefully, carefully.
We measure each red worm carefully, early in the morning.

We don't leave them out too long, out too long, out too long.
We don't leave them out too long, early in the morning.

We put them back into the bin, into the bin, into the bin.
We put them back into the bin, early in the morning.

Names: _____ Date: _____

Student's Page

WORM INVESTIGATION SHEET

Place your worm on a damp paper towel where you can observe it. Make certain to keep the paper towel wet so that the red worm can breathe.

1. What color is the worm?

2. What shape is the worm? Use one word to describe it.

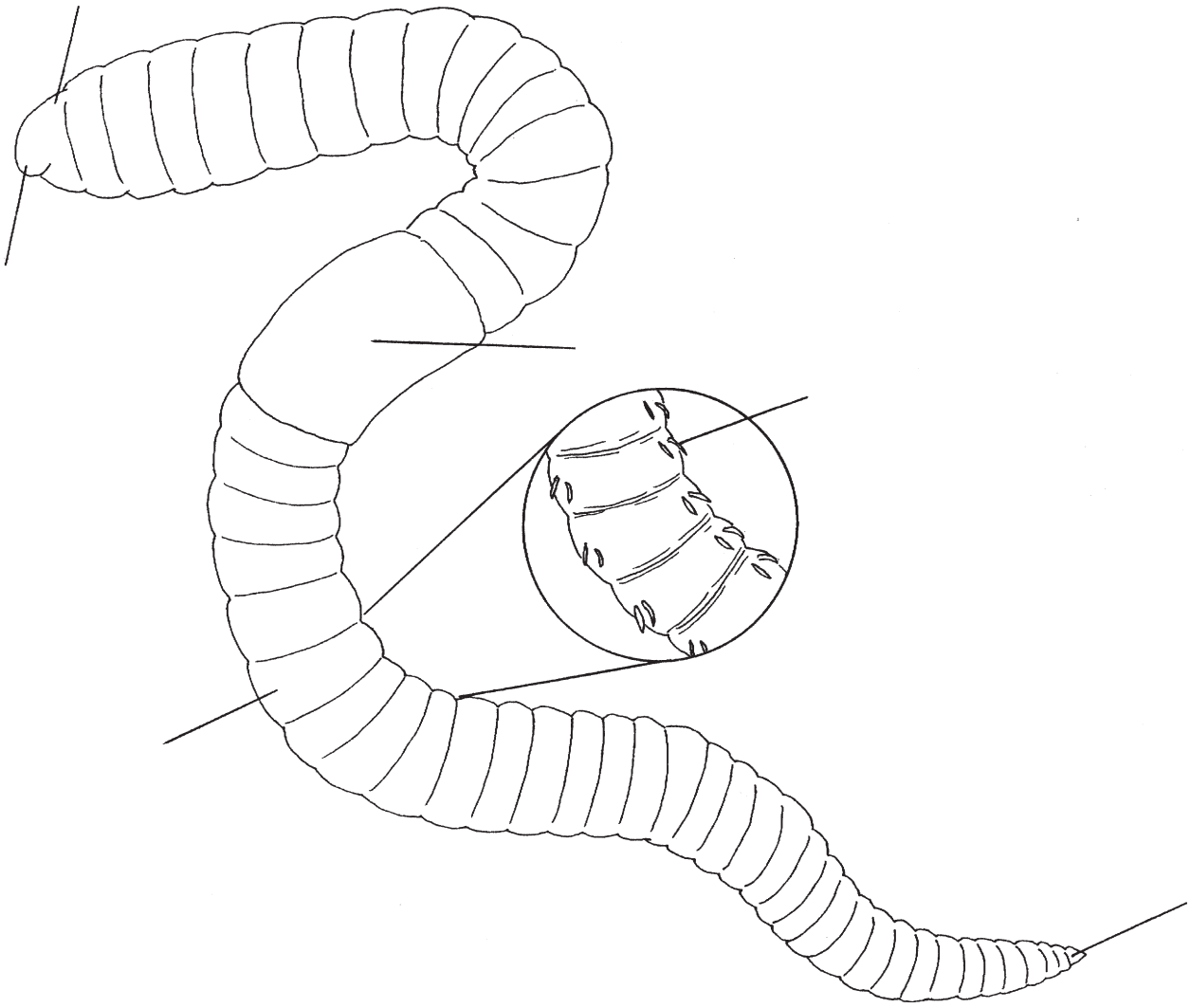
3. How does the worm's skin feel?

4. How can you tell which is the front end of a worm and which is the back end?

5. Draw the worm on the back of this sheet. Label the **head, tail, mouth, segments,** and **band**. Draw a line pointing to each part and write the name on it.

Transparency

A RED WORM



Transparency

DO RED WORMS PREFER LIGHT OR DARK?

Class predictions:

_____ Number of students predicting that the red worms will move away from light.

_____ Number of students predicting that the red worms will move toward light.

Worm	**Worm did not move.**	**Worm crawled to dark.**	**Worm crawled to light.**
Worm A			
Worm placed between dark and light			
Worm placed in light			
Worm placed in dark			
Worm B			
Worm placed between dark and light			
Worm placed in light			
Worm placed in dark			
Worm C			
Worm placed between dark and light			
Worm placed in light			
Worm placed in dark			
Worm D			
Worm placed between dark and light			
Worm placed in light			
Worm placed in dark			

BACKGROUND INFORMATION FOR THE TEACHER

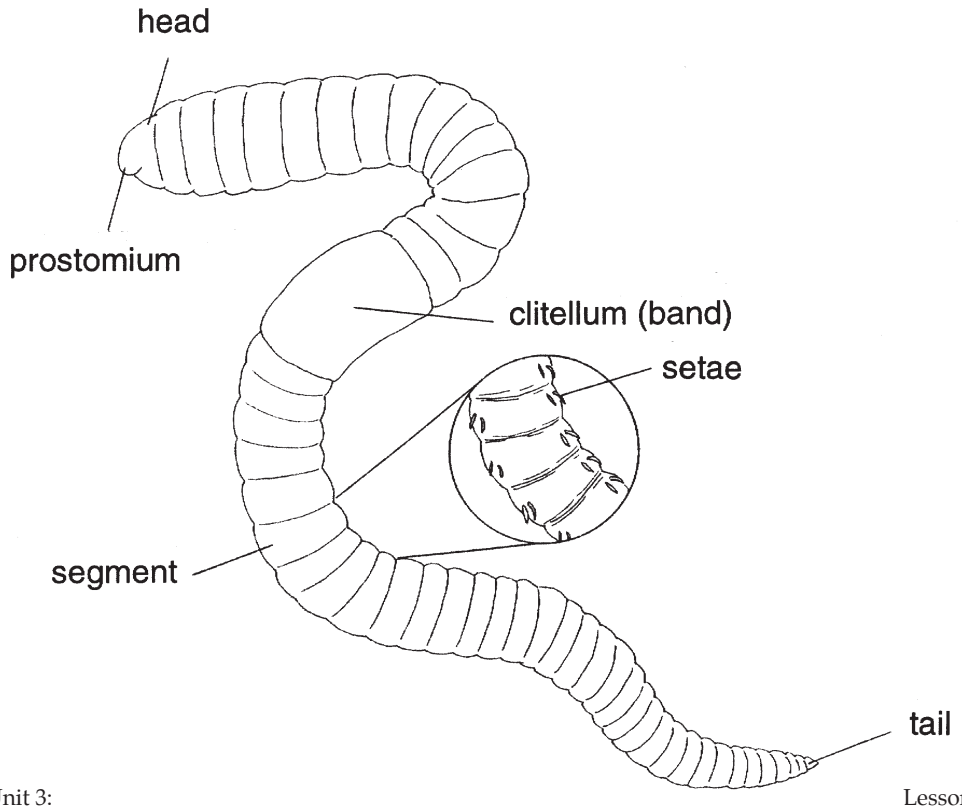
Red worms live naturally in decaying leaf litter, compost piles, or manure just above the ground's surface. Microorganisms such as bacteria and fungi aid worms, which do not have teeth, by breaking down pieces of food. Bacteria act as digesters, and fungi break down cellulose. Red worms also eat the bacteria and fungi.

A red worm's mouth has a small sensitive pad of flesh, called the prostomium, that protrudes above its mouth and stretches out to sense suitable food particles. Worms have a muscular gizzard, which functions similarly to that of birds. Small grains of sand and mineral particles lodge in this gizzard. Muscular contractions compress these hard materials against each other and the food, mix it with some fluid, and grind it into smaller particles. Undigested matter, such as soil, will pass through their lengthy intestines. The tiny, dark-colored masses the worms deposit are called worm castings. Other names for worm castings are worm manure or worm feces. Castings contain many nutrients which plants need to grow.

Red worms move by contracting and relaxing their muscles in waves, alternating between circular and long muscles. Contraction of the circular muscles forces the worm's body forward. Then the long muscles contract, drawing the tail end of the worm towards the skinny front end. When the long muscles contract, the circular muscles relax, causing the worm to become thick. To keep from sliding during movement, tiny bristles called setae act as brakes to hold part of the worm's body against the surface. The worm moves forward and backward in similar ways.

Even though red worms have no eyes, they do have sensory cells, concentrated on their skin at the front end of their bodies, which detect light. Red worms prefer darkness; when they sense light, they move away from it. However, they can be observed under a red light (used in photographic darkrooms or a flashlight covered with a red transparent plastic) without causing them to crawl away from the light.

Worms respire by absorbing oxygen through the wet surfaces of their bodies. Their bodies must be moist in order for the exchange of air to take place. A damp, but not soggy, environment is essential for the survival of red worms. Strips of damp newspaper fluffed up to allow oxygen to circulate make ideal bedding for red worms in a worm bin.



NOTES

LESSON 3: Cycles in Nature and Red Worm Development

Note: For this lesson, you will need the items you buried approximately one month ago in "Preparing the Decomposition Experiment" (page 106).

LESSON'S CONCEPTS

- "All organisms create waste through the use of natural resources, and that waste is cycled through natural systems." ("Conceptual Matrix for Waste Management")
- In the cycles that occur in nature, materials, such as nutrients, are recycled. Worms play an important role in recycling nutrients.

PURPOSE

Students will learn about the role of cycles in nature by observing the stages and results of decomposition.

OVERVIEW

In this lesson students will:

- Examine the stages of decomposition of the items they buried at the beginning of this unit.
- Design a game to model the water cycle and identify a water cycle in the worm bin.
- Illustrate the stages of growth of a red worm.
- Determine the role red worms play in the nutrient cycle.
- Make a mural of cycles in a well-functioning vermicomposting bin.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS

- Students identify the cycles they observe occurring in nature and in a well-functioning vermicomposting bin.
  - "Cycles, such as the water cycle and the nutrient cycle, are characteristics of environments that support life." (*Science Framework*, page 136)
  - "Plants and animals have predictable life cycles" (which students need to understand). (*Science Content Standards, Grades K–12*; Grade 2; Life Sciences, Standard 2)
  - "Each species has its own life cycle." (*Science Framework*, page 139)
  - "To develop historical literacy, students must . . . understand the meaning of time and chronology." (*History–Social Science Framework*, page 13)
- Students examine stages of decomposition and locate evidence of animal waste.
  - "All organisms create waste through the use of natural resources and that waste is cycled through natural systems." ("Conceptual Matrix for Waste Management")

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, ordering, relating

TIME

20–30 minutes to prepare for the lesson;
45–60 minutes for three or four days to implement the lesson

VOCABULARY

cycle, decompose, decomposers, life cycle, nutrient cycle, water cycle

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Locate an area on the school grounds or in the school's neighborhood where students can find organic items (from living things or things that used to be living), such as leaves and animal droppings (e.g., from dogs) that are rotting or decomposing.

MATERIALS

For "Pre-Activity Questions"

___ A potted plant

For "Part I, Examining Decomposition"

___ The pieces of trash buried in soil from "Preparing the Decomposition Experiment"

___ Rubber or plastic gloves for students to use when sorting the trash buried in soil

___ The piece of bread in the resealable plastic sandwich bag prepared in "Preparing the Decomposition Experiment"

For "Part II, Acting Out the Water Cycle"

___ Quart jar

___ Plastic wrap to go over the opening of the jar

___ Rubber band

___ Two or three tablespoons of water

For "Part III, Observing and Identifying the Stages in the Life Cycle of a Red Worm"

___ Paper plates (up to the number of students in your class)

___ A handful of contents from a worm bin for each pair of students

___ One magnifying lens for each pair of students

PRE-ACTIVITY QUESTIONS

A. Ask students to look at the potted plant and then discuss the following:

- What will we probably do with this plant when it dies? *Throw it into a garbage can; feed it to the red worms.*
- What would happen to this plant if it lived outside and died? *The street cleaners would pick it up; it'll just lie there; something might eat it.*
- What would happen to this plant if it grew and died in a forest? *Something might eat it; it might turn into soil.*
- What can help turn plant parts into soil? *Bugs and small things, red worms, bacteria and fungus.* (Students might not know the answer to this until the end of this lesson.)
- What would happen if everything that ever died (plants and animals) and all the parts of plants (e.g., leaves) and animals (e.g., droppings, feathers, fur) stayed where they were and did not decompose? *We would have a big mess.*

B. Ask students to think of a bicycle. What part of the bicycle is the "cycle"? *The round wheels.* Ask what students think a cycle is. *A cycle is something that goes round and round.* (A cycle is a series of changes that lead back to a starting point.) Ask students to think about the seasons: winter, spring, summer, fall, and back to winter. How is that a cycle? *The seasons repeat in sequence and go back to a starting point.*

C. Ask students to work in groups to develop their definitions of a cycle, and then have them share their definitions with the rest of the class. Post these definitions on a wall display about cycles.

PROCEDURE

Part I, Examining Decomposition

A. Tell students that in this lesson they will learn about the decomposition process.

B. Remind students of what they predicted and drew in "Preparing the Decomposition Experiment" concerning what will or will not decompose. Show them the butcher paper with their predictions and their illustrations.

C. Dump the contents of the container set up in "Preparing the Decomposition Experiment."

- Have students use gloves to locate the various pieces of trash that were buried.
- Ask students to describe what they see. Then ask:
  - Which items look as if they are decomposing?
  - Did any item totally decompose? If so, why do you think this happened?
  - Which items do not look as if they are decomposing? Why do you think this happened?

- Have the class design a chart that shows what decomposed, what started to decompose, and what did not decompose. Compare this chart to what students predicted in "Preparing the Decomposition Experiment."

D. Ask students to look at the bread in the bag and to describe what is happening.

- Lead students to conclude that tiny decomposers, such as bacteria and fungi, are eating the bread and breaking it down into its basic components, including nutrients.
- Ask what we can do with this bread. *It could be buried in soil and checked for decomposition in a couple of weeks; it could be fed to the worms.*

Safety Note: Students should not open the plastic bags if there is evidence of growing mold because high concentrations of spores may be present.

Note: See the 4–6 Module, Unit 3, Lesson 2, for activities on scavengers and decomposers.

E. Lead students on a walking field trip on the school grounds or in the school's neighborhood to observe items, such as leaves and animal droppings, that are rotting or decomposing. (Do not let students touch any animal's droppings.) On this walk students should look for materials that originated from living things.

F. Back in the classroom ask students to share what they have observed. How did they know that something was rotting (or decomposing)? *It looks like it's breaking down; it smells.* What will happen to an item once it has decomposed? *It becomes part of soil.*

G. Ask students to give an example from the walk of something that is part of a cycle.

Part II, Acting Out the Water Cycle

A. Discuss with students the parts of a water cycle:

- The rain falls down on the Earth.
- The water runs down into creeks and rivers, lakes, and into the ocean.
- Some rainwater seeps into the ground and ends up in groundwater.
- The sunlight evaporates the water into the sky where rain clouds form and rain (or snow) falls on the Earth.

B. Ask students how the water cycle is a "cycle"? *It is a series of changes that go back to the beginning and keep repeating over and over again.*

C. Demonstrate the water cycle by using a jar with a couple of tablespoons of water. Secure, with a rubber band, plastic wrap over the top of the jar and set the jar in a sunny place for about an hour or until some of the water evaporates. Water will condense on the plastic. Move the jar away from the sun, and have students observe the "rain" as the water in the jar cools.

D. Have the class help you come up with a game that can be played outside to show the parts of the water cycle and to show how water cycles from the sky to the ground.

E. Play the game with the class. Adjust the rules of the game, as needed, to make the cycle work.

F. Back in the classroom, have students look for evidence of a mini-water cycle working in the worm bin. Check the lid for condensation. See whether the water is "raining" inside the worm bin.

Part III, Observing and Identifying the Stages in the Life Cycle of a Red Worm

A. Provide a handful of contents (shredded newspaper, red worms, food, worm castings) from the vermicomposting bin and a magnifying lens for each pair of students. Ask them to locate the following:

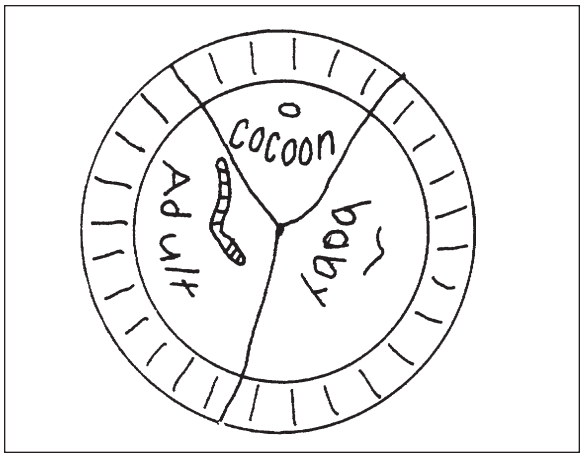
- A worm cocoon. It is the size of a grain of rice and shaped like a lemon. Over time, the cocoons change color from white to yellow to brown. Students might have difficulty locating worm cocoons, so if a student finds one, make sure that the whole class gets to see it. If your worm bin was set up recently, your students might not find any worm cocoons.
- Baby worms. They are whitish in color.
- Adult worms.

Note: If you have access to the Internet, visit www.wormwoman.com to see a baby worm hatch from its cocoon.

B. Ask students to work in pairs or groups of three to describe or show a red worm's life

cycle in one of the following ways (encourage students to use the book *Squirmy Wormy Composters* as a reference):

- Use a paper plate separated into three sections in which each stage of the life cycle (cocoon, baby red worm, adult red worm) is illustrated.
- Compose a poem about a red worm and its life cycle.
- Write a story about a red worm and its life cycle.
- Make a mobile by hanging an illustration of each part of the red worm's life cycle from a piece of cardboard.



Life cycle of a red worm drawn on a paper plate. Submitted by Ted Schut, first-grade teacher, Ripona Elementary School, Ripon Unified School District.

DISCUSSION/QUESTIONS

A. Ask students what is considered waste in nature. *Leaves, animal droppings.* Why are we not surrounded by nature's waste? *Decomposers, like bacteria and fungus, decompose waste. Red worms and other living things eat waste.*

- Ask whether all animals produce waste. If there were no decomposers, what would the world be like? *The world would be full of animal waste*.
- Tell students that scientists call animal waste scat, droppings, feces, and manure (manure usually describes waste from plant-eating animals). Ask students how scat is part of a cycle. Based on students' responses, explain that animals need to get rid of body wastes. When animals produce scat, they allow more room for new food in their bodies to provide them with nutrients to live. But scat contains nutrients, too. Many small animals (e.g., scarab beetles, sow bugs, red worms) and other living things, like fungus and bacteria, eat scat and manure. The scat decompose and become part of soil to provide nutrients to plants that in turn feed animals that produce more waste. This is why many farmers use manure from cows, horses, and sheep as fertilizer for their crops.

B. Tell students that plants also drop their waste on the ground. Ask them what this waste could be. *Leaves, branches, flowers.* Ask them to explain what happens to plants' parts (e.g., leaves, branches, flowers) when they fall off the plant. Lead students to the following answer: *The plants are decomposed by bacteria and fungi, and their nutrients become part of the soil again, providing nutrients to other plants, thereby continuing the cycle. The nutrients are also used by new plants growing in the area.*

APPLICATION

A. Ask students to identify the types of natural cycles that exist in a well-functioning vermicomposting bin. *Water cycle, nutrient cycle, oxygen cycle, life cycles.* Discuss:

- What do you need to monitor in the bin to make certain that all cycles are working? *Monitor for moisture (water cycle), food (nutrient cycle), worms (life cycles).*
- What is one way that you can make sure that there is an adequate supply of oxygen for the worms? *Keep the paper strips fluffed up so air can move around them. Make sure that the worm bin has air holes.*
- What will happen to the red worms if the cycles in the worm bin do not work? *The red worms will die, and there might not be any eggs in the bin to hatch to replace them.*

B. Make a mural of cycles in the vermicomposting bin or a mural of the vermicomposting cycle. This could be done as a class or in groups.

- Cycles in the vermicomposting bin would include the water cycle, nutrient cycle, oxygen cycle, and life cycle.
- The vermicomposting cycle would include building a bin, preparing the bedding, adding the worms, adding

the food waste, harvesting the castings, fertilizing the garden, growing vegetables, eating the vegetables, and feeding vegetable waste to the worms.

C. Have students discuss as a class one or two student volunteers' daily activity cycles. For example, wake up, get dressed, eat breakfast, go to school, eat lunch, play, do homework, eat dinner, brush teeth, go to bed, wake up . . ..

Homework Assignment: Ask students to describe their daily cycle. For example, I get up in the morning and wash my face and brush my teeth. Next, I have breakfast. Then I go to school . . ..

Note: For younger students describe someone's daily cycle together as a class.

D. Ask students:

- What are some examples of cycles in nature? *Water cycle, season, life cycle.*
- How does vermicomposting keep food wastes in a cycle instead of a one-way route to the landfill? (Help students come up with the italicized answers.) *It allows people to recycle food wastes; and once it is added to soil, it recycles nutrients. These nutrients can be used to grow plants we use for food.*

E. Have students review their definitions of cycles, which they developed in their groups at the beginning of this lesson, and encourage them to modify these if they think it is necessary. Ask the groups to share their present definition and to explain why they decided on the present version.

F. Ask students to write a sentence or two in their journals about what they have learned in this lesson. They can also draw pictures. Have them share their journal entries in small groups. Check each student's writing.

EXTENSIONS

A. Students can make certain that adequate oxygen is available to the red worms and other living things in the worm bin by keeping the paper fluffed up. They can regularly measure the thickness of the paper strips in the bin to determine when the paper is becoming compacted (thus, the amount of oxygen would be reduced).

B. Illustrate a life cycle of a pumpkin.

C. Learn and sing with the class the songs "Decomposition" and the "Water Cycle Boogie" by the Banana Slug String Band.

RESOURCES

Videos

Cycles in Nature. BFA Educational Media, 1980 (9 minutes).

Describes a variety of cycles.

Waste. Take a Look series. Cary, N.C.: TV Ontario, 1986 (10 minutes).

Shows how things decay and the value of recycling.

Books

Allen, Marjorie N., and Shelly Rotner. *Changes*. New York: Simon & Schuster, 1991.

Colored photographs show and simple text describes various living things as they go through changes in their lives. For example, the life cycle of a butterfly and a tree throughout the seasons are shown.

Donahue, Mike. *The Grandpa Tree*. Boulder, Colo.: Roberts Rinehart, 1988.

Describes the life cycle of a tree and the animals that live in and around it. At the end when the grandpa tree falls, the animals make homes in it, and the "sawdust mixed with dirt becomes food for flowers."

Gomi, Taro. Translated by Amanda Mayer Stinchecum. *Everyone Poops.* Brooklyn, N.Y.: Kane/Miller Book Publishers, 1993.

In simple text and colored illustrations, the author describes various animals and their droppings.

Johnson, Hannah Lyons. *From Seed to Jack-O'-Lantern.* New York: Lothrop, Lee & Shepard, 1974.

Explains the life cycle of a pumpkin.

Kalman, Bobbie, and Janine Schaub. *Squirmy Wormy Composters.* New York: Crabtree Publishing Company, 1992.

Describes red worms and how to set up a vermicomposting bin. Contains ideas for activities for students to learn more about worms.

Tresselt, Alvin. *The Gift of the Tree.* Illustrated by Henri Sorensen. New York: Lothrop, Lee & Shepard Books, 1992.

Text and colored paintings describe the life, death, and decomposition of an oak tree.

Viorst, Judith. *The Tenth Good Thing About Barney.* Illustrated by Erik Blegvad. New York: Macmillan Publishing Company, 1975.

A child's cat Barney dies, and the child's father asks the child to identify ten good things about Barney. The tenth good thing is that Barney will enrich the soil in which plants will grow.

Audiotapes

Dirt Made My Lunch, recorded by the Banana Slug String Band, 1989.

This tape includes the song "Decomposition" by Steve Van Zandt.

Slugs at Sea, recorded by the Banana Slug String Band, 1989.

This tape includes the song "Water Cycle Boogie" by Steve Van Zandt.

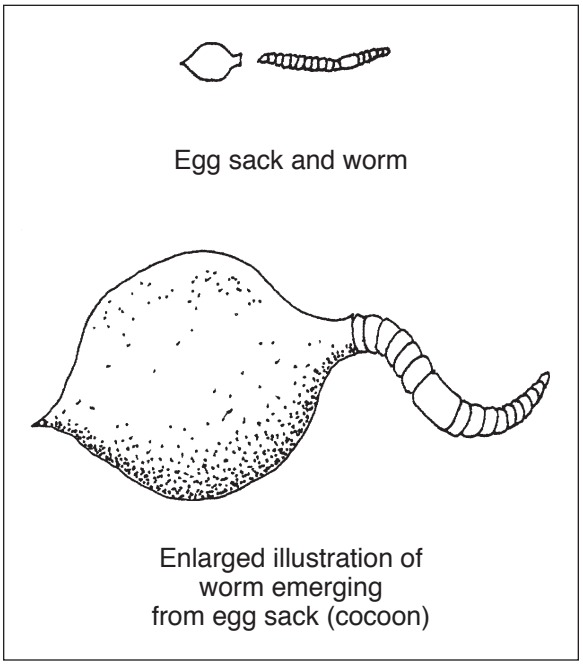
To order the above tapes, call the Banana Slug String Band at 1-888-327-5847.

Web site

www.wormwoman.com

Shows a baby worm hatching from its cocoon.

Additional Web sites are listed in the "Appendix F–VI, Vermicomposting Web sites."



BACKGROUND INFORMATION FOR THE TEACHER

A cycle consists of a series of changes that lead back to a starting point or involve a continuous sequence of occurrences that are repeated. Decomposition is part of a cycle in which nutrients are recycled from dead to living things. (A nutrient is any chemical element or compound that an organism must take in order to live, grow, or reproduce.) A water cycle is the movement of water on Earth through living and nonliving things. The life cycle of a red worm begins with an egg, continues with the hatching of the egg, the growth of the red worm into a mature adult, and eventually the production and fertilization of eggs by mating adults. When the worm dies, its body decomposes and enriches the soil.

When any plant or animal dies, decomposers start to use the dead material as food. Decomposers include microscopic living things, like bacteria and fungi (e.g., yeast, mold, mildew). Most of these cannot be seen with the naked eye. Decomposers break down large chemicals into smaller and simpler materials, such as nutrients and minerals. This process is called decay, rot, or decomposition. These simpler materials, which are essential for life, can now be used by living plants to grow.

All previously living things decompose. Animals and plants contain nutrients (chemical compounds) and when they die, decomposers can release these nutrients into the soil where they may be held in solution by water. Plant root hairs absorb this moisture full of nutrients, which eventually spread into the stems and leaves of plants and are used by the plant to live and grow.

But organisms do not have to die to be part of the nutrient cycle. Waste excreted by animals is also high in nutrients. Decomposers release these nutrients into the soil. Plant parts (e.g., leaves, branches, and flowers) dropped on the ground by plants contribute to organic material for decomposers to process. For example, when a plant grows in the spring, its roots take in nutrients from the soil. In the fall of the year, leaves from the plant fall to the ground, and as they decompose, the nutrients which were in the leaves are returned to the soil by decomposers. Then the tree uses these nutrients to live and grow.

If nothing decomposed, the soil would not get back the nutrients that plants use to grow. Without nutrients plants could not live, and the animals that depend on the plants for food would not survive.

Natural cycles can completely convert organic waste into nutrients for living things. Humans are the only known species to produce things (e.g., plastics) that cannot be reabsorbed by natural cycles.

The water cycle consists of a continuous sequence of precipitation (rain or snow): evaporation of water from land and from rivers, lakes, and oceans; condensation of water vapor in the sky to form clouds; and back to precipitation on the land and bodies of water. A mini-water cycle can be observed in the worm bin, especially if some water is condensing on the lid and dropping on the paper strips.

Red worms, like all other living things, have a life cycle. Red worms hatch from eggs, and when grown to maturity, produce eggs, which start the cycle again. Each red worm is both male and female. A swollen section or band, called a clitellum, on a red worm's body contains eggs and sperm. A mucous produced by the clitellum allows sperm from one worm to pass to another worm. After two worms mate, each develops a cocoon on its clitellum. As the cocoon comes off the worm, it picks up both the eggs from its body and the sperm (stored in special sac-like openings in the worm's skin) which it received from its mate. The cocoon then slides off the worm's body. The cocoon seals itself and fertilization takes place inside it.

A red worm's cocoon is the size of a grain of rice and shaped like a lemon. Over time, the cocoons change color from white to yellow to brown. One to several baby worms emerge from the cocoon after three weeks. Each is approximately one-half to one inch long. It takes red worms from four to six weeks to mature enough from hatching to start reproducing.

NOTES

LESSON 4: The Effects Worms Have on Soil

LESSON'S CONCEPTS

- Red worms turn food waste into compost that can be used to improve soil.
- People and other living things depend on soil.

PURPOSE

Students will learn how red worms improve soil and how people depend on the soil enriched by the worms.

OVERVIEW

In this lesson students will:

- Observe, touch, and describe soil.
- Examine and describe worm castings and compare them to soil.
- Discuss the effect worms have on soil and how their actions may benefit other organisms.
- Sing a song about the importance of worms and soil to people.
- Design collages showing ways people use soil.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS

- Students work together as they observe soil and worms and make collages depicting people's use of and dependency on soil.
  - "Earth is made of materials that have distinct properties and provide resources for human activities. As a basis for understanding this concept, students know . . . rock, water, plants, and soil provide many resources, including food, fuel, and building materials that humans use." (*Science Content Standards, Grades K–12*; Grade 2; Earth Sciences, Standard 3e)
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students will . . . observe common objects using the five senses." (*Science Content Standards, Grades K–12*; Kindergarten; Investigation and Experimentation, Standard 4a)
  - "To participate effectively in society, students need to . . . develop group interaction skills." (*History–Social Science Framework*, page 24)
  - "To develop geographic literacy, students must . . . understand human and environmental interaction." *(History–Social Science Framework*, page 16)
- Students describe in their journals why soil is important. They also describe how soil helped to supply one of their meals.
  - Students "select a focus when writing." *(English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 8)
  - Students "use descriptive words when writing." *(English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 8)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, relating

TIME

30–45 minutes to prepare for the lesson; 60–90 minutes to implement the lesson

VOCABULARY

worm castings, soil

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Collect worm castings from the worm bin. (If the worm bin has been operating for a couple of weeks, you should have at least a cup of worm castings.) Another place to get worm castings is from a worm supplier (see list in Lesson 1).

___ **3.** Write the words to "Soil Is Good" (page 147) on the chalkboard or piece of butcher paper.

MATERIALS

For "Pre-Activity Questions"

___ 2 cups of garden soil
___ 2 pieces of sandstone or dirt clods
___ 1-quart transparent plastic container with lid and enough water to fill it half full

For "Part I, Examining Worm Castings"

___ A cup of worm castings from the worm bin (or from a worm supplier)
___ Magnifying lenses

For "Part II, Identifying Ways People Use Soil"

___ The transparency "Soil Is Good"
___ Assorted magazines for students to locate pictures showing ways people use soil
___ One sheet of construction or butcher paper for each group for the collages
___ Nontoxic glue
___ Scissors

For "Application"

___ A resealable plastic sandwich bag for each group

PRE-ACTIVITY QUESTIONS

A. Ask students to describe soil, as you write their responses on the chalkboard or on a piece of butcher paper.

B. The following activity can be done outdoors or indoors. If going outdoors, bring the two cups of garden soil. Ask students to stand or sit in a circle.

- Tell students that you will be giving some students handfuls of garden soil and that they should pass the soil to the persons on their left until all soil samples have been passed all the way around the circle. If you are worried about students spilling the soil, place the soil in several small containers for them to pass around.
- Give several students handfuls of soil or containers of soil.
- As they are passing the soil around, ask students to feel the soil and to say words that describe this soil.
- After all students have passed around the soil, if it is not already in a container, gather the soil in a container.
- If outdoors, go back to the classroom and have students add to the list which describes soil. They should describe the soil they passed around.

Note: The reason that several handfuls of soil were passed around is that students might become more observant as they see several soil samples and hear other students describe them.

C. Ask students what is in soil. *Dirt, pieces of plants, small rocks, water.* Write down students' responses under the heading "What Is in Soil?" on the chalkboard or a piece of butcher paper and save for later in the lesson. Discuss how students think soil is made. (Students might not know the answer at this time.)

- Tell students that they will simulate how water begins to make soil.
- Show two pieces of sandstone (or dirt clods). Place one in a plastic container of water and ask ten students to shake it ten times.
- Have students notice the particles of rock that are on the bottom of the container. Explain that particles of rock are in soil.
- Discuss some ways that rocks break down into smaller particles (e.g., wind, rain, sunlight, ice). Have students use the other piece of sandstone or dirt clod to demonstrate another way that rock breaks down into particles of soil.
- Can there be parts of plants and animals in soil? *Yes.* Ask students to explain. *When parts of plants or animals fall to the ground, they become part of soil. When plants and animals die, parts of them become soil.*

PROCEDURE

Part I, Examining Worm Castings

A. This activity can be done outdoors or indoors. Ask students to stand or sit in a circle. Bring a cup of worm castings (but do not tell students what they are).

- Tell students that you will be giving them a mystery soil. They should keep passing the mystery soil to the person on their left until all students have had a chance to inspect it. If you are worried about students spilling the mystery soil, especially if they guess what it is, leave it in the container for them to feel as they pass it around.
- Give a student a handful or a container of mystery soil.
- Ask the student to feel the mystery soil and then to pass it to the student on his or her left.
- As students are passing the mystery soil around, ask them to say words that describe this mystery soil.
- After all students have passed around the handful of mystery soil, if it is not already in a container, place the mystery soil back in a container.
- If outdoors, go back to the classroom and compile, on the chalkboard, a list of words that describe the mystery soil.

B. Ask students how they think their mystery soil is similar to the garden soil they examined during the "Pre-Activity Questions" part of this lesson. *The soil is dark, crumbly.* Ask students how it is different. *It seems fluffier and darker in color.*

C. Ask students to describe how they think this mystery soil was formed. Students' answers should relate to what they discussed about where soil comes from in the discussion in "Pre-Activity Questions."

D. Have students guess where this mystery soil came from. Record students' responses. *The garden, from someone's yard.* Reveal to students, if they have not already guessed, the source of the mystery soil, which was their worm bin.

E. Discuss with students how the worm castings were formed. Have students examine the worm bin's contents as you discuss this. *The worms ate the paper and food waste and produced worm castings*. You might want to have students revisit their thoughts on where their mystery soil came from and their comparisons to garden soil.

F. Provide magnifying lenses for students to observe worm castings.

Note: Make certain that the children wash their hands after handling the worm castings.

Part II, Identifying Ways People Use Soil

A. Have students sing "Soil Is Good" sung to the tune of "Doe, a Deer."

B. Brainstorm what things people get from soil. *Food, building materials for homes, water from wells, materials for clothes.*

C. Provide each group with several magazines. Allow approximately ten minutes for students to locate pictures of people using soil or of things that people need that they get from soil. Each student should cut out three or four pictures.

Optional
After groups have acquired pictures, ask students to categorize these items according to the different ways people use them. Have students explain these categories orally as you circulate among the groups. *Growing food, making clothing.*

D. Ask students to make a collage out of the different ways that people use soil or items that come from soil. Provide a large piece of construction paper or butcher paper for group collages, scissors, and white nontoxic glue.

E. Encourage groups to share their collages with the class.

DISCUSSION/QUESTIONS

A. Discuss with students:

- Based upon what you have learned about the worms in the worm bin, how do you think worms might help the soil? *They make castings.* Remind students what they learned about nutrients in Lesson 3. When worms

Students in Lynda Mooney's first-grade class at Las Palmas Elementary School make a collage of ways people use soil.

deposit castings in the soil, the castings become nutrients in the soil. Plants use these nutrients to live and grow. Worm castings are excellent soil enrichers.

- Why is soil important to living things? *It provides them with food and shelter; plants grow in soil; animals walk on soil.*
- How do people use soil? *To grow fruits and vegetables, to build on, to walk on, to live on.*
- How does soil provide you with lunch? *Farmers grow food in soil, and I eat the food.*
- What would the world be like if all soil was like the sand from the beach? *Many plants could not grow. Not all animals could live in the sand. It would be hard to build on.*
- How do worms help improve the soil for people? *Worms add nutrients to the soil so people can grow food.*

B. Ask students to review their responses at the beginning of the lesson about their descriptions of soil and "What Is in Soil?" Ask whether they think that everything on these lists is correct. If not, what would they change? What should be added? Ask students to explain their answers.

C. Ask students to describe in their journals why soil is important. Encourage them to use descriptive words in the paragraphs that they write.

APPLICATION

Homework Assignment: Assign students to draw or write how soil helped to supply one of their meals (e.g., milk and pancakes—milk, cow, grass, soil; pancakes, wheat, soil; and syrup, maple tree, soil).

A. Ask students to share their homework assignment by drawing on the chalkboard the steps from soil to one of their meals. Have students describe their drawings.

B. Have students work in groups, and have each group find something to put into a resealable plastic sandwich bag that represents how soil is used by people or other living things. This could be a piece of wood or paper (to represent that trees grow in soil and that people use wood or paper), an apple core (food), an illustration like a

(Use the school's letterhead.)

Dear Parent or Guardian,

Please read the following information with your child:

As part of our vermicomposting unit, we are learning about the importance of soil and have discussed how our food comes from soil. Please assist your child in selecting a meal and then have your child illustrate with drawings and labels the role of soil in producing that meal. For example, if your child picked breakfast and had milk and pancakes, he or she would probably draw and label the following:

- Milk, cow, grass, soil
- Pancakes, wheat, soil
- Syrup, maple tree, soil

Thank you,

house (people build houses on soil or make parts of houses from materials found in soil), or a burrow (animals use soil for shelter). Then have groups switch their bags with another group and have each group describe what is in the bag they received and what the connection of the item in the bag is to soil.

C. Ask students to write a sentence or two in their journals about what they have learned in this lesson. They can also draw a picture. Have them share their journal entries in small groups. Check each student's writing.

Project Idea: Have students plant flowers in planters on the school grounds or develop a school garden.

EXTENSIONS

A. For an in-depth study of soil, implement Unit 2, "Protecting Soil," from *A Child's Place in the Environment* series.

B. Sing "Dirt Made My Lunch" by the Banana Slug String Band (see "Resources, Audiotape").

RESOURCES

Video

Soil and Decomposition. New York: BFA Educational Media, 1986 (16 minutes).

Shows how plant fertilizer is made by nature and how it is manufactured by people. Time-lapse photography shows the decomposition process of dead leaves changing to fertilizer.

Books

Bourgeois-Addison, Paulette. *The Amazing Dirt Book*. Illustrated by Craig Terlson. Reading, Mass.: Addison–Wesley Publishing Company, 1990.

Contains activities to do with dirt.

Burke-Weiner, Kimberly. *The Maybe Garden*. Hillsboro, Ore.: Beyond Words Publishing Co., 1992.

A woman with a beautiful garden encourages her child to plant various plants. The child imagines things which could be done with each plant.

Curricular Guide

Clymire, Olga. *Protecting Soil*. Unit 2 of A Child's Place in the Environment series. Sacramento: California Department of Education, 1997.

Contains 20 interdisciplinary lessons that focus on the importance of soil and culminates in a soil-enriching project. The lessons integrate science, history–social science, and English–language arts.

Audiotape

Dirt Made My Lunch, recorded by the Banana Slug String Band, includes the song "Dirt Made My Lunch" by Steve Van Zandt. Music for Little People, 1989.

A tape and booklet with the words to this and other environmentally-oriented songs.

SOIL IS GOOD

(Sung to the tune of "Doe, a Deer")

When you dig in the moist, brown earth,
You will find bugs, plants, and worms.
Soil is home for squirmy worms,
Ants and slugs and also germs.
Soil needs air to make life thrive,
So the underground world will stay alive.
We need soil to grow our food.
Soil is life;
It feeds us good! good! good! good!

Submitted by Gayle MacDonald-Gura's third-grade class, Lower Lake Elementary School, Konocti Unified School District.

In this lesson, students will be learning about soil and its importance to living things, including people.

Soil is made up of various sizes of rock (mineral) particles (e.g., sand, silt, clay), water, air, liv-

ing organisms, and parts of decomposing dead plants and animals. Soil provides a place for terrestrial (land) plants to live. The plants obtain water and nutrients from the soil and use it for anchoring their roots. Many animals also use soil. Some obtain nourishment from dead plant and animal matter; others feed on soil organisms. Some animals (e.g., ground squirrels and burrowing owls) might use soil as shelter from predators and extreme temperatures.

People use soil to grow plants for food (e.g., corn), fiber (e.g., cotton), and shelter (e.g., Douglas fir tree). People mine, from soil and rocks, a variety of minerals (e.g., iron, copper) for building and manufacturing products. People also build many things on top of soil, including homes, stores and other businesses, and roads.

Almost everything people eat comes either directly or indirectly from the soil. Most vegetables, fruits, and grains for bread and cereals are grown in soil. The animals some people eat, like chickens or cows, get their nutrition from plants that grow in the soil. Milk products come from cattle that feed on grass grown in soil.

People depend on healthy soil. An effective method for improving soil is by adding compost or vermicompost, both of which are full of nutrients that plants need in order to live and grow.

Vermicomposting has many benefits to people and the environment. Not only does it produce nutrient-rich castings, but it is also an effective recycling option. The worms eat organic material, such as paper and food waste, and turn it into a rich organic soil amendment. This eliminates the need to dispose of organic material in a landfill. For more information on organic materials, see "Appendix C–VI, Organic Materials," and "Appendix D–II, Maintaining a Vermicomposting System."

LESSON 5: Using Compost and Promoting Vermicomposting

Note: If your worm bin is not ready for harvesting, you can still implement "Part III" and "Part IV" in this lesson.

LESSON'S CONCEPTS

- Red worms turn food and paper waste into compost that can be used to enrich soil.
- People can participate in actions that enhance their environment.

PURPOSE

Students will learn ways to harvest and use worm compost. They also share information about red worms and vermicomposting with other students.

OVERVIEW

In this lesson students will:

- Harvest the vermicompost from the worm bin.
- Conduct an experiment to test whether worm compost affects plant growth.
- Read or listen to *Miss Rumphius* by Barbara Cooney and *Johnny Appleseed* by Eva Moore and discuss the special things each character did to improve the environment.
- Make a red worm mascot, puppet, or clay model and use these to share what they know about red worms and vermicomposting.
- Write poems, songs, and stories or design murals, illustrations, and posters to teach others about the importance of vermicomposting.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students use puppets or clay models to share what they know about red worms and vermicomposting with classmates and design posters to share information with other students in their school.
  - "People can learn from each other by telling and listening, showing and watching, and imitating what others do." (*Benchmarks for Science Literacy,* page 140)
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students will . . . communicate observations orally and in drawings." (*Science Content Standards, Grades K–12*; Kindergarten; Investigation and Experimentation, Standard 4e)
- Students read (or listen to) *Miss Rumphius* by Barbara Cooney and *Johnny Appleseed* by Eva Moore.
  - "Students identify the basic facts and ideas in what they have read, heard, or viewed." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 2)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing

TIME

10–20 minutes to prepare for the lesson; 60 minutes for two days to implement the lesson, plus time over several weeks to gather information as the plants are growing in different types of soils

VOCABULARY

Ask students to select words they are curious about that apply to this lesson.

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Obtain six potted plants of the same species. (You might be able to get some slightly unhealthy looking plants donated by a nursery or donated by a parent.)

___ **3.** Ask students to bring one clean sock to class so each student can make a red worm puppet. (Bring some extra socks for those students who could not bring them.)

MATERIALS

For "Part I, Separating the Compost from the Worms"

___ A sheet of plastic (or a drop cloth or plastic table cloth) approximately 4 feet to 6 feet square
___ Three 1-gallon-size containers to separate worms, bedding, and castings (The cafeteria may have some containers.)

For "Part II, Testing Whether Worm Compost Affects Plant Growth"

___ Six potted plants of the same species
___ Soil
___ Poor quality soil, such as sandy or clay soil
___ Worm compost

***For "Part III, Reading or Listening to the Stories,* Miss Rumphius *and* Johnny Appleseed"**

___ The books, *Miss Rumphius* by Barbara Cooney and *Johnny Appleseed* by Eva Moore

For "Part IV, Making a Worm Mascot, a Sock Puppet, or a Clay Model"

___ Transparency of "A Red Worm" from Lesson 2

For the Worm Mascot

___ One tan-colored nylon stocking
___ One nylon stocking in a lighter shade
___ Newspaper
___ Construction paper
___ String or yarn
___ Other items for decorating the worm mascot (See "Making a Worm Mascot" on page 155)

For the Sock Puppet

___ One clean sock for each student
___ Markers
___ Construction paper
___ Glue
___ Scissors
___ Yarn

For the Clay Model

___ Red or brown modeling clay

PRE-ACTIVITY QUESTIONS

A. Ask students to look inside the vermicomposting bin and determine how the rich compost can be separated from the worms. List their ideas on the chalkboard. *Pick out worms; put all the food on one side and wait until the worms move to that side; take out one handful at a time and separate the worms from the compost; dump the bin's contents on a plastic sheet and separate worms from the castings.*

B. Discuss with students what could be done with the compost from the vermicomposting bin. (This discussion will be continued in "Part I," section "D.") *Plant plants in soil mixed with the compost; put it in a container and see if worms hatch; put around trees; put in the garden; put in soil of potted plants.*

PROCEDURE

Part I, Separating the Compost from the Worms

A. When the compost is ready:

- Allow groups of students to try the various methods the class has recommended in their responses to the "Pre-activity Questions."
- Assign one group to follow the procedure on how to harvest the compost described in "Background Information for the Teacher." (Dump three-fourths of the bin.)
- Another group could spread newspaper on each student's desk in the group and place one or two handfuls of worms and compost from the remaining contents of the bin on the newspaper. Students can pick out the worms from the compost as they listen to music or listen to a story.

For Older Students

B. Do the following:

1. When the compost has been separated from the worms, food, and remnants of bedding, ask students to weigh and record the weight of each of the following:

- Compost

- Worms (worms can also be counted)
- Food and remnants of bedding

2. Compare the present weights of the different components in the worm bin to their weights when they were added to the bin.
3. Ask students to describe in their journals the sorting process for vermicompost.

Worm Investigations

We separated the red worms from the soil. They felt slimy. The worms were wiggling around.

How we did it:

First we got four piles of soil and worms from the worm bin. Then we put them in the sun and waited. After some time we put the soil in one container and worms in another container. Then my group collected food for the worms, such as apple cores, celery, and bread.

Submitted by Gayle MacDonald-Gura, third-grade teacher, Lower Lake Elementary School, Konocti Unified School District.

For All Students

C. Continue the discussion the class started in "Pre-Activity Questions," and have students decide what to do with the compost they collected.

- Students might want to add some compost to some potted plants or to plants growing on the school grounds (get approval from administrators first).
- Students could package the compost to sell and write up a vermicomposting information sheet.
- Students could use the compost to mix with soil in which to plant flowers for Mother's Day or Father's Day.
- Students could use the compost to test the growth of their plants. (This is described in "Part II.")

Part II, Testing Whether Worm Compost Affects Plant Growth

A. As a class, design an experiment with plants to see whether worm castings can actually make plants healthier and/or grow faster. With the class develop:

- A hypothesis—what students think will happen
- An experiment
- Criteria for what will be considered healthy (very green leaves, lots of leaves) for a plant
- A way to monitor the growth of the plants (For example, measure how tall and how wide they are; count the number of leaves; compare the size of leaves.)

Picture intentionally deleted.

Students from Mario Chang's second-grade class at Mission Education Center sort vermicompost on the school grounds.

- A plan for using the same type of plants to compare and for making certain that all plants get the same amount of water and sunlight

B. One way to set up this experiment is described below:

- Use six plants from the same species (e.g., coleus or beans).
  - Two plants (A1 and A2) could be planted in soil from the school yard or an empty lot.
  - Two plants (B1 and B2) could be planted in one-fourth worm castings and three-fourths soil.
  - Two plants (C1 and C2) could be planted in half soil and half sandy or clay soil.
- Have students observe and record over time any differences in the health and growth of each type of plant.
- Plants will need to receive the same amount of water and sunlight.

Note: It is possible that no visible difference becomes evident. If there are no visible differences, this might show that using castings in replacement of soil is as good as soil. Also, there may not be significant differences if the soil in which the plants were planted was full of nutrients. The type of plants selected for this experiment might also affect the results. Some plants are adapted to thrive in poor soil.

C. Have students conduct their experiments.

D. After several weeks, discuss the results of the experiment. Ask whether students found out what they wanted to know and what else they might want to know (e.g., the ideal amount of worm compost for a specific plant). List students' responses on the chalkboard. Consider encouraging students to plan additional experiments. These can be done as a class, in groups, in pairs, or on an individual basis.

Note: Another way to test vermicompost is to use two outdoor planter boxes. Place several cups of vermicompost in the soil in one planter box and no vermicompost in the other planter. Using poor quality soil could show more dramatic results. Plant a variety of flowers, using the same species in both planters. Water both planters with the same amount of water.

Part III, Reading or Listening to the Stories, *Miss Rumphius* and *Johnny Appleseed*

A. Read to or have students read *Miss Rumphius* by Barbara Cooney and *Johnny Appleseed* by Eva Moore. (See section "B" and, if the compost is ready, decide whether you want students to separate the worms from the compost as you read one of the books.) After reading each book, ask students what was special about what each character did. *Miss Rumphius' grandfather worked to make the world better and taught Miss Rumphius to do the same. Miss Rumphius wanted to make a better world, so she planted flowers called lupines to make places more beautiful. Johnny Appleseed was making a better world by planting apples trees and giving away seeds and seedlings for others to plant and enjoy.*

B. Ask students what they could do on the school grounds to make it look better. *Plant plants.* Students might also say that helping the existing plants by using compost to enhance the growth of plants might be a good idea. The compost from vermi-composting can be used as fertilizer for existing plants and/or to grow new plants.

Project Idea: If students say that planting some plants on the school grounds would make it look better, help students to plan and implement this project.

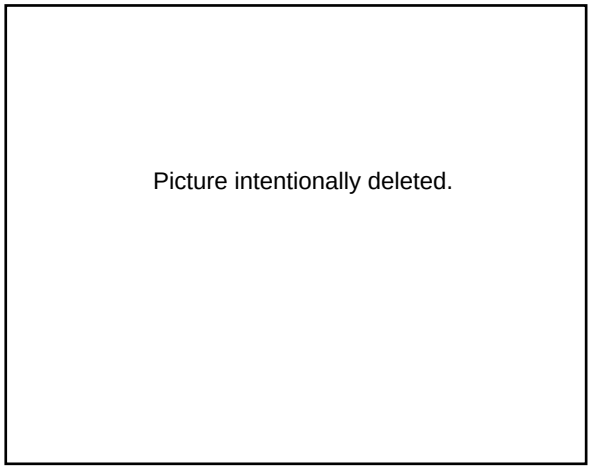
Part IV, Making a Red Worm Mascot, a Sock Puppet, or a Clay Model

A. Show the transparency of "A Red Worm," from Lesson 2. Have some students help you make a model worm mascot out of nylon stockings while other students make their own worm out of socks or mold worms out of clay. To make the red worm mascot out of nylon, do the following or use the directions, "Making a Worm Mascot" by Donna Flores, at the end of this lesson.

- Stuff a nylon stocking with newspaper and tie string or yarn to make segments.
- Make a flap over the mouth out of construction paper. (Have students determine how to make one.)
- Brainstorm ways to make setae on its body.
- Add the clitellum, the swelling or band

which is usually distinguished by its lighter color. This could be done using a piece of lighter shade of stocking tied around the first third of the worm.

- When the mascot worm is complete, have the class come up with a name for the mascot.



A student from Lynda Mooney's first-grade class at Las Palmas Elementary School holds up a model worm mascot.

B. Provide a sock for each student who wants to make a sock worm puppet. Students should already know that real red worms do not have eyes and that they have five hearts (see Lesson 2 for more information). If lighter colored socks are used, students can use markers to darken the clitellum and add the bands to show segments. Students can also draw the hearts. If darker colored socks are used, students can glue pieces of construction paper for the segments, clitellum, and the hearts. If students do not want a puppet, they can stuff the sock with newspaper and use yarn to make segments and to close the end of the worm.

C. Provide clay for those students who want to mold their worms.

D. After all the members of the class have completed their worms, ask students to show their worms to the class.

E. Have students use the red worm mascot, puppet, or model to share with the class one thing they know about worms or vermicomposting. Students should not repeat what other students have said.

Project Idea: Have students put together the information they shared in a script for a puppet show. Arrange for your students to go to other classes to present their puppet show about red worms and vermicomposting. This show can also be presented during a school assembly and at the school's open house.

DISCUSSION/QUESTIONS

A. Why is vermicomposting important? *It reduces the amount of garbage that goes to a landfill; the compost can be used to enrich the soil so that plants and soil animals grow better; it provides food for red worms.*

B. What are the steps to harvesting the compost in a vermicomposting bin? (See "Background Information for the Teacher.")

APPLICATION

Do "A" or "B" (or both with older students).

A. Discuss with students why people should know about vermicomposting. *It is a way to keep food waste from being landfilled; it is a way to recycle nutrients.*

- Develop as a class a bank of key phrases that support important ideas about vermicomposting.
- Break students into cooperative learning groups and ask them to develop posters that advertise one of the key concepts.
- With permission from administrators, have students hang up some of the posters throughout the school. Make sure that these posters do not end up as litter.

Note: With younger students, you might want to do the following as a class or set up stations:

B. Ask students to meet in groups and decide what they want to do to share what they know about red worms and vermicomposting. For example, they can:

- Write and recite a poem about red worms.
- Write and sing a song about red worms. (For ideas students can watch the Banana Slug String Band's video listed in "Resources." Although no song about red worms is featured, students can get ideas for words from songs about other animals.)
- Write and read a story about red worms.
- Explain something about vermicomposting through the imaginary character "Professor Red Worm."

- State several facts about red worms.
- Make a mural, painting, or illustration about red worms or vermicomposting and have the worm puppet or clay model explain it.

Red Worm
Red worm, red worm, grows so slow,
Red worm, red worm, way to go.
Red worm, red worm, eat a few leaves,
Red worm, red worm, compost these.

Oh, Lovely Invertebrate
No eyes, no ears, no nose,
You live where fungus grows;
You have a clitellum, so we know
you'll mate.
Oh, lovely invertebrate, you are so great.

Submitted by Gayle MacDonald-Gura's third-grade class, Lower Lake Elementary School, Konocti Unified School District.

Project Idea: Students could package the vermicompost and sell it to parents or other community members. Students could also include information about the benefits of vermicomposting or how to build and maintain a worm bin.

Project Idea: Students could organize and conduct an annual worm festival. They could develop stations for students from other classes to visit. A demonstration on how to vermicompost can also be included.

EXTENSIONS

1. Have groups of students put on a puppet show demonstrating how worms help to recycle our food waste.
2. Have your class visit a local community garden. Have students ask about composting or have a gardener visit the class.
3. Have students learn about composting without worms. See "Books" in the "Resources" section.

RESOURCES

Videos

Dancing with the Earth. Banana Slug String Band. Available from The Let's Get Growing! Company, 1900 Commercial Way, Santa Cruz, CA 95065; 1-800-408-1868; FAX (408) 476-1427 (40 minutes).

Shows the Banana Slug String Band performing its songs, including "Dirt Made My Lunch" and "Decomposition."

The Rotten Truth. Pleasantville, N.Y.: Sunburst Communications, 1991 (30 minutes).

Describes how to compost.

Books

Backyard Composting: Your Complete Guide to Recycling Yard Clippings. Prepared by Harmonious Technologies. Ojai, Calif.: Harmonious Press, 1992.

A step-by-step guide on how to compost.

Bond, Ruskin. *Cherry Tree.* Illustrated by Allan Eitzen. Honesdale, Penn.: Caroline House, 1991.

A girl in northern India plants a cherry seed and cares for it as it grows into a fruit producing tree.

Campbell, Stu. *Let It Rot! The Gardener's Guide to Composting*. Pownal, Vt.: Storey Communications, Inc., 1990.

Provides background information on composting and explains various ways to compost.

Cooney, Barbara. *Miss Rumphius*. New York: Viking, 1982.

A story about Miss Rumphius, who plants lupine because she believes that people should do something to make the world more beautiful.

Ikeda, Daisaku. *The Cherry Tree.* New York: Alfred A. Knopf, 1991.

Story about an old man and two children attempting to save a cherry tree in time of war.

Moore, Eva. *Johnny Appleseed*. New York: Scholastic, Inc., 1970.

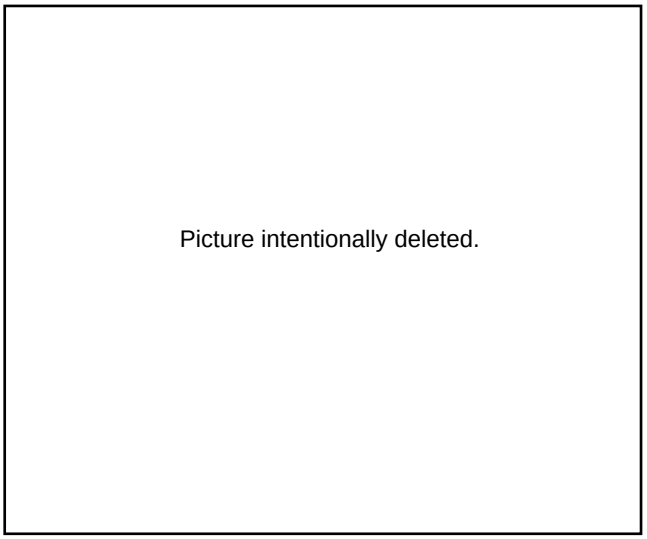
The story of Johnny Chapman who got the nickname of Johnny Appleseed because of his enthusiasm about planting apple trees and his generosity in providing apple seeds to settlers.

MAKING A WORM MASCOT

by Donna Flores

Materials:

____ One thigh high nylon
____ One tan piece of felt
____ One yard of burgundy quilted material
____ Black thin yarn
____ Glue gun



Two students from Donna Flores's third-grade class at Nightingale Elementary School hold two worm mascots made in class.

1. Roll the burgundy quilted material lengthwise.

2. Slide material into nylon.

3. Knot the open end of the nylon.

4. Cut the elastic and excess nylon close to the knot.

Segments

5. Make segments by tying black yarn around the worm about every four inches.

Clitellum

6. Cut the felt in half. Roll one piece lengthwise and put it around the worm about one-third of the way down from the head's end. Use a glue gun to fasten the edge across. This is the clitellum.

Flap

7. From the other piece of felt, cut a "U" shape. This is the flap that goes on top of the head. Use a glue gun to glue it down.

Bristles

8. Cut yarn into one-and-one-half to two-inch pieces. (You need enough for one pair for each segment.) Fold the cut yarn in half. Drop some glue where you want the bristle and apply the folded yarn.

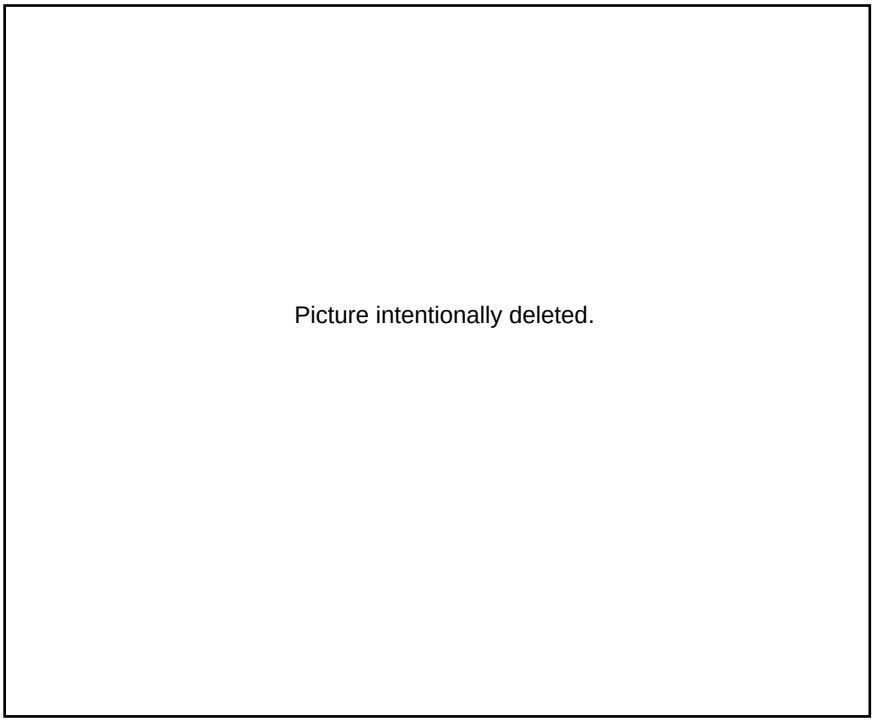
BACKGROUND INFORMATION FOR THE TEACHER

The following provides directions for harvesting compost from the worm bin:

Note: Be sure to monitor your bin and harvest the compost when the contents of the bin become mostly castings. The worms will stay in the bin if they have proper bedding, moisture, temperature, and food. Without those things, they may try to leave the bin in search of better living conditions, or they could die.

After a period of three to six months, you will notice that the food and bedding in the worm bin have been almost completely transformed into worm castings, the nutrient-rich waste material that worms excrete. Now is the time to harvest the compost and change the bedding.

- The first step is to assign a group of students to prepare new bedding for the worms while another group of students harvests the compost. (For directions on how to prepare bedding, see the K–3 Module, Unit 3, Lesson 1, "Procedure, Part I, Section C" or "Appendix D.")
- Put down a sheet of plastic (e.g., a drop cloth, a plastic table cloth) approximately four feet by six feet for the second group of students. Spread it out in an open area (the floor or outside on the playground). Dump the entire contents of the bin out onto the plastic sheet—worms, food, remnants of bedding, and castings.
- Sort the material into several (six to nine) cone-shaped piles (wider at the base and narrower at the top). If outside, allow sunlight to shine on the piles. If indoors, put a bright light over them, or ensure that the room is well lit. Since worms dislike light, they will burrow down deep into the pile to avoid it. Gradually scoop off materials from the tops of the piles; you will be able to watch most of the worms bury themselves deeper in the pile. Put the vermicompost (worm castings) in a container. The vermicompost can be used later to enhance the soil for house plants or gardens or to use in plant experiments. Put the worms in a second container, and put any uncomposted food waste or old bedding into a third container.
- When you reach the bottom of the piles, you will find a lot of worms. Put them in the container with the other worms. When all of the piles are sorted, add the container with the uncomposted food waste and old bedding to the bin where the first group of students has placed the new bedding.
- Then place the worms in the bin. Allow the bright light to shine on them for a few minutes so that they bury themselves in the new bedding. Then add some fresh food waste, cover with shredded paper, put the cover on your worm bin, and have your students continue to feed and monitor the bin for another three to six months.



Students from Mario Chang's second-grade class at Mission Education Center make a garden box before enhancing the soil with vermicompost.