2.5 Testing Conditions That Promote Decomposition

Action Synopsis

Students test factors that promote the growth of microbes, then use their findings to make compost.

Session 1		40 minutes
1. Present the challenge of testing conditions to make dead plants decompose.		*posing a challenge*
2. Brainstorm factors that might promote microbe growth and decomposition.		*generating ideas & questions*
3. Work in pairs to choose a variable to test and outline experiment plans on a "Research Proposal."		*designing experiments*

Session 2		40 minutes
1. Set up experiments.		*investigating*
2. Record experimental setup in journals.		*documenting*

Continued

Sessions 3–5 — **40 minutes**

1. Monitor experiments and keep records. — *observing & recording*
2. Evaluate weaknesses of experiments described in "Science Fair Stories." — *applying knowledge*

Session 6 — **1 hour**

1. Discuss results of experiments. — *processing findings*
2. Draw conclusions about best conditions for microbe growth. — *reflecting*
3. Design and set up a decomposition (compost) chamber. — *applying knowledge*
4. Make plans for monitoring compost over time. — *planning*

Desired Outcomes

Throughout the lesson, check that students:

✓ Understand that invisible spores of microbes are in the air, water, and on all non-sterile surfaces.

✓ Discover that certain physical conditions, such as moisture and warmth, help microbes grow.

✓ Can explain the connection between the growth of microbes on dead plants and decomposition.

✓ Are refining their experimenting skills, such as defining a research question, controlling variables, using replicates, making measurements, documenting results, and drawing conclusions.

What You'll Need

Sessions 1–6

For the class:

- ❑ 2.5 gallon (30 x 15 x 17 cm) plastic animal cage with cover (or a similar clear plastic container to use as a decomposition chamber)
- ❑ clear plastic bag large enough to line the decomposition chamber
- ❑ 6 cups of alfalfa hay
- ❑ 6 cups of hardwood shavings
- ❑ materials to vary conditions for growing microbes (see "Getting Ready")

Continued

Session 1

For each pair of students:
- ❑ copy of "Research Proposal" (pages 230–231)

Session 2

For the class:
- ❑ miscellaneous containers (see "Getting Ready")

For each pair of students:
- ❑ 4 sandwich-size ziplock baggies
- ❑ masking tape or permanent marker

Sessions 3–5

For the class:
- ❑ measurement and observation tools (see "Getting Ready")

For each pair of students:
- ❑ 2 hand lenses
- ❑ copy of "Science Fair Story #3" (page 232)
- ❑ copy of "Science Fair Story #4" (page 233)
- ❑ copy of "Science Fair Story #5" (page 234)

Vocabulary

COMPOST - Decayed plants, usually used for improving garden soil.

REPLICATES - Identical copies of an experiment.

Getting Ready

Session 1

- Gather a variety of materials that students can use to vary the conditions of their hay samples, such as soil, decomposing leaves, water, mushrooms, freezer packs, non-electric heating pads, black construction paper, and "compost starter" (a commercial product that contains microbe spores).
- Decide on pairs of students to work as research teams, or plan to let them choose partners.

Session 2

- Collect some containers for students to use while conducting their experiments, such as plastic cups for carrying water and trays on which to examine compost.
- Display the hay, baggies, and materials for varying experimental conditions on a centralized table so that students can quickly identify and get what they need.

♦ Assemble measurement and observation tools for students to use to monitor their experiments, such as rulers, a balance, measuring cups, dropping pipettes, thermometers, and a microscope.

Action Narrative

Session 1

How could we imitate the decomposition that happens outdoors right here in the classroom? Your challenge over the next week is to test conditions that will make these dead plants decompose.

Show students the bags of hay and wood shavings, and the empty container that they'll make into a decomposition chamber. Discuss why hay and wood shavings are dead plants (i.e., hay comes from plants that are mowed, harvested, dried, and then baled; and wood shavings come from trees).

What do you think you'd have to do to make the hay and wood shavings decompose in this container? Think about what causes decomposition, and what the conditions were like in places outdoors where you saw the most evidence of decomposition.

Make a class list of students' suggestions. Probe for the reasoning behind their ideas, asking questions such as *Why do you think adding water would help?* Their responses might reveal lingering misconceptions. If so, remind them that dead plants break down because microbes consume them, so they'll want to create conditions that will help decomposer organisms live and multiply.

What conditions will make the dead plants decompose?

Make the plants wet

Keep the plants in a dark place

Put the plants under pressure, like when they're under stuff outside

Add soil

Add a mushroom

Add manure

Put the plants between layers of soil

Add microbes

Give them sunlight

Keep the plants warm

Rip the plants into tiny pieces

Give them lots of air

These are ideas for variables you could test. The next step is to plan experiments so that we know the best way to make this container into a "decomposition chamber" for our dead plants.

You and a partner will use small samples of hay to test the conditions you think are the most important or interesting. Then when we figure out what conditions make microbes grow the best, we will use our findings to set up the decomposition chamber with all of the plant material, and whatever else you decide to add.

Make sure students follow the reasoning of using microbe growth as an indicator of optimal conditions for decomposition. Since it would take too long to wait for the sample material to decompose completely, students will need to assume that conditions that make the most microbes grow are the best for creating a decomposition chamber.

With your partner, choose a variable you'd like to test and write your names beside it on our list, or add a new idea you'd like to investigate. More than one pair can test the same variable. In fact, it is better that way. Does anyone know why?

See how much intuitive sense students have about why experiment REPLICATES are important, then introduce the term to them. Scientists set up more than one trial of an experiment so they can be more sure of their conclusions. If something happened once, it might have been by chance. If it happened 100 times out of 100 trials, then a scientist can be quite sure it happened because of the test conditions.

If students need help understanding experiment replicates, you could share a scenario such as: Let's say you want to see whether boys or girls can jump farther. So you ask one boy and one girl to jump, measure the length of each jump, and draw a conclusion. Could you be confident that your conclusion was correct? What could you do differently to be more confident in your conclusion?

Give pairs a few minutes to choose a variable and record their selections. Once students see what everyone has chosen, they might want to make adjustments to test a greater variety of variables, or to have at least two pairs replicate each test.

Each pair will get four baggies and a small amount of hay to put in each.

Show students the baggies, hay, and the materials they can use to vary conditions for growing microbes.

Notice that the hay includes seed heads, stems and leaves. What will you want to make sure of when you choose hay to add to your baggies?

To make their tests fair, students will want to use the same part(s) of the plant in each baggie. Microbes often grow better on the stems and leaves of alfalfa hay than on seed heads, so students might want to include a small piece of each part of the hay in each baggie to make sure that they'll see microbe growth.

You'll have the rest of the period to plan your experiment with your partner. Scientists usually have to write up a plan and have it approved by other scientists before they can proceed with their research. Write your plans on this "Research Proposal" and then go over it with me before you begin your experiment.

Planning Experiments

Some issues about experimental design that you might want to address with small groups or the class as a whole include:

Defining a Question. A good research question contains specific information about the kinds of comparisons that will be made in an experiment. For instance, the question *Will more microbes grow on wet hay than on a dry hay?* is more helpful than *Does water help microbes grow?* The question *Will adding soil to a baggie with hay make microbes grow on the hay more quickly than on plain hay?* is better than *What will happen when we add soil to hay in a baggie?*

Adding Microbes. Students might wonder where the microbes that are supposed to grow on the hay will come from. Remind them that microbes are everywhere. Reproductive spores of fungi and the resting spores of bacteria are already on the hay, waiting for the right conditions to grow. They can introduce more microbes by adding things to the hay, such as soil, moldy material, mushrooms, or compost starter .

Testing a Combination of Variables. Students might want to test several variables together, such as soil and water, or darkness and warmth. This is alright, but makes things slightly more complicated. If they combine soil and water for instance, they won't know if both conditions were really necessary for the microbe growth, or if they would have seen the same results by changing just one of the variables. Students can deal with this by having all four combinations (e.g., dry hay, wet hay, hay with dry soil, and hay with wet soil). They might not need to set up these extra tests themselves if other research teams are already doing them.

Creating Replicates. Students should set up at least two replicates in their experiments, especially if they have chosen a variable that nobody else in the class is testing.

Observing Evidence of Decomposition. From their experiments with Jello cultures, students should have a good idea of what something looks like when microbes are growing on it. Although bacterial colonies might form on the hay, students are more likely to see fungi. A slimy appearance and odors are also indicators of decomposition.

Predicting Results. The "Predictions" section of the "Research Proposal" asks students to list several possible results. Some students might just name three different types of changes for the treatment group (e.g., *the wet one will get fuzzy; it will get mushy; it will start to break apart*). Encourage them to consider the possibility that there could be no changes in the treatment as compared to the control, or that the treatment and control groups could both show changes.

Tomorrow bring in any materials you need that we don't already have.

Have students who finished their "Research Proposal" hand it in for you to review and initial.

Session 2

Today you'll set up your experiments. First, finish your "Research Proposal" if you haven't already. Once I've initialed it, go ahead and get started.

Expect that students won't realize difficulties with their plans or a better way to do things until they begin working with materials. Encourage them to refine their methods as necessary as they go along.

Sometimes students are less accurate in setting up their tests than their plans specify. Ask them if they are doing everything they can to create equal conditions in the treatment and control baggies, except for the variable they are testing. This could involve measuring or weighing the hay, measuring water so they know how much to add to each of their replicates, or keeping the baggies in the same conditions. If students forget to label their baggies, you might ask them how they'll be sure which is the treatment and which is the control.

After students use the materials they need to set up their experiments, clear away the leftovers and arrange the table with observation and measurement tools. It might help to tape labels to the table to show where each tool should be returned at the end of each period.

Help students find places to keep their experiments. Those who are testing conditions such as warmth, sunlight, or darkness might need special locations for their baggies.

When you're finished setting up your experiments, make an entry in your journals. Describe what you did, draw a picture of your setup, and record what the hay looks like now so you'll have something to look back on when you think it is showing signs of decomposing.

Communicate the importance of keeping good records by giving students enough time during class to make a detailed journal entry, or by assigning journal writing for homework.

Sessions 3–5

Check your experiments and make careful notes of your observations. Use hand lenses to get a closer look at what's happening in the baggies.

In addition to writing descriptions, have students think about if and how they could quantify their results. One idea is to make a rating system for the amount of fungal growth.

0 - no fungi visible,

1 - a few strands of fungal hyphae are present

2 - fungi all over the sample

3 - fungi so dense that the hay is no longer visible

Students might want to base their ratings on the consensus of several people's opinions, to slightly reduce the subjectivity. You might want to help students develop a chart for recording results.

Date	Baggie #1 wet	Baggie #2 Dry	Baggie #3 wet	Baggie #4 Dry
5/3	0	0	0	0

Take time to look over students' journals and encourage them to show them to each other. This helps them value journal keeping as a way to develop and display creativity, documentation skills, and reflection. Their writing, charts, and drawings can also spark discussions about their work.

Let the experiments run over a weekend if possible, since the longer they sit, the more dramatic the results will be.

What to Expect

Fungi will grow most quickly on hay that is kept warm and moist. Students won't see any microbes after one day, although they might see discoloration of the leaves and a yellowish tint to the water they added, due to dissolved material leaching from the leaves. By the end of the second or third day they'll begin to see fuzzy molds and fungal hyphae, especially thin white networks of strands and black dots of spores along the hay stems, which will increase daily. If students added so much water to their baggies that the hay is saturated and no oxygen is available, bacteria that are "anaerobic" will grow, and a noticeable odor resulting from gases and other products they release could result.

Each day when you're done taking notes on your experiments, work with your partner on some more "Science Fair Stories."

Give each pair of students three more science fair stories to work on together and/or complete on their own for homework. Here are some things to look for in their responses, and to go over in a class discussion:

Science Fair Story #3: Paul's Pollution (Focus: Keeping Accurate Records)

1) Advice to Paul should concern improving his record-keeping habits.

2) Charts for Paul's data should have a place for the date and for the number of duckweed, snails, algae, and water fleas in the mini-ponds with and without laundry soap.

Science Fair Story #4: Juan's Wonderful Worms (Focus: Interpreting Results)

1) Juan lost points because he didn't take all of his data into account when drawing a conclusion.

2) The best conclusion is that the worms had no clear preference for either soil as measured in this study. However, students might also reason that: a) the worms liked the woods soil better because there were more in it two times out of three that he checked; b) the worms liked the woods soil better because there were more in it the last day; or c) the worms liked the field soil better because an average of 10.3 worms were found there per day, and only an average of 9.7 per day were found in the woods soil.

Science Fair Story #5: Maritza's Marigolds (Focus: Planning a Whole Investigation)

1) Maritza's research question could be something like: *Do marigolds watered with water that egg-shells have soaked in grow taller* (or look greener, or flower sooner...) *than marigolds watered with plain water?* The question should include more specific terminology than "grow better".

2) Students will probably predict that the marigolds receiving eggshell water will grow taller (or look greener, or flower sooner...), since that's what Maritza's grandmother claims.

3) Students should define how many plants to use as a treatment and how many as a control, pot sizes, amount of soil, size of marigolds to start with, and amount of water each will receive. They should define a watering schedule for the duration of the experiment. Students should plan to observe and measure indicators of plant health, such as height, number of leaves, greenness of leaves, and size of flowers.

4) Charts should include a space for dates and sections for recording measurements of 32 treatment and control plants.

Session 6

Prepare to share your results with the class by discussing these questions with your partner.

Write several questions on the board to focus students' discussions.

1) What variable did you test?

2) Did your treatment change in comparison to your control? In what ways?

3) Were the results of your replicates the same?

As each pair reports its results, summarize the findings on a class chart. You might want to list those that tested the same variable together for easy comparison.

Research Team	Variable	Microbe Growth Treatment	Control
B.K. & L.T.	soil	2	0
T.J. & M.L.	soil	3	0
S.T. & J.H.	water	3	0
T.H. & A.R.	mushroom	2	0

(0 none; 1 little; 2 medium; 3 lots)

Facilitate a discussion of the results with questions such as:

Was there variation in the replicates?
Students may have seen variation in how samples of hay responded to the same variable. Their challenge is to decide whether the variation among replicates was so great that they can't draw a conclusion about the kind of change their variable causes, or whether the variation was small enough that a clear trend was still evident.

Which variables created the best conditions for microbes to grow?
Any variable that added moisture to the hay should have promoted microbe growth. If students added moist items (e.g., soil, a mushroom, moldy leaves) ask them how they could figure out if it was the moisture or something else about the items (e.g., microbe spores on them) that promoted microbe growth in their experiment. They might suggest testing dry and moist samples of the items as variables. Moisture plus warmth promotes even more microbe growth, but warmth alone does not. Like all living things, microbes need moisture to carry out life functions.

What are some examples of how people try to keep plant material dry to prevent decay?
Students might mention farmers who try to cut, bale, and store hay in dry weather.

What would happen if you treated a dead plant with a chemical that prevented decomposers from attacking it, and then exposed it to rain and wind?
Students' responses will reveal whether or not they still harbor the misconception that physical factors alone can cause decay. Normal rain and wind might cause some physical breakdown, but it will be minuscule in comparison to the breakdown caused by decomposers. For example, fence posts, telephone poles, and wood decking that are treated with preservatives to deter microbial decay last longer than untreated wood, despite being exposed to the same weather.

Did some variables cause changes to happen more quickly than others?
Since students monitored their experiments on a regular basis, they can compare notes to see which variables caused changes to appear sooner than others.

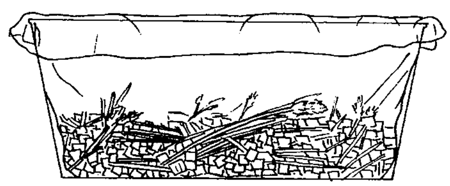
Now it's time to use our findings to design a decomposition chamber. What conditions should we create in the chamber to cause the dead plant material to decompose?

This is a good opportunity for students to think through and use what they've learned about decomposition. Encourage them to challenge and elaborate on one another's suggestions until everyone agrees on what to do.

Water is the only essential ingredient to add to the contents of the decomposition chamber, but students might make strong arguments to add other ingredients as well.

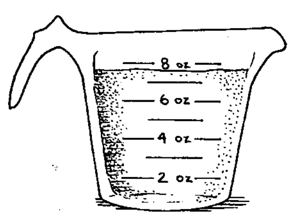
The next step is to set up our decomposition chamber. We'll need to line it with a plastic bag. Every few days we'll remove the bag, close it up, and shake it to expose the bottom and center of the rotting plant material to air.

If the moist material doesn't get air, bacteria that can live without oxygen start growing. They give off smelly gases (like ammonia and hydrogen sulfide), and other chemical products that will stink up the classroom.



How much water should we add?

Too much water will fill up all the air pockets, so again only the bacteria that don't need oxygen and produce a rotten odor will take over. It is best to add 1 cup of water at a time until the hay feels like a squeezed out sponge.

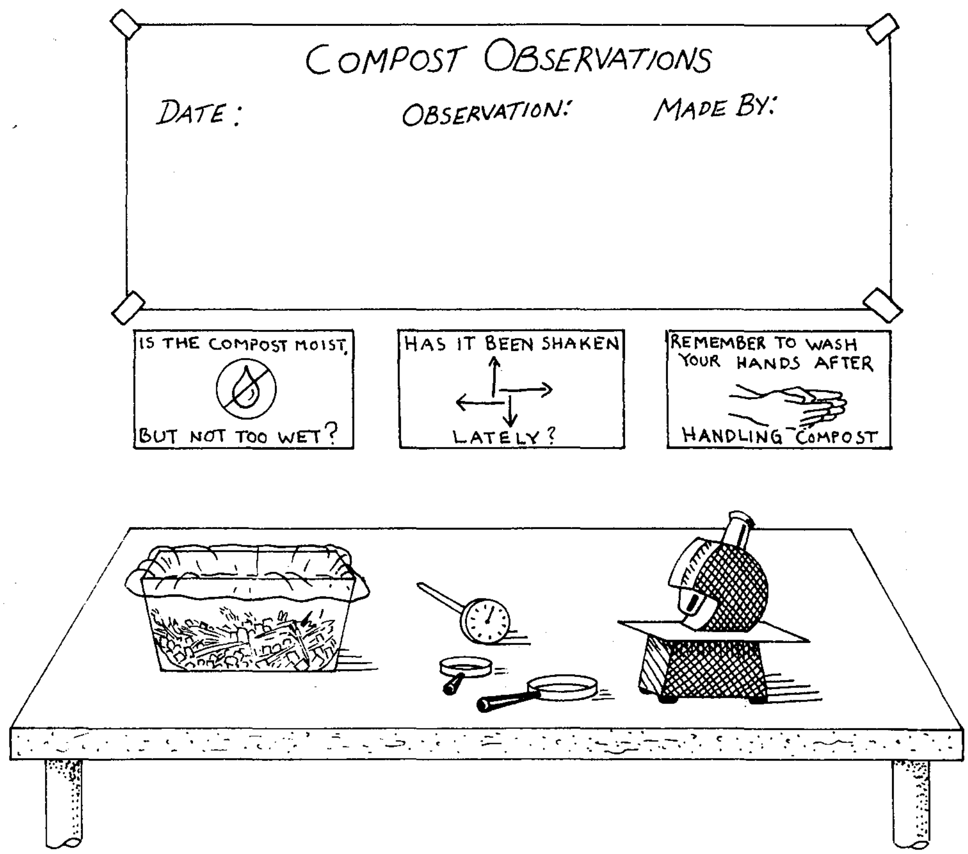


Does anyone know what gardeners call the material they get by letting dead plants rot?

Introduce the word COMPOST if students are not familiar with it.

We'll keep some observation tools by the decomposition chamber, so you can monitor what happens as dead plants turn into compost.

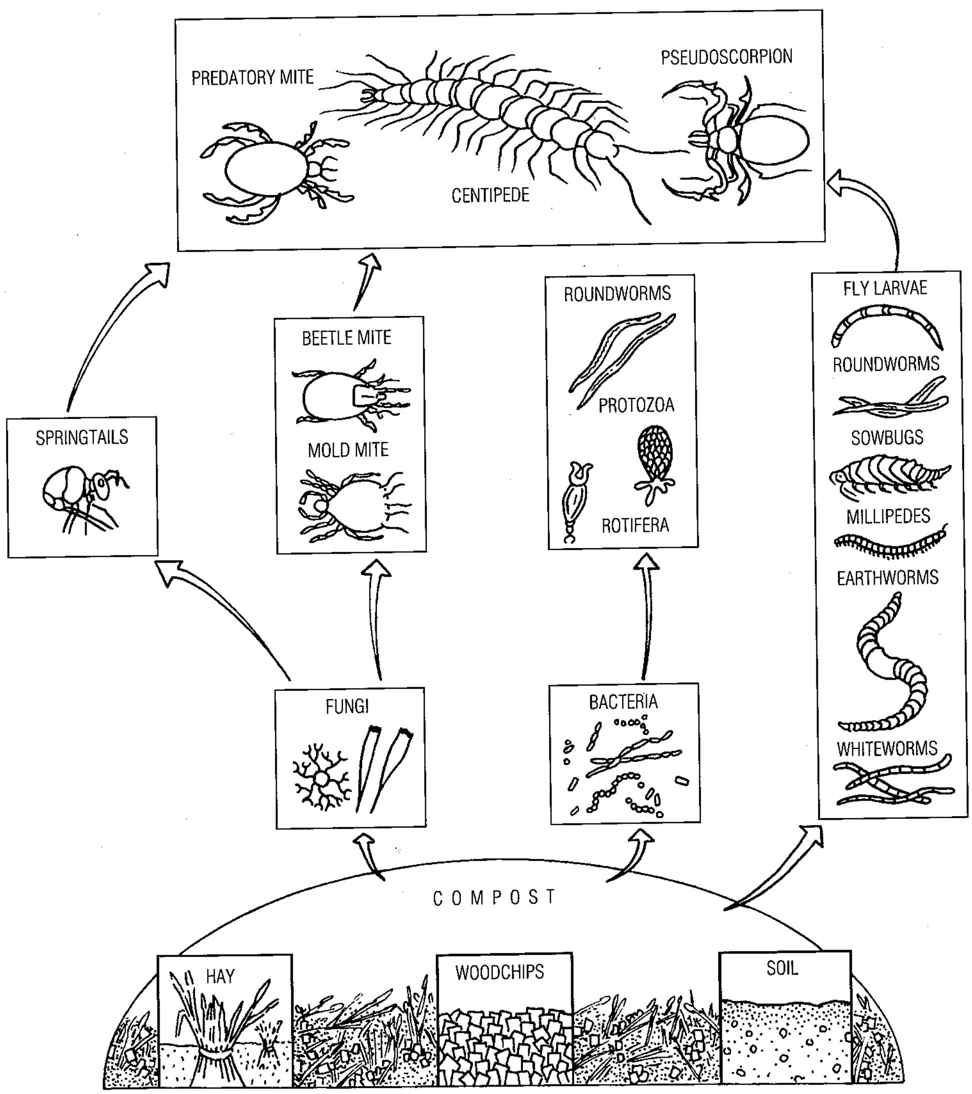
Show students the materials you've gathered, such as a thermometer, spoons and petri dishes, hand lenses, and a microscope. Have students take the temperature of the center of the compost just after they set it up, and each time they shake it. Keep a notebook or chart by the decomposition chamber where students can record their observations.



Compost Happenings

Temperature. Much heat is released by microbes as they consume dead plants. Students should be able to detect temperatures in the compost that are higher than air temperature. When microbes have optimum food and moisture, compost temperatures can reach as high as 65° C (150° F). Brush turkeys in Australia and some kinds of crocodiles bury their eggs in piles of decomposing plants to use the heat produced as an incubator.

The Compost Community. If students have added soil to the compost, they've probably introduced some invertebrates as well as microbes. By examining samples of compost with hand lenses and a microscope, students might find some of the organisms pictured below.



After students have observed the compost for a few weeks, bring out the class chart made during Lesson 2.1, listing ideas about what happens to plants after they die. Have students revise and enhance the list to reflect their new knowledge about decomposition.

The compost will be used during Module 3. If you don't plan to do Module 3, keep the decomposition chamber going as long as students are interested, then talk with them about what they could do with the compost (e.g., add it to the soil around plants near the school building).

Ongoing Assessment

Student Reflections

Have students send a C-Mail message, or record thoughts in their journals. Optional writing prompts include:

How did you feel while doing the experiment (e.g., excited, frustrated, impatient, curious, disgusted, overwhelmed, creative)? Why?

If there were no decomposers on earth, then...

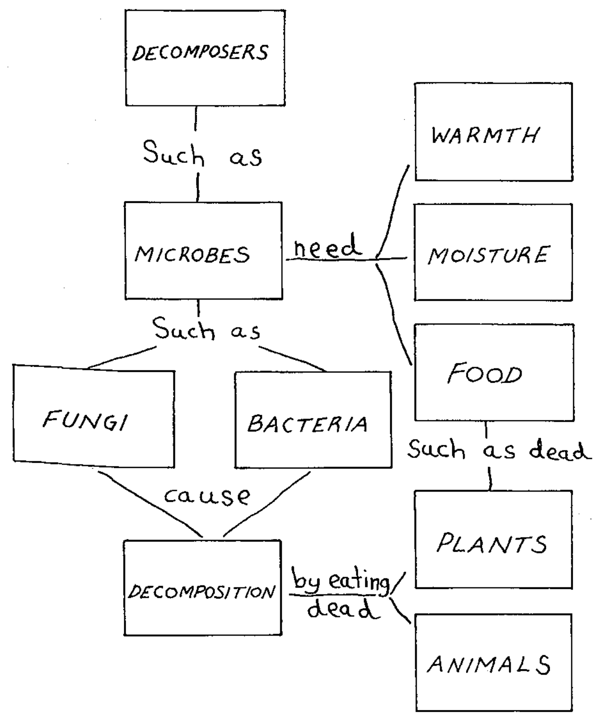
Teacher Reflections

- ❑ Are students comfortable with and able to use the logic and methods of controlled experimentation?
- ❑ Do they understand that physical conditions such as moisture and warmth can make it easier for microbes to consume their food and reproduce, but that these conditions alone do not cause decomposition?
- ❑ Did they show thoughtful use of results when deciding how to set up the decomposition chamber?

Extensions

Burial Studies. Help students bury equal size samples of the same item, such as spinach leaves, in the top 5 cm of soil in different locations. Mark the locations with a stick or ribbon. Check back every few days to see how the materials have changed. Try a variation by burying the samples in a coarse mesh such as cheesecloth or plastic screening, to exclude larger soil organisms, and in a tight mesh such as panty hose, to exclude all but microbes. Students could also bury different biotic and abiotic items in the same location and compare their rates of decomposition.

Concept Maps. Introduce concept mapping to students (see pages 25–27) if they are not already familiar with the process. Select all or some of the concept map cards on pages 43–44, then copy one set of cards for each group of 3–4 students. Have them construct concept maps that display their ideas about decomposition. Help students compare their new concept maps with those they made after Lesson 2.1, to see how their ideas have changed.



Do Not Rot. Challenge students to figure out what conditions *prevent* microbes from growing on organic matter. Keep one piece of a fruit or vegetable, unenclosed and unaltered, at room temperature as a control. Have students take other pieces of the same item and treat them in a variety of ways that might prevent them from decaying.

Desert Decomposition. If you live in an arid region, have students find a shrub with dead leaves beneath it. Use a watering can to wet the leaves and the ground beneath them. Check back daily. Termites should respond to the moisture and consume the dead leaves quickly.

Test Writing. Have groups of students write several questions and answers on microbes and decomposition, then submit them to you for possible use on a class quiz.

NAME(S)______________________________ DATE__________

RESEARCH PROPOSAL

QUESTION

1. Write the question that you want to answer.

____

____

FAIR TEST

2. Describe a fair test you'll do to answer your question.

____

____

____

____

3. What variable are you testing?

____

4. Draw and label your experimental setup. Circle the variable that you are testing.

Remember, everything should be exactly the same in the treatment and the control except for the variable you're testing!

TREATMENT	CONTROL
How many of these will you set up?______	How many of these will you set up?______

MATERIALS

5 List everything you'll need. Specify exact amounts.

OBSERVATION AND CARE PLAN

6

WHAT	HOW	WHEN	WHO
What will you do, watch, and measure to answer your research question?	How exactly will you make observations and measurements?	How often?	Who will do each job?

PREDICTIONS

7 What do you think the result of your experiment will be? Why?

What other result could there be?

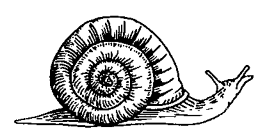
Can you think of another possible result?

☐ Check here when this plan has been reviewed.

Reviewer's Initials: ____________

NAME(S)______________________________ DATE__________

SCIENCE FAIR STORY #3



PAUL'S POLLUTION

Paul wanted to study water pollution for his science fair project. He got two 1-gallon jars and made them into mini-ponds. He added the same amount of pond water, duckweed, snails, algae, and water fleas to each jar.

Paul then added a small amount of dissolved laundry soap to one pond, and left the other pond alone. He kept the jars near the window in his bedroom for two months to observe what things grew or died.

The first time he collected data, Paul counted the amount of duckweed in each jar. His notebook and pencil were downstairs, so he kept the numbers in his head. Then he counted how many snails were still alive in each jar. As he was adding up numbers, Paul decided that he better get his notebook. On his way through the living room he saw that his brother was watching his favorite television show, so he sat down to watch. After the show he got his notebook and wrote down the numbers he could remember.

A week later, Paul used his microscope to see how many water fleas were in samples of water he took from each of his ponds. He jotted down the numbers on the back of a bubble-gum wrapper. A few days later, Paul realized that he had thrown out the gum wrapper by mistake.

1. How can Paul improve his experimenting skills?

____

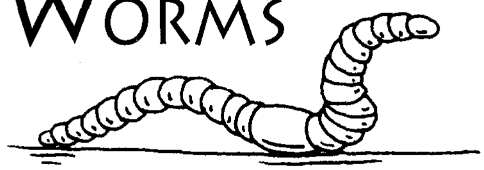
____

2. Make a chart or charts that Paul could use for keeping track of his data. Use the back of the sheet.

NAME(S)____ DATE__________

SCIENCE FAIR STORY #4

JUAN'S WONDERFUL WORMS



Juan loved to fish, and was good at digging up earthworms. When it came time to do a science experiment, he decided to investigate what kind of soil earthworms prefer.

Juan dug up some soil from the woods, and some soil from a field. Then he put the piles of soil next to each other in his backyard. He put 20 worms in between the two piles.

Here are Juan's findings:

Date	Woods Soil	Field Soil
April 25	12 worms	8 worms
April 30	6 worms	14 worms
May 5	11 worms	9 worms

Juan decided that the clearest differences were on April 30th, so he concluded that worms prefer field soil.

1. Why do you think Juan lost points from the Science Fair Judge for his conclusion?

____

____

2. What should Juan have concluded from his experiment? Explain your answer.

____

____

____

NAME(S)________________________________ DATE________

SCIENCE FAIR STORY #5

MARITZA'S MARIGOLDS

Maritza's grandmother always lets eggshells soak in the bottom of her watering can. She says that the eggshells add something to the water that helps her plants grow better.

Maritza wants to test her grandmother's eggshell method for a science fair project. She has 32 marigold plants to use for her test.

Plan an experiment that will help Maritza find out what she wants to know:

1. Write a research question that Maritza can test.

   ____

   ____

2. Make a prediction.

   ____

3. Describe a fair test Maritza could do. Remember to include:

   - What materials she should use
   - How she should set up the experiment
   - What she should do to keep the experiment running
   - What observations and measurements she should make

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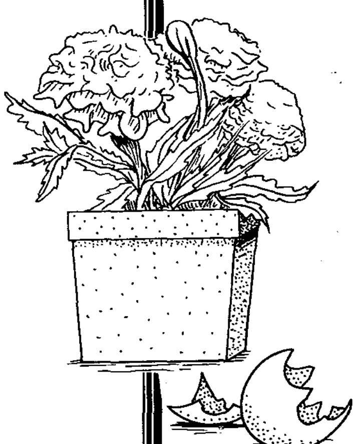

4. Make a chart that Maritza could use to record her data. Use the back of the sheet.