3.1 A Challenge from GROW

Action Synopsis

Students observe soil samples, talk about where soil nutrients come from, receive a letter from a company that wants to know if dead plants can be used as fertilizer, then develop research questions.

One Session	1 hour	
1. Discuss what plants need to grow.		*examining prior ideas*
2. Examine soil samples to decide which would be best for plant growth, and jot down observations and ideas.		*observing & recording*
3. Talk about plants' needs for nutrients, and nutrient cycling.		*introducing new information*
4. Read a letter from a company requesting research on the potential for using dead plants as fertilizer.		*linking to real world*
5. Write and discuss research questions.		*developing research questions*

Desired Outcomes

Throughout the lesson, check that students:

✓ Understand that nutrients are the invisible building blocks that make up all living things.

✓ Know that all living things need nutrients to grow and stay healthy.

✓ Have ideas about where nutrients in soil come from.

✓ Can form a research question.

What You'll Need

For the class:
- ❑ houseplant

For each group of 3–4 students:
- ❑ small clear bag or container of poor soil, such as sand or clay (see "Getting Ready")
- ❑ small clear bag or container of good potting or garden soil (see "Getting Ready")

For each student:
- ❑ copy of the letter from GROW (page 267)

Vocabulary

NUTRIENT CYCLE - The transfer of nutrients back and forth between living things and the non-living environment (soil, water, and air).

Getting Ready

- ♦ Students need to be familiar with compost before this lesson, and will need compost for this module's central experiment. If you haven't done Module 2, see "Planning Ahead" on page 256 for information on setting up compost in the classroom.
- ♦ Decide on groups of 3–4 students.
- ♦ Before photocopying the letter from GROW for each student, make one copy of the original. Personalize the letter by typing the class research company name (optional, see pages 15–16), and the school's address in the space provided above the salutation.
- ♦ Put a few tablespoons of the two types of soil in separate bags or containers for each group. You can get rich soil from a garden, woods, or a landscaped area, or purchase potting soil. If you use potting soil, mix in some compost or decomposed plants you find

outdoors to give students clues about where soil nutrients come from. You can find poor soil that has little organic matter in places such as driveways or parking lots, or you can purchase sand. Label each of the bags of poor soil "A," and each of the bags of rich soil "B."

Action Narrative

During the next few weeks, we'll be experimenting with plants to learn how they get what they need in an ecosystem. What do you already know about what plants like this one need to grow?

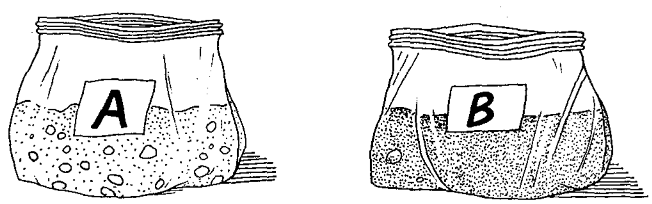
Show students a houseplant, then make a class list of their ideas.

What Plants Need to Grow

Sunlight
Air
Water
Soil

I have some soil samples for you to look at. Talk with your group about which soil would be better for growing plants and why.

Assign students to groups, and give each a sample of both kinds of soil. Suggest that they appoint a recorder to jot down their observations, choice, and reasons. They'll need about 5 minutes.



If you are in an arid region where plants such as cacti grow in sandy soil, you might want to have students think about garden plants rather than native plants for this exercise. But if you prefer to have them consider native plants, you can have an interesting discussion about the two resources plants take in through their roots: water and nutrients. Explain that some plants are more suited to growing in sand because they need well-drained soil. The trade-off is that they get fewer nutrients from sand than they would from soil that contains more organic matter and also holds more water.

Let's hear what you think.

Ask which groups chose soil A and which chose soil B, then ask for their reasons. Most students will choose the soil that looks richer. Their reasons could include: it's darker, it's more like a garden, it's easier to grow roots in, it's fluffier, it will give them better "food," it has more good stuff in it, it will hold more water, etc.

If your students' comments reveal naive ideas about soil being food for plants, you might want to take time during this module to review photosynthesis. See pages 119–121 for more information.

You've mentioned a lot of different reasons why some soil is better for plants. We're going to focus on one of those reasons— that plants need to get nutrients from soil. Plants need nutrients—invisible mineral particles —for the same reasons that people do: the bodies of every living thing are made of tiny nutrient particles. Also, we need nutrients to grow and stay healthy. Do you have any ideas about where the nutrients that plants get from soil come from?

Have students look at the soil sample they decided was better for plants. Ask them to look for clues about where the many invisible nutrients in it might have come from. They will most likely say that the nutrients came from weathered rocks, and from plants and animals that have decomposed, which is true. (In addition, air is a source of some soil nutrients, such as nitrogen, but the complexities of nutrient cycles that occur partially in the air won't be addressed in this module.)

Discussing where plants get nutrients will help you begin to assess students' prior ideas about nutrient cycling. Their ideas will continue to surface during later activities, which will provide opportunities for you to help them confront and revise their naive notions. A key realization that students should develop is that unlike animals, plants (with a few exceptions, such as Venus flytraps) can't digest living or dead plants or animals. Plants need to take up particles that have already been broken down ("pre-digested") by decomposers. See the passage below for information on some of the ideas and confusion your students might reveal about nutrient cycling as the module progresses.

Children's Ideas About Nutrient Cycling

Many children have an intuitive idea that dead plants make soil better for living plants, but their understanding of how this happens can be quite vague. Consider this interchange between two sixth-grade boys:

David: *Like when a plant falls down, it's dead, the dirt covers it. So then it connects to the root of a tree and helps the tree get bigger.*

Luis: *It makes the tree healthier, grow. The dead plant still helps.*

David: *It's like it's not dead, it still lives.*

These boys don't mention that decomposers break down dead plants, nor do they seem to have any idea that decomposition releases nutrients from dead plants, that in turn become part of living plants. They imagine a dead plant connecting to the root of a living plant, but do not yet have concepts and images necessary to explain what happens on an invisible level.

Understanding nutrient cycling requires being able to imagine and accept that all matter is made of particles that are so tiny that they're impossible to see, even with the most powerful microscopes. These particles—atoms and molecules—are the building blocks of all living and non-living things. Some of these building blocks, such as nitrogen, phosphorus, carbon, and potassium, are called nutrients because they're essential to all life. Nutrients cycle back and forth between non-living substances and organisms' bodies.

Children have a difficult enough time accepting the basic principle of the particulate nature of matter, but can find it especially unbelievable that both living and non-living things are made of the same basic "stuff." Here is an example of one fifth- grade girl grappling with this notion at two different points in time:

How can something alive be made of atoms and molecules? "Made of" makes it sound like someone made it, and plants, they just grow, nobody makes them out of anything.

I thought before atoms and molecules were only in non-living things. But I saw a book with pictures of circles and stuff, atoms and molecules, and next to them there were children jumping. But children are living. So then I said, atoms and molecules can't be in non-living things if they're in living things like children.

Because this girl imagines that living and non-living things must be made of fundamentally different substances, she would have a hard time accepting that the same particles that make up the non-living environment actually become part of living things, and vice versa. Even though it would be helpful for her to know that all matter is made of the same basic building blocks before she studies nutrient cycling, it is also possible that first-hand investigations and discussions about cycling could help her develop the concept of the particulate nature of matter.

Another confusing nutrient cycling issue for children can be the distinction between microbes and nutrients. Since both microbes and nutrients are invisible parts of compost, children sometimes think that microbes fertilize plants, rather than the nutrients that microbes release. Hopefully if students have cultured microbe colonies during Module 2, they will understand that microbes are living things. The exact nature of nutrients may be less clear, however, as it is for this sixth-grade boy:

Hold it, are nutrients living or non-living? I'd like to know, I'm not sure. How can they help plants if they're dead?

His use of the word "help" when explaining what nutrients do for plants is revealing. Children tend to think of nutrients as assisting in a process of keeping an organism alive and making it healthy, but are unaware that nutrients also make up the tissues of living things. Students' understanding needs to be expanded to include a structural, as well as a functional, role for nutrients.

Many challenging subconcepts, such as the particulate nature of matter, conservation of matter, the cause of decay, the nature of growth, and even photosynthesis and respiration, make nutrient cycling a particularly complex concept for children to grasp fully. It's essential to give students the opportunity to explain and work through their ideas as they do nutrient cycling investigations. This will help them develop a basic mental model of nutrient cycling. When they take biology and chemistry courses in high school they'll be able to add more abstract details to this basic framework. The following explanation of nutrient cycling by a sixth-grade Eco-Inquiry student illustrates a solid, basic level of understanding:

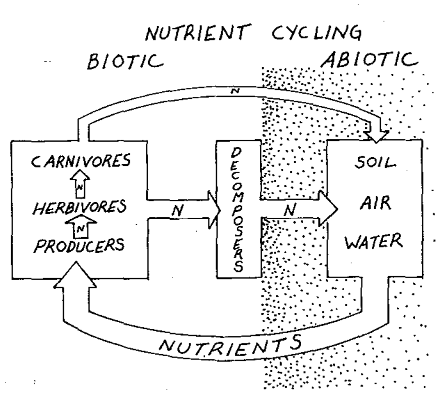
> *Let's say you bury a dead pig. Decomposers like microbes, mushrooms, worms, and ants eat it up, break it down, and put nutrients back into the soil. Then plants take the nutrients up and we eat the plants. Or the plants die and decompose. The others around them are happy and living while they're getting rotten. Then the living plants have offspring, then those have babies, then maybe in like, a million years, the nutrients will all still be going.*

When we observed our decomposition chamber, we talked about what could be happening to the matter that the dead plants were made of. Do you remember any of our ideas?

Have students review their thoughts about the fate of dead plant matter that emerged during the discussion suggested on page 218, and compare these with the ideas they've just offered about where soil nutrients come from.

Every living thing is made of invisible nutrients. When nutrients go from the non-living environment—the soil, air, or water—to being part of living things, and then back to the non-living environment, this is called a NUTRIENT CYCLE. Nutrients go back and forth between non-living substances and living things over and over and over.

Students don't need to absorb or completely understand this definition of nutrient cycling yet since they'll have a chance to work through the concept as they do their upcoming experiment. If, however, you feel they would benefit from more elaboration on the concept at this point, you could draw an explanatory diagram such as:



NOTE: Some nutrients leak, leach, or are released as wastes from plants and animals, and enter into the abiotic environment without passing through decomposers.

This diagram simplifies nutrient pathways (e.g., some animals eat decomposers but there is not an arrow from decomposers to carnivores). It also does not include oxygen, carbon dioxide, or water cycles.

We've received a letter from a company that wants you to help them figure out if dead plants can be used as fertilizer for living plants. This will give us a chance to try to complete a whole nutrient cycle right here in the classroom.

Hand out and go over the letter from GROW. The ideas for advertisements mentioned in the letter will be the basis for students' final performance assessment, so you don't need to explain this aspect of the challenge yet. Tell students they'll come back to it after they've fulfilled GROW's first request—doing research on the effects of decomposed plants on the growth of living plants.

Students will ask whether the GROW company really exists. Play up the simulation to whatever extent you feel is appropriate. Students usually know that GROW isn't real, but depending on the personality and maturity of the group, they sometimes enjoy having you play along as though GROW is an actual company. Another approach would be to tell students that this is a simulation of the kind of work scientists are asked to do as consultants or when they are employed in industry.

Scientists always begin their investigations with a question. Take a minute to put GROW's request into the form of a research question. Use your journal to help you think. Write and revise a question until you have it in a form that tells others what kind of comparison you want to make.

If students didn't get practice forming research questions by doing Module 2, give them examples of an explicit and a vague research question and have them tell you how they differ. For instance, *Will a bean plant grow taller after one month in potting soil than in sand?* is a more helpful question for guiding research than *Is potting soil or sand better for plants?* Using these examples, students can generate a few criteria for a good research question.

Have students work on their own to write a question. If they aren't accustomed to using writing as a tool for clarifying thoughts, encourage them to get a phrase down on paper and then add to, delete, or change the words to make their research question more specific.

Let's hear the questions you wrote.

Write the first few questions on the board. As a class, refine the wording until you have a question that students feel reflects GROW's request the best.

Do plants watered with compost tea grow taller than plants watered with plain water?

Are there any other related questions you're interested in studying?

Some students might want to study the effects of compost tea (nutrients dissolve in water before plant is watered), while others might be interested in testing the effects of compost as a soil additive (nutrients dissolve in water as plant is watered). They might also have ideas for testing different types of compost or dead leaves collected from outdoors, using composts at different stages of decay, using different strengths of compost tea, comparing plant growth with compost tea versus commercial fertilizer, or testing compost's effects on different types of plants.

Decide with the class whether all groups should study the same question or if they prefer to do a variety of studies for GROW. If everyone does the same study, students will have a lot of replicates of the experiment, giving them more confidence in their results. Also, the whole class can have discussions focused on the same issues. One possibility is to have each research team set up the same basic experiment, and then have those who are interested do a sideline experiment as well.

For homework, write down ideas of ways to set up an experiment to test our question. Tomorrow you'll share your ideas with your group and then work together on a "Research Proposal."

Ongoing Assessment

Student Reflections

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

If I was a plant root that could think and talk, what would I say about living in the two types of soil we looked at?

Where does my body get nutrients and what does it use them for?

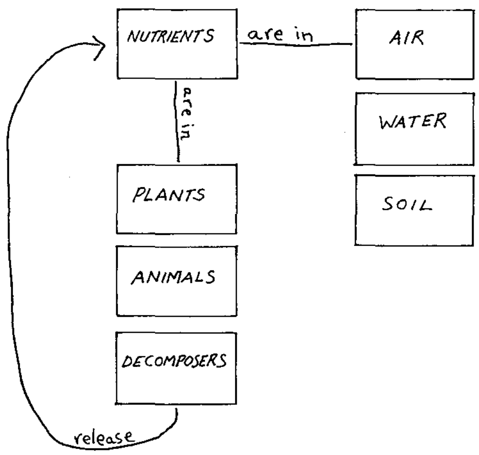
Working for GROW is going to be ____________ because...

Teacher Reflections

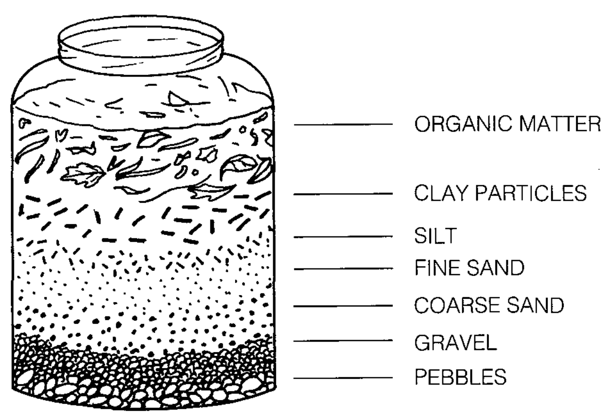
- ❑ Are students aware of what plants need to grow?
- ❑ How much intuitive sense did they already have that nutrients in soil come partly from dead plants that decomposers have broken down?
- ❑ How successful were they at using the process of writing to develop a research question?
- ❑ Which of the possible research topics seems to intrigue them the most?

Extensions

Concept Maps. Introduce concept mapping to students if they are not already familiar with the process (see pages 25–27). Select all or some of the concept map cards on pages 43–44, then photocopy one set of cards for each group of 3–4 students. Have them construct concept maps that display their ideas about nutrient cycling. Ask them to save their concept maps so that they can compare them to maps they'll make as an extension to Lesson 3.6.



Soil Organic Matter Test. Have students put the two soil samples they examined in two small jars of water and shake them. Then let the jars sit undisturbed. After 20–30 minutes the sample will have separated into layers according to the density of different soil particles. Soil that contains organic matter will show a dark layer of these particles floating on or just below the water surface. Below these will be clay particles suspended in the water, making it cloudy. On the bottom of the jar there will be a profile of particles: silt on top, then fine sand, coarse sand, gravel, and finally pebbles on the very bottom. Students can add a pinch of alum (an inexpensive powder available at pharmacies) before they shake the jars to promote a more marked separation of organic matter and heavier minerals.



G. R. O. W.

Green Recources of the World, Unlimited

Dear Researchers,

GROW is a company that makes and sells products to help people grow healthy plants. Our latest idea is to sell fertilizer made from dead plants. Our problem is that we aren't completely sure if dead plants make good fertilizer.

Since we don't have any scientists on our staff, we'd like you to do some research for us. Could you figure out if decomposed plants help living plants grow? People like to use liquid fertilizer. So, we'd like to see if "compost tea," made from decomposed plants soaked in water, can be used as a fertilizer.

After you finish your experiments, we'd also like your ideas for advertisements we could do to tell the public about your research and the products we develop from it. We'd also like the ads to teach people about nature's way of recycling nutrients.

I hope you'll help us out. All of us at GROW are eager to hear your results.

Thank you!

Sincerely,

Mary Gold

Mary Gold
President