



Roots and Shoots

Lesson Plan

Overview

In this lesson, students will learn that plants are more than meets the eye—they consist not only of shoots (stems, trunks, and leaves), but also of all-important roots. Students will first learn about different types of roots by observing and comparing photographs. Then they will observe the growth of a lima bean plant and document changes in root and shoot size by creating scaled drawings or taking digital photos. Finally, students will create a “paper garden” in which they categorize plants according to how their roots can access water underground. By the end of the lesson, students will have an understanding of the important shapes and functions of the often “unseen side” of plants—their roots.

Suggested Lesson Sequence	Please see the Greenlinks module description.
Lesson Level	Entry/Intermediate
Mathematics Connections (Keywords in BOLD)	<p>Students will estimate and compare area of shoot and root growth using a centimeter grid.</p> <p>Students will interpret a simple number line to draw depth of groundwater table.</p>
Science Connections (Keywords in BOLD)	<p>Students will learn about variations in root system shapes and sizes.</p> <p>Students will learn that plant roots are essential for anchoring plants as well as water and nutrient absorption.</p> <p>Students will learn that changes in groundwater depth can affect a plant's health.</p>
Technology Connections (Keywords in BOLD)	<p>Optional use of a digital camera to document root growth.</p> <p>Optional use of computer to view root systems</p>

	and document plant growth.
Lesson Assessment Tools	<p>Assessment and Standards Table (Word)</p> <p>Assessment Activity Description (below)</p> <p>Authentic Assessments (below)</p>

Materials

- Interactive slide show ([Powerpoint](#))
- Lima bean seeds
- Small clear plastic cups
- Potting soil
- Digital camera (optional)
- Plant Growth Chart ([Word](#))
- Several overhead transparencies of Roots and Shoots Grid ([Word](#)) and marking pen
- Art supplies (e.g. paper, colored pencils, crayons)
- Grow a Paper Garden activity sheet ([Word](#))
- Glue
- Scissors

Vocabulary

- **Root:** The part of a plant that absorbs water and nutrients, and usually grows underground.
- **Shoot:** The part of a plant that grows above ground; includes stems, trunks, and leaves.
- **Nutrient:** Organic matter that provides living organisms with what is needed for growth and development.
- **Absorption:** The process of taking something in; soaking it up.
- **Anchor:** To hold in one place.
- **Estimate:** A rough calculation; an educated guess based on evidence or (non-exact) information

Vocabulary Note: During this lesson, students will read some long passages of text on the activity sheet. Students may be unfamiliar with some of the vocabulary presented in the text. This is done intentionally, to build reading skills and to spur additional conversations and discussion about these words and their meanings. Encourage your students to ask about words they may be unfamiliar with that occur in the readings.

Procedure

I. Assessing Prior Knowledge

To begin the lesson, ask students to describe a plant. After several students have offered their descriptions, draw a simple picture of a plant on the board, incorporating their descriptions. It is most likely that the students will first describe the shoots, or aboveground, portion of the plant. If none of the students mention the roots of the plant, prompt them by asking a question such as, "Is there any part of a plant that we cannot see?" (You might also want to have a branch or clipping from a plant available to talk about differences between it and a complete plant.) Then, ask the students to predict what they think the root growth of a plant will look like, and draw the root portion of the plant according to their descriptions. Ask them to describe what they know about the purpose of plant roots. Make a list of student's ideas on the board or chart paper.

II. Contextual Preparation: Roots of the World Activity

As a class, view the interactive [slide show](#). In this slide show, students will read about several different kinds of roots. Discuss the different roots with the class, and ask the students why different plants might have developed different root systems, as seen in the photos. Prompt them with questions such as the following if necessary: What type of soil are they growing in? Do the plants grow all year? How big are the shoots of the plants connected to (above) the roots?

III. Student Activities - Planting and Observation

Activity #1: Planting and Observation

1. In the next portion of this lesson, students will grow lima bean plants and observe and record root and shoot growth over the next two or three weeks. Present the seeds to the class, and tell them that they will be growing plants of their own. Ask the following types of questions of the class:

What do you think the root growth of a lima bean seed will look like?

How fast do think the roots will grow?

How long do you think the root will be?

How high do you think the green shoot will be?

Why do you think plants grow roots?

Do you think the roots will be bigger or smaller than the shoots?

2. Demonstrate how to plant the seeds and then have students plant their own. Students may

work alone, in pairs, or small groups. To begin, add potting soil to a small plastic cup. Plant a lima bean seed about 1 centimeter under the soil and close to the edge of the cup. It is a good idea to plant a few extra seeds, as not all will germinate. Water regularly to keep soil moist, but take care not to waterlog the soil.

3. After a few days, the seed will germinate and students should begin to observe root and shoot growth. Use the [Plant Growth Chart](#) to document growth. Have students take digital photos of their plants, or if a camera is not available, have students draw the growth they observe (The use of small pieces of graph paper that can be glued to the growth chart will help students to keep their drawings to scale). If photos are taken, either print them out and glue to growth chart or upload the photos to the computer for observation.

4. To estimate the extent of root and shoot growth, print out the "Roots and Shoots Grid" and make several overhead transparencies of the grid. Demonstrate how students can carefully remove shoots with connected roots from the soil. Shake off the soil and place on a white piece of paper. Place the grid transparency on top of plant and trace the shoot and roots using two different colors. (If transparencies and dry erase markers are in short supply use hard copies of the sheet and show students how to trace around their plants.) The students should then trace their own plants and count the number of squares to estimate the total area of root growth (and shoot growth) in cm^2 . Note: Teachers should save the bean plants, as they will be used in the [Plants to Soil lesson](#).

5. As an alternative, students may place the grid transparency over the photo or drawing of the plant's roots and shoots to estimate the area of root and shoot growth (if their photo or drawing area is similar in size to the actual root and shoot growth). However, teachers should discuss with the class the potential for this measurement to be different than if they were measuring the plant directly.

6. Using the student's observations, digital photos or drawings, and estimation of total area of root and shoot growth, the teacher should lead the class in a discussion and refer back to their original predictions and prior knowledge.

Activity #3: Grow a Paper Garden

1. Now, students will learn more about roots and their functions by creating their own "paper garden." Pass out copies of the [Grow a Paper Garden](#) activity sheets. Have students cut out paper plants and glue them to two blank "gardens." They will then follow the directions on the worksheet to explore the relationship between water stored under ground and plant roots.

NOTE: the text on this activity sheet is extensive. You may wish to help students work through this text as a group, before they begin the activity. The students will learn about ground water (the "groundwater table") and that ground water can nearly reach the surface during the wet season, but then deepens during dry or drought seasons. Students will see that not all roots can reach the water table during the dry season. Help students to understand

that roots need to be able to access water in order to stay alive. You might want to remove the root system from one of the extra bean plants in order to observe what happens to the plant as a result.

Questions for Class Discussion

1. Why do you think plants grow roots?

(Roots grow to provide an "anchor" for plants in the soil. Roots are also essential for water and nutrient uptake in the soil. Nutrients are like "vitamins" for the plants.)

2. What was the total area of root growth for your plant? What was the total area of shoot growth for your plant? How do the two areas compare with each other? Why do you think the roots spread in many directions?

(Even though we cannot usually see them, roots are often more extensive than the shoots of a plant. This is partly because the roots need to spread out broadly in the soil to absorb water and nutrients.)

3. Why might some plants want deep tap roots, but other plants might want shallower fan roots?

(Deep tap roots can access deeper water, but shallow fan roots can access more water and nutrients near the surface if the water table is shallow enough.)

IV. Assessment

Students should understand that roots provide an anchor for plants in the soil and a means for plants to absorb water and nutrients. This will be demonstrated by their discussion and documentation of plant growth through digital photos or drawings. Students should also be able to use a grid to estimate the total area of root or shoot growth. They should also recognize that even though they can usually only see the shoots of plants, there is a very large amount of plant material that cannot be seen—the all-important roots!

Learning Extensions for Authentic Assessment

1. To demonstrate how roots absorb water and nutrients, teachers can involve students in a kinesthetic activity. First, place several small cups of water and several pieces of nutritious food (or pictures of nutritious food) to represent nutrients around the room. The teacher, representing the stem and leaves of the plant, should then stand in the front of the room.

Students, representing the root growth, should one-by-one connect to the teacher and then to each other by holding each other with one hand. (Ideally, students should spread out like a fan from the teacher. However, it may be necessary for students to form a "tap root" in order to reach a far-away cup of water or nutrient source). Using the second hand to represent root hairs, students will grab hold of the water or nutrients and pass them to the "teacher plant." The class should then discuss how this activity represents how roots absorb water and nutrients in soil.



2. Lead a class discussion around the fact that some plants have special root systems that connect many shoots together. One example of such a plant is the aspen tree grove. Did you know that aspen tree groves have been shown to be one of the largest organisms in the world? The reason is that one aspen grove spanning a large area can be entirely connected by the same root system. (As a result, the genetic makeup (DNA) of one aspen shoot (tree) is often exactly the same as another aspen shoot (tree) hundreds of meters away!) Share this story with your students, and have them draw an aspen grove so that

the above-ground and interconnected below-ground portions can be seen. Why might it be advantageous to have such a root system? One reason is that new "shoots" can be easily produced without the need for producing seeds. Another reason is that if water dries out in one portion of the grove, the root system is extensive enough to locate water for the entire grove. Finally, such a root system allows aspen to regenerate quickly after fires, because spreading by "runner" roots is a very fast, effective way for the surviving aspen to re-colonize burned-out areas.