# Hold on Tight!
# Lesson Plan

**Overview**

In this lesson students will explore the close connection between plant roots and the soil in which they grow. Students will learn that the plant roots and soil are in relationship with each other. Soils provide plants with nutrients that are absorbed through the roots. On the other hand, roots keep plants and soil from blowing away in strong winds, and keep soil from being washed away by water. Students will examine photos of uprooted trees and desert areas to help them understand the strong interconnection between plant roots and the soil in which they grow. They will also conduct experiments designed to highlight this mutual relationship between roots and soil. Teachers should expect to spend several days exploring this lesson with students.

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| Suggested Lesson Sequence | Please see the Greenlinks module description. |
| Lesson Level | Intermediate |
| Science Connections | · Students will explore the connection between **plants** and **soil** by investigating the **root mass** on plants.<br>· Students will explore the relationships among **roots, soils**, and **erosion.** |
| Math Connections | · Students will use mathematical tools (**e.g. area, volume, linear measurements, mass**) to compare the amount of soil on various roots. |
| Lesson Assessment | · Assessment and Standards Table (Word)<br>· Assessment Activity Description (below)<br>· Authentic Assessment (below) |

**Materials**

- One small pail of dirt or soil
- Several potted plants, or as an alternate, two patches of grass growing in soil. Though they may be small, the plants should be healthy enough to have developed a substantial root system. They also should be potted in a container that can be easily removed so that students can eventually observe the roots. Some ideas on obtaining these plants include:
    1. Buy from a store (usually the easiest option)

2. Dig up small patch of grass or plants using a trowel or shovel
3. Grow them from seeds (such as a bean plant, as in the Roots and Shoots lesson).

- Toothpicks
- Wire pipe-cleaners
- Small tub of water (may not be necessary)
- Newspaper
- Two empty plastic cup
- Root Explorations activity sheet (Word)
- Root Connections activity sheet (Word)

**Vocabulary Note**: During this lesson, students will read passages of text on the activity sheets. Students may be unfamiliar with some of the vocabulary presented in this lesson. 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**

This lesson will cover two concepts that are central to understanding the relationships between plants and soils. The first concept is that roots anchor plants in the ground and keep them from tipping over, even in strong winds or after a snowfall. The second is that by "grabbing" on to soil, healthy roots keep soil intact, making wind and water erosion of soil less likely.

**I. Assessing Prior Knowledge**

The two primary concepts of this lesson (roots anchor plants, and roots help prevent soil erosion) should be introduced in this opening conversation with students. Possible discussion questions might include:

- How are plants anchored in soil? *(Roots provide a solid base that stabilizes plants in the soil.)*
- What happens when wind blows strongly against plants? *(If your small plants are available, students could blow on the plants to see that, although the top of the plant might sway in the wind, the base of the plant is firmly anchored in the soil.)*
- What would happen to the top of the plant if the stem is cut near the soil? *(Students should predict that the plant will fall over, even without any wind. Teachers might demonstrate this phenomenon by standing a pencil on its eraser. As the pencil tips over, ask students why trees do not do the same thing. After all, tree trunks and branches can weigh thousands of pounds. Why do they not fall over, even in strong wind?)*
- What sort of root structure might exist underground to allow the plant to be anchored

upright against a heavy wind? *(Have students discuss what they think the plant roots look like below ground.)*

## II. Contextual Preparation

In this part of the lesson, students explore some of the previous discussion questions with real plants and soil. Using a potted plant as an example, begin by asking students to predict what would happen if they were to try to pull the plant out of the soil by the stem. (*Students may predict that the plant roots will come out cleanly, or will come out with some dirt attached, or that the plant stem might break because the plant is so firmly rooted.)*

As a way to prepare students for what they will find when they eventually examine the roots of the plant, a toothpick and wire pipe-cleaner may be used as a helpful way for students to recognize the importance of roots for both plants and soil. Engage the students in the following activity and discussion.

- Have a student insert a toothpick about half-way into the pail of bare soil. The toothpick should be relatively stable from side to side. Ask the student to try to blow it over with her breath. The toothpick should not fall over.
- Leaving the toothpick in the soil, do the same thing with a pipe-cleaner. Have a student insert a pipe-cleaner about half-way into the soil. It also should be relatively stable.
- Next, students will pull both the toothpick and pipe-cleaner from the soil. Before they do so, ask them to predict what they will find. *(Students may suggest that dirt will be caught within the small fibers of the pipe-cleaner. They may also predict that the toothpick will come out cleanly.)* After discussing these predictions, have the student pull the toothpick out of the soil. Did it come out of the soil easily? *(Yes, it should have come out very easily because there is nothing holding it in the soil.)* Is the toothpick clean, or does it have some soil particles attached to it? (*The toothpick will likely be clean.)* Repeat the process with the pipe-cleaner. Did it come out cleanly, or where there small particles of dirt in the fibers? (*There should be small particles of dirt trapped within the fibers of the pipe-cleaner.)* Did it come out as easily as the toothpick, or did you sense some small resistance as you extracted it from the soil? *(Later in the lesson, it will be important to make the link between the small fibers of the pipe-cleaner, and the small hair-like fibers that students can see on roots. It is these fibers on roots that are essential for obtaining nutrients and water for the plant, as well as clinging to the soil.)*
- Based on these results, ask the students to predict what they will find when the same process is completed with the real plant. Will it blow over? Will the roots come out cleanly, like with the toothpick? Will they look more like the pipe-cleaner?

## III. Student Activities

1. Plant roots

With one of the potted plants (or sod), ask another student to give a light tug at the base of the stem of the plant (or at the base of several blades of grass) in an attempt to pull it out of the soil.

If the plant does not come loose immediately, ask students to hypothesize why, unlike the toothpick, the plant remains rooted in the soil. *(There must be something under the soil that is clinging to the plant to hold it in place.)*

Students should be able to see that the plant is so firmly anchored that the stem will likely break before the plant (including roots) could be extracted from the soil. So, while still holding the stem, peel away the plastic pot or cup in which the plant is growing and place the plastic and any soil that is left behind on a piece of newspaper. This "loose" soil is soil that was not held by the plant roots. Pour this loose soil from the newspaper into an empty plastic cup and set it aside. (Note: If you are working with a piece of grass sod, simply lift the grass off of the piece of newspaper by holding on to the blades of grass. Loose soil should be visible on the newspaper.)

2. Root Descriptions

Below the stem, the root mass will be holding the remainder of the soil. Students may wish to take turns holding the plant stem with the attached root/soil mass to examine it closely. Keep the newspaper under the root mass so that it can catch any additional falling soil, and add this soil to the plastic cup holding the other loose soil. Ask the students to share their observations about the root/soil mass with the rest of the class. Some discussion questions could include:

- How heavy does the plant feel? *(This is an important question as the **mass** of the soil trapped in the root system serves as an anchor for the plant.)*
- What does the root/soil mass look like?
- How does the root mass differ from the part of the plant that is above ground?
- How is this different from what you observed with the toothpick and the pipe-cleaner?

3. Separating roots and soil

After all of the students have had the opportunity to see the plant up close, the next step is to separate the roots from the soil. This can be done in different ways depending upon the type of plant and how well developed the root mass is. Gently massage the root mass, catching all of the soil on the newspaper. Place this soil into a second plastic cup. This is

the "root" soil that was held by the plant roots. (Note: In some cases the root mass may be very tight and difficult to separate from the soil it holds, as in the case of grass sod. You may need to "wash" the soil away from the roots by massaging the root mass in a small tub or beaker of water. Allow the sediment to settle to the bottom, for students to observe.)

**Ask students** to compare the amount of "loose" soil and the amount of "root" soil in the two plastic cups. How does the amount of "loose" soil compare with the amount of "root" soil in the two plastic cups?

4. Observing bare roots: Classroom discussion

The following questions may generate discussion about the roots under observation:

- Can you describe these "clean" roots? *(On the Root Explorations activity sheet, students will have opportunity to draw pictures of roots as they observed them.)*
- Are all of the roots the same size?
- What is the shape of the roots?
- Compare the two piles of soil – the soil not held by the roots, and the soil held by the roots. How would you compare these two amounts of soil? *(Students may wish to weigh these respective amounts of soil, or develop other comparative measures like spreading the soil out on paper and measuring the area that it covers. They might also put the soil into two equally-sized containers and measure/compare the relative volume of each pile of soil.)*
- Why would the shape of the roots tend to help the roots hold on to the soil? *(Answer: The roots work together to enclose the soil. Students may wish to think of the roots making a "net" or "webbing" to capture and contain the soil.)*
- Why would plants have so many fine roots? *(Answer: so that they may gain nutrients and water from many different small locations, also known as "microsites", in the soil.)*

5. Distribute the Root Explorations activity sheet

Comments on Root Exploration Questions:

1) The roots act as an anchor for the plants. As discovered in the investigation, the roots act as "webbing" and cling to the soil. These balls of soil act as heavy anchors (heavy relative to the rest of the plant) that keep the plant stable.
2) No dirt stuck to the toothpick. The toothpick does not have the ball of small roots that become entwined with each other, and the soil in which the plant exists.
3) Pictures will vary.
4) Answers will vary. Responses should include the notion that the mass of small roots grow together and through the soil acting as a net that clings to the soil.

6. Root Connections activity sheet

As this discussion comes to a close, students should complete the Root Connections activity sheet by viewing the images on a computer.

Comments on Root Connections Questions:

1) Answers will vary and might include: the roots vary in size; the roots appear to grow out from the trunk in a circular fashion; the roots are still clinging to soil and rocks; some of the roots appear to be broken which suggests that the soil was clinging to them very tightly – tightly enough so that even the force of a large tree falling over could not even extract the roots from the soil; etc.
2) No, there are very few plants in the soil. Without plants and their roots to hold the sand in place, it can be carried away by wind and water very easily. Yes, blowing sand can be seen in the background.
3) No; Without topsoil, plants could not survive. They depend on the soil for nutrients, obtaining water, and stability.
4) The tan color surrounding the Red Sea indicates a vast desert area. Further south on the map image of Africa, green vegetation can be seen. The desert regions surrounding the Red Sea are vulnerable to high winds. The satellite image from July 11, 2002 shows how widespread dust storms can be in this area when it gets windy.
5) In the 1930s, the United States suffered four severe drought periods. These droughts made it very difficult for farmers and ranchers to grow plants, and therefore throughout the Great Plains, topsoil was blown away by strong winds. The Great Plains at this time were commonly referred to as the "Dust Bowl." As a result of the "Dust Bowl", new soil conservation methods were devised to improve farm practices. Students may answer that to avoid another dust bowl, farmers should plant more crops or more trees to keep the dust from blowing. Other ways to minimize soil erosion include limiting the number of livestock on rangelands, or leaving the dead plant material on the surface rather than tilling it below the ground.
6) More. Without water, plants will not grow. Without plant roots to hold soil, it is much more likely to be blown by wind.
7) Answers will vary. Plant more plants, do not till under plants even after they have died, use land for plants instead of grazing animals, etc.
8) Answers will vary. Students should be able to express this mutual relationship between plants and soil – plants need soil to survive (nutrients and stability), and soil needs plant roots to keep from being eroded by wind and water.

## IV. Assessment

After students have completed the activity sheets, ask them the following questions to assess their understanding of the relationship between plant roots and soils:

1. Why are soils important for plant growth?
2. How do plant roots hold soils? (their network creates a "webbing" that can hold tightly to the soil)
3. Is there more or less loose soil when plants are growing in the ground?
4. When strong winds and rains occur, what would happen to soils if there were no plants growing in them? (Answer: They would be carried away through a process called *erosion*.)

**Lesson Extensions for Authentic Assessment**

1. Students may write a short story as if they were a root, growing in the soil. The story might include how the root grows to wrap around soil particles. Some other threads that the students might write about include: What animals and insects might a root see? What would a root search for from day to day? What happens to roots when it rains?

2. Many roots are eaten by humans. Have students write down all of the roots or root parts they have ever eaten (e.g. carrots, parsnips, turnips, radishes, potatoes, yams, beets, etc.). The students could also share stories about these roots – perhaps they have planted them in a family garden, seen them at the store, have them in their lunches, etc.

3. Did you know that there is a large region of sand dunes in the middle of the United States? The Nebraska Sand Hills cover the western half of Nebraska and extend into parts of Colorado and South Dakota. Today, most of the Nebraska Sand Hills are thinly covered with grasses, which keep them stable. In the past, however, droughts reduced the amount of vegetation and the dunes could begin to move. Study the location of the Sand Hills on maps, and learn about the climate of the Sand Hills region. How might the Sand Hills be similar to a desert region? How do they differ from a desert region? What might happen to the Sand Hills if climate changes in the central United States?

4. Roots come in many shapes and sizes. Some root systems are fanned out close to the surface, while other roots (called taproots) extend very deeply into the soil. Have students think about why different plants might have different root systems. If they were a plant growing in the desert, what would be the advantage of having a shallow root system? (Possible answer: They could soak up rain water from over a large area)

5. Did you know that roots actually create new soil in which to grow? Some roots create new soil by mechanically breaking apart rocks. Have your students look for evidence of roots breaking apart rocks in the following photo: