ROOTING INTO THE SOIL:

Examining the Relationship between Plants, Soil, and Water

Grades 4–8

I. Introduction

In preparation for a school visit to the Huntington Botanical Gardens' Reading Plants tour, we will conduct an experiment to compare how water moves through different soils and to discuss the implications for plants growing in different climates and environments.

II. Objective

- To develop skills in observation and analysis through participation in a hands-on scientific experiment.

III. Standards Addressed

Earth and Space:
Basic Earth Processes

(Grades 3-5)
The composition and properties of soils (e.g., components of soil such as weathered rock, living organisms, products of plants and animals; properties of soil such as texture, capacity to retain water, ability to support plant growth)

Benchmarks for Science Literacy (1993), American Association for the Advancement of Science, page 73

Science Content Standards, Grades K-12 (2000) California State Board of Education, Standard 2-3c

(Grades 6–8)
Components of soil and other factors that influence soil texture, fertility, and resistance to erosion (e.g., plant roots and debris)

Benchmarks for Science Literacy (1993), American Association for the Advancement of Science, page 73

Science Content Standards, Grades K-12 (2000) California State Board of Education, Standard 2-3c

Life Sciences:
How Species Depend on One Another and on the Environment for Survival

(Grades 3-5)
The behavior of individual organisms is influenced by internal cues (e.g., water pressure) and external cues (e.g., changes in the environment), and that organisms have senses that help them to detect these cues

Science Framework for California Public Schools Kindergarten Through Grade Twelve (1990), California Department of Education, page 119

An organism's patterns of growth are related to the nature of that organism's environment (e.g., kinds and numbers of other organisms present, availability of food and resources, physical characteristics of the environment)

Benchmarks for Science Literacy (1993), American Association for the Advancement of Science, page 116

Science Framework for California Public Schools Kindergarten Through Grade Twelve (1990), California Department of Education, page 137

Science Content Standards, Grades K-12 (2000) California State Board of Education, Standards 4-3a, 4-3b

(Grades 6-8)
An organism's ability to regulate its internal environment enables the organism to maintain stable internal conditions while living in a constantly changing external environment

Science Framework for California Public Schools Kindergarten Through Grade Twelve (1990), California Department of Education, page 119

IV. Background

Plants, Soil, and Water

During your visit to the Huntington Botanical Gardens, your class will visit three different gardens: the Desert Garden, Lily Pond Garden, and the Jungle Garden. Each of these gardens represents a distinct ecosystem, where plants are adapted to the unique conditions of their local environment: from the arid, sunny climate of the Desert Garden to the wet and shady Jungle Garden.

Water is, of course, one of the most important elements for a plant's growth and survival. (Plants need light, water, and carbon dioxide, along with some trace nutrients in order to generate their own food in a process known as photosynthesis.) In the Desert Garden, there is an abundance of plants that are adapted to very little water. Evidence of these adaptations is seen in structures such as spines, leaf hairs and water storage tissues. The Jungle Garden contains many plants with large leaves, which are adapted to gather as much sunlight as they can from the shady under-story. You will also see buttress roots that support tall trees in the soil where nutrients are quickly recycled and so remain in the top layers of the ground. Finally, the Lily Pond Gardens provide a habitat for many aquatic plants. These plants face an abundance of water, and have adapted to ensure that they will get the air and light they need to survive.

In different environments, there will also be very different soils. The kind of soil, whether it is sand or clay, dry or wet, depends on a number of factors. Geology, weather, plant and animal life all help to determine the qualities and make-up of soil. Most plants root into soil, where their roots will take up water and nutrients such as nitrogen, phosphorous and potassium that are necessary to their health and survival. With this experiment, we will examine how water moves through different kinds of soil and we will discuss the implications for plants growing in different environments.

V. Materials Needed (for each group of 3 students)

- Sand, pumice (or perlite, rinsed and dried first)
- potting soil
- Measuring cups (3)
- Measuring scoops (3)
- Funnels (3)
- Pitchers (3)
- Coffee filters (funnel-shaped)
- Water

VI. Lesson Activities

1. Discussion Guide your students through a discussion of plants—what all plants need (sunlight, carbon dioxide, nutrients, water) to grow and reproduce. Focus particularly on how plants root into soil for physical support, but also to take up water and nutrients. Talk about different root strategies: some plants have shallow, spreading roots while others have deep taproots.

   Why would these different strategies exist?

[Plants have adapted over time to take advantage of different conditions. Plants with shallow, spreading roots (ficus, palms, many cacti) can take in water and nutrients near the surface of the soil. Plants with deeper roots (dandelion, acacia, tamarix) could reach underground water stores and nutrients that have moved down through the soil.]

If we know something about the water and nutrients available in soil, could we predict what kinds of roots plants might have in a particular soil?

2. This experiment is also an excellent opportunity to discuss the scientific method. Formulating a hypothesis about what is going to happen will help students to reason through the process and to analyze the results in a critical and thoughtful manner.

   a. Introduce the different soils you will be using: sand, pumice (a lightweight volcanic rock), and potting soil.

   b. Examine and describe the different soils. Compare the feel and texture of each. Which is the most dense? Which soil material do you think water will move through most quickly?

   c. Set up one funnel in each measuring cup, then place a coffee filter in each funnel.

   d. Discuss why it is important to measure the same amounts of soil and water in each container. (*The amounts need to be the same so that you can compare relative differences—these are called "controls" in the language of scientific experiments*.)

   e. Measure a scoop of each soil material into the different funnels.

   f. Predict which material the water will pass through most quickly, and which will be the slowest. Record your predictions.

   g. At the same time, pour the measured cups of water into each funnel.

   h. Watch to see which goes the fastest. The results may be surprising!

   i. Discuss and record the results. Compare them with your predictions.

   j. Decide what kinds of roots plants might have if they were growing in each of these soils. Where would the roots have access to more water and nutrients?

   k. If you would like, you can add another cup of water to see if anything changes now that the soil materials are wet. Once something is full of water, it is saturated. In this case, water should pass more quickly through the material, as most of the space available in the soil is already full of water.

VII. Discussion Questions

1. What do plants need to grow and survive?
2. How do plants get what they need? (i.e. water, air, light, nutrients)
3. What do the roots of a plant do?
4. Why is soil important for plants?
5. Why are soils different in different climates?
6. If you were a plant growing in a desert, what kind of roots would you have? Why?
7. If you were a plant growing in a rain forest, what kind of roots would you have? Why?
8. If you were a plant that grew along the water's edge, what kind of roots would you have? Describe them.

VIII. Extension Activities

1. Design three different plants: one for the desert, one for a rain forest, one for an aquatic environment. Think about different leaves, roots, stems and seeds these plants would have.

   How would you take advantage of the different climates for your plants?

   How would you protect the plants from potential dangers (i.e. heat in the desert, drowning in a pond)?

2. Draw and label your plants with all of the adaptations you have come up with. Grow seeds in different kinds of soil. Predict which seeds will grow the fastest. Monitor their growth and keep records of when the seeds germinate and how much they grow each day. (Radishes are fast-growing plants, but experiment with different kinds of seeds. Try some cactus seeds, native plants like California poppies that are likely drought-tolerant, or some water-loving tropical plants.)

IX. Vocabulary

(See also the Reading Plants primary and secondary vocabulary lists.)

porous	having space for water or air to move through
perlite	lightweight volcanic rock that is crushed and added to soil to make it more porous (and it's more readily available than pumice—try a garden center)
pumice	lightweight volcanic rock that is crushed and added to soil to make it more porous
soil	surface layer of the earth containing broken-down rocks, minerals, and decaying organic material