Learning from Leaves: Adaptations to Differing Light Levels

Grades 3–6

I. Introduction

Plants, like all other living organisms have basic needs: a source of nutrition (food), water, space in which to live, air, and optimal temperatures in order to grow and reproduce. For most plants, these needs are summarized as light, air, water, and nutrients (known by the acronym LAWN).

Students will carry out an experiment to see the effect of different light levels on growth and health of plants from two different environments.

II. Objectives

- Students will draw conclusions about adaptations to a specific environment based on measurements and observations of plants from a tropical rain forest and desert environments grown at low and high light levels.
- Students will make inferences about the concept of adaptations, and how adaptations that enable an organism to thrive in one environment may ensure its demise in another.

III. Standards Assessed

Grades 3–5

Life Sciences

Science Content Standards K–12 (2000), California State Board of Education

- Plants have structures that serve different functions in growth, survival and reproduction (3-3.a).
- Students know examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands (3-3.b).

Grades 3–5 (cont.)

- Ecosystems can be characterized by their living and nonliving components (4-3.a).
- In any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all (4-3.b).

Investigation and Experimentation

Science Content Standards K–12 (2000), California State Board of Education

- Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students should develop their own questions and perform investigations (3–5, 4–6, 5–6).
  - Use numerical data in describing and comparing objects, events, and measurements (3–5.c).
  - Predict the outcome of a simple investigation and compare the results with the prediction (3-5.d).
  - Collect data in an investigation and analyze those data to develop a logical conclusion (3–5.e).
  - Identify the dependent and controlled variables in an investigation. Construct and interpret graphs from measurements (5-6.d).

The Living Environment

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

- In any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all (5.D. 3–5).

Grades 6–8

Life Sciences

Science Content Standards K–12 (2000), California State Board of Education

- The number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition (6–5.e).

Investigation and Experimentation

Science Content Standards K–12 (2000), California State Board of Education

- Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students should develop their own questions and perform investigations (6–7; 7–7; 8-9).
  - Students will recognize whether evidence is consistent with a proposed explanation (6–7.e).

The Living Environment
Benchmarks for Science Literacy (1993), American Association for the Advancement of Science

- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce (5.A 6-8).
- In all environments—freshwater, marine, forest, desert, grassland, mountain, and others—organisms with similar needs may compete with one another for recourses, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions (5.D 6-8).

IV. Background

While at the Huntington Botanical Gardens, your class will visit three different gardens: the Desert Garden, Lily Ponds, and Jungle Garden. Each of these gardens represents a distinct plant community in which plants exhibit adaptations to the unique conditions of their local environment.

Plants meet their needs in different environments in different ways, since the quantity or quality of resources varies from one ecosystem type to another. In order to appreciate the complexity of natural communities and make comparisons between them, students need to understand the basic needs of living organisms and how these resources are obtained.

Limiting Factors: One ecological principle that can be explored in this lesson is the concept of the limiting factor. Limiting factors can be defined as environmental aspects that limit the success of one or more organisms in a given community or ecosystem, acting to restrict one or more of its functions (for instance, photosynthesis may be restricted in plants that grow on the floor of a tropical rain forest). By exploring the basic needs of plants (light, air, water, and nutrients), and making community measurements, students can begin to appreciate that one of these basic resources may occur in abundance in one environment (say "sun" in the desert) but be limiting in another ("sun" is a limiting factor on the floor of a tropical rain forest).

Light level variations in different environments and their effect on leaf development and growth: In dry, hot, sunny environments, water is often a limiting factor. Leaves from these environments may exhibit special adaptations that retard water loss. For example, the leaves may be covered with a thick waxy layer that keeps moisture inside the leaf. On the other hand, there may be excessive radiant (sun) energy in deserts that, when absorbed by leaves and other plant parts, is converted to heat. If the temperature levels of the absorbed heat are high enough, cells may begin to die and molecules (for instance, in the chloroplasts) may begin to disintegrate.

Studies have shown that wide leaves heat up more than narrow leaves of the same length. In general, small, narrow leaves are well adapted to hot, dry, sunny environments. Leaves may also be arranged vertically to reduce exposure to the hot, drying sun when the sun is at its zenith.

In moist, shady environments light may be a limiting factor. Leaves from these environments may exhibit adaptations that enhance their ability to absorb the sunlight that penetrates to the forest floor. Large leaves arranged horizontally absorb the maximum amount of light possible. Where radiant energy is scarce, overheating is not a problem and leaves may have a low length to width ratio.

Wetlands present special challenges to plants. Water is not a limiting factor in permanently wet marshes and ponds, but can be limiting on a seasonal basis in some river and stream channels in southern California (abundant in winter, limiting in summer). Sunlight may be abundant in open areas above the surface of the water, and limiting below the water surface or in the shade of tall emergent plants. Often the appearance of the leaves in a wetland environment will be a clue as to the seasonal nature of the water supply.

For simplicity's sake, we are going to focus this activity on plants from a hot, dry, sunny environment and a moist, shady environment.

V. Materials Needed (for each group of 3–4 students)

- 2 identical plants from a rain forest environment (*Philodendron* or other "rain forest" house plant with large, deep green, horizontally-oriented leaves)
- 2 identical plants from a desert environment (desert cactus or other desert plant)
- sunny outdoor area for growing plants (a small table, cart, or bench that can be moved inside at night works well if no space is available) or sunny windowsill
- low-light environment for growing plants (shelf in classroom away from direct light)
- labels to place on sides of pots
- marking pens
- data sheets (see below)
- measuring cups
- water

VI. Procedure

Explain to the students that they will be doing an experiment to see if plants differ in their tolerance of light levels. For instance, plants growing on the floor of a rain forest have really need sunlight in which to grow. Ask them to formulate a hypothesis about what is going to happen in the experiment. Ask students to be specific in their predictions. Discuss scientific methods with your students and ask

them to determine which variables are dependent and independent. These early steps will help them reason through the process and analyze the results in a critical and thoughtful manner.

1. Divide the students into groups of 3-4 students.
2. Provide each group with two identical plants from the tropical rain forest and two identical plants from a desert environment.
3. Label one plant with group name/number and the word "rain forest—high light" (for instance, "Table 1—rain forest—high light"). Label the other plant with group name/number and the words "rain forest—low light" ("Table 1—rain forest—low light"). Do the same for the desert plant.
4. Use the data sheet at the end of this lesson plan to write out the hypothesis for this experiment and to make initial, baseline measurements of each plant's height, number of leaves and flowers, and their respective color. These may change during the experiment, so it is important to accurately record these measurements at this time.
5. Place all the plants that are labeled "high light" in one area in a sunny location outside or on a windowsill.
6. Place all the plants that are labeled "low light" in a low light environment that still receives some indirect sun, such as a windowsill under deep eaves in the classroom, or a more centrally placed table.
7. Establish a routine for watering the plants that are labeled "high light"— check them every day, and water them when the soil begins to dry out. Also check the plants in the low light environment and keep them watered, if needed. (Note: in this experiment, the amount of sunlight is the only experimental (independent) variable, so it is important to keep plants in both locations evenly moist).
8. Repeat measurements of both plants at least once a week.
9. Carry out the experiment for 4 weeks and then have students record their results on their data sheets, as well as on classroom charts and graphs that summarize the data for the whole class.
10. Discuss the results.

VII. Discussion Questions Including Those Related to *Reading Plants*

1. What happened to the plants that received ample sunlight during this experiment?
2. How did the rain forest and desert plant differ in their response to full sunlight?
3. What happened to the plants that received low light levels?
4. How did the rain forest and desert plant differ in their response to low light?

5. Discuss how adaptations that enable a plant to survive the heat and dryness of a hot, dry, sunny environment are not effective in a low light environment such as the forest floor in a rain forest.

6. Discuss how adaptations that enable a plant to survive the moist, low light environment of a forest floor in a rain forest are not effective in a hot, dry, sunny environment.

7. Summarize the adaptations that enable a plant to flourish in a hot, dry, sunny environment and a moist, low light environment.

VIII. Web Links

Observe a Leaf: Lesson Plans Page (EdScope, L.C.C.)
Activity in which students collect, observe, and describe leaves.
< http://www.lessonplanspage.com/ScienceLeafObservations.htm >

Water Science for Schools (United States Geological Survey)
Background, links, and online activities related to water.
< http://wwwga.usgs.gov/edu >

Vocabulary

adaptation	a change in plants and animals over many generations in response to environmental conditions
environment	conditions; all the conditions around a plant or an animal, such as, amount of space in which to live, climate, other plants and animals, etc.
limiting factor	an environmental aspect that limits the success of one or more organisms in a given community or ecosystem, acting to restrict one or more of its functions

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Name:_____ Date: _____

Name of plant:_____

My hypothesis:

Procedure I used:

Rain Forest Plant High Light	Rain Forest Plant Low Light
Baseline—first day of experiment Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	***Baseline—first day of experiment*** Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:

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Rain Forest Plant High Light	Rain Forest Plant Low Light
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
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Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:

Learning from Leaves: Adaptations to Differing Light Levels

Desert Plant High Light	Desert Plant Low Light
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:

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Desert Plant High Light	Desert Plant Low Light
Baseline—first day of experiment Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	***Baseline—first day of experiment*** Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:
Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers:	Date: Height of main stem: # leaves: color of leaves: # flowers:. color of flowers: