Learning from Leaves: A Look at Leaf Size

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).

Plants meet their needs in different environments in a variety of ways, since the quantity or quality of resources varies from one ecosystem type to another.

II. Objectives

- Students will make measurements of leaves from different environments.
- Based on measurements and observations of these environments, students will make inferences about the environmental variables that might contribute to differences in leaf size and texture.

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).
- 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).

Grades 3–5 (cont.)

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).
  - Students will use numerical data in describing and comparing objects, events, and measurements (3–5.c).
  - Students will collect data in an investigation and analyze those data to develop a logical conclusion (3–5.e).

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).
  - 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

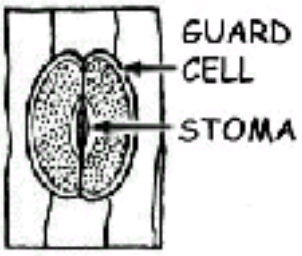
- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce (5.A 6-8).
- In all environments—freshwater, marine, forest, desert, grassland, mountain, and others—organisms with similar needs may compete with one 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 the 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.

Leaves contain chloroplasts where photosynthesis occurs. During photosynthesis, chlorophyll (the green pigment contained in chloroplasts) captures the energy of sunlight and transfers it to other molecules within the chloroplast. Thus, radiant energy from sunlight, carbon dioxide from air, and water and nutrients absorbed by the roots are used to make glucose (sugar). Oxygen is a byproduct of photosynthesis and is used by most living things (including plants) to carry on respiration.



Plants take in air through small openings in their leaves (and sometimes stems) called stoma (plural = stomata) that are surrounded by guard cells. Stomata look like a pair of lips and when they open, carbon dioxide moves into the leaf while oxygen and water move out of the leaf. This latter process is called transpiration.

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).

Leaf size as a reflection of the environment: In dry, hot, sunny environments, water is often a limiting factor. So 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. Small leaves have less total surface area than large leaves, and they lose less water than large leaves. Overheating can also be a problem for large leaved plants in dry, hot environments. Studies have shown that wide leaves heat up more than narrow leaves of the same length. An evaluation of the length to width ratio of plants from different habitats

can yield interesting results. In general, leaves with higher length-to-width ratios are relatively elongate and narrow and dissipate heat faster than leaves with smaller length to width ratios. Leaves with higher length-to-width ratios have more surface area per volume for heat loss than leaves with lower length to width ratios. 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. One factor that is often limiting is oxygen, which is needed by plant roots for respiration. Many wetland plants have leaves with special air-conducting tissue (called aerenchyma) that aids in oxygen transport to roots. 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

- large leaves from plants found in a shady environment (local streamside trees such as sycamore, or a leaf or cutting of *Philodendron* or another tropical forest species from any plant store)—two or more different kinds of leaves would be optimal. Keep leaves on stems in jars of water or in Ziploc bags.
- small leaves from plants found in a hot, dry environment (local chaparral plants such as *Ceanothus*, or a leaf or cutting of *Crassula* or another desert species from plant store or yard)—two or more different kinds of leaves would be optimal. Keep leaves on stems in jars of water or in Ziploc bags.
- rulers
- pencils or pens
- data sheets

VI. Procedure

Guide your students through a discussion of the needs of living things. Discuss photosynthesis, transpiration, and limiting factors. Ask students to compare and contrast the environmental variable in a desert compared with a tropical rain forest.

1. Divide the students into groups of 3-4 students.
2. Provide each group with the leaves of plants from a dry, hot, sunny environment and those from a shady, moist environment. Ask students to describe the leaves on their data sheets. Factors to consider include overall shape, size, color, and arrangement on the stem. Ask students to feel the leaves with their eyes closed and describe any differences in thickness or texture. If possible, measure leaf width with a ruler.
3. Ask students to sort the leaves into two groups: one group representing plants they think are from the hot, dry, sunny environment and the other group representing plants they think are from a shady, moist environment.
4. Measure the length and width of six leaves from each plant. Measurements should be made across the longest and widest parts of the leaves. Record measurements on data sheet.
5. Determine the average length and the average width for each plant sample. Then calculate the average length and width for the plants from the hot, dry, sunny environment and for plants from the shady, moist environment.
6. Calculate the length to width ratio for each leaf type by dividing the average leaf length by the average leaf width.

VII. Discussion Questions

1. What differences did you observe between the leaves from a hot, dry, sunny environment and those of a shady, moist environment?
2. From which environment did you measure larger leaves? Smaller?
3. What environmental variables do you think affect leaf size in these two habitats?
4. What do you think the limiting factors are in each of these habitats?
5. Why do you think the length-to-width ratio might be relevant?
6. Which plants had the thickest leaves?
7. Which plants had the thinnest leaves?
8. What advantage do you think leaf thickness might give to a plant?

VIII. Discussion Questions Related to ***Reading Plants***

After your visit to the Huntington Botanical Gardens, explore the following questions:

1. What patterns can you see in leaf size in the Jungle Garden compared with the Desert Garden? (*Jungle Garden plants tend to have very large leaves while Desert Garden plants have no leaves, tiny leaves, or spines*.)

2. Can you discern differences in leaf orientation as well? (*More vertically oriented leaves in Desert Garden, more horizontal leaves in Jungle Garden*.)

IX. Extension Activites & Web Links

See the other Learning From Leaves lesson plans.

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 >

Vocabulary

adaptation	a change in plants and animals over many generations in response to environmental conditions
chlorophyll	the green pigment in plants that captures the energy of light and enables them to make sugars
chloroplast	an oval-shaped body in plant cells that contains chlorophyll and is the site where photosynthesis and starch formation occur
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
nutrient	a necessary ingredient for a plant's growth and survival, such as, nitrogen or potassium
photosynthesis	the process in plants by which the sun's energy (light energy) is captured by chlorophyll and converted to chemical energy that is stored in sugars, by combining carbon dioxide (CO_2) and water (H_2O) to make sugars ($C_6H_{12}O_6$) and release oxygen (O_2): $6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$
respiration	the process in living organisms by which sugars ($C_6H_{12}O_6$) are combined with oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O), and to release energy for the organisms' use in growth, etc.: $C_6H_{12}O_6 + 6\ O_2 \text{ —> } 6CO_2 + 6H_2O + \text{energy}$
stoma (pl. stomata)	a very small pore in the surface of a leaf (oxygen and carbon dioxide from the air enter through the stomata; oxygen, carbon dioxide, and water vapor leave through the stomata)
transpiration	the loss of water vapor by plant parts that occurs mostly through pores (stomata) on the leaf surfaces

Learning from Leaves: A Look at Leaf Size

Name:________________________________ Date:____________

Plant name:

Habitat or plant community you think it is from:

	Leaf length	Leaf width
Leaf #1		
Leaf #2		
Leaf #3		
Leaf #4		
Leaf #5		
Leaf #6		
Average		

Length width/ratio:

Plant name:

Habitat or plant community you think it is from:

	Leaf length	Leaf width
Leaf #1		
Leaf #2		
Leaf #3		
Leaf #4		
Leaf #5		
Leaf #6		
Average		

Length width/ratio:

Plant name:

Habitat or plant community you think it is from:

	Leaf length	Leaf width
Leaf #1		
Leaf #2		
Leaf #3		
Leaf #4		
Leaf #5		
Leaf #6		
Average		

Length width/ratio:

Plant name:

Habitat or plant community you think it is from:

	Leaf length	Leaf width
Leaf #1		
Leaf #2		
Leaf #3		
Leaf #4		
Leaf #5		
Leaf #6		
Average		

Length width/ratio: