



Botanical Garden Programs: Reading Plants

LEARNING FROM LEAVES: A LOOK AT LEAF COLOR



Grades 3–6

I. Introduction

Plants, like all 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).

Leaves come in a broad range of colors, from white to various shades of green, as well as incorporating reds, purples, and yellows. This lesson focuses on leaves of various shades of green.

II. Objectives

- ◆ Students make measurements of temperature using different shades of fabric.
- ◆ Students will then apply that information to studies of leaf color in plants from different environments.
- ◆ Based on measurements and observations of leaves with different colored surfaces, students will make inferences about the environmental variables that might contribute to differences in leaf color.

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).

Grades 3–5 (cont.)

- ◆ Students know examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands (3-3.b).
- ◆ 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).
 - 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).
 - Students 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 resources, 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. There, radiant energy from sunlight, carbon dioxide from air, and water and nutrients absorbed by the roots are combined to make glucose (sugar). Oxygen is a byproduct of photosynthesis and is used by most living things (including plants) to carry on **respiration**.

There are two main green pigments in the chloroplasts, Chlorophyll a and Chlorophyll b. Chlorophyll a is the primary pigment that captures sunlight and transfers it into chemical energy during the course of photosynthesis. Chlorophyll b, along with others (chlorophyll c in some algae, carotenoids and phycobilins with red, yellow, orange, and purple pigments), are accessory pigments that transfer absorbed energy to Chlorophyll a in photosynthesis.

Light-colored leaves that look white or gray have green pigment, but leaf surface modifications mask the color. The surface layer of some leaves produce hairs that have a variety of functions, which can include retaining moisture, reflecting heat and light, and protecting the leaf from herbivores.

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 color 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 covering of hairs that trap moisture that may be escaping from the leaf during the process of **transpiration**. The presence of this moisture on the hairs around the **stomata** can slow down the transpiration process by increasing the relative humidity near the leaf surface.

Overheating can also be a problem for many plants in dry, hot environments. Since only about 3% of incoming radiant energy is utilized in photosynthesis by plants in full sun, the rest of the absorbed radiant energy may be converted to heat, essentially cooking the leaves. Heat loss is possible when the plant transpires (but adequate water is a necessity for this process), as well as by physical processes that involve carrying heat away from a plant surface (for instance, toothed leaves may increase air turbulence, creating little breezes that carry away some of the heat). In addition, plants have adaptations that prevent heat absorption in the first place, such as smaller leaf surfaces and light coverings on the surface of the leaves. Studies have shown leaves covered with light colored wax or hairs may absorb less than 50% of the radiant energy of dark-colored leaves.

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 dark green leaves arranged horizontally absorb the maximum amount of light possible. Where radiant energy is scarce, overheating is not a problem and leaves are dark in color.

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)

- ◆ white, black, and green fabrics or bandanas. All should be of same thickness and texture.
- ◆ 3 thermometers
- ◆ dark green leaves from plants found in a shady environment (local streamside trees such as sycamore, or 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.
- ◆ gray leaves from plants found in a hot, dry environment (local chaparral plants such as white sage (*Salvia apiana*), or leaf or cutting of Dusty Miller or another gray-leaved 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.
- ◆ plant light intensity meter (reasonably priced models can be ordered from the NASCO catalog)
- ◆ 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 variables of a desert compared with a tropical rain forest.

1. Divide the students into groups of 3-4 students.
2. Provide each group with 3 different colored fabrics and thermometers.
3. Place thermometers on sunny windowsill or out on a sunny bench. Cover each thermometer with a different colored fabric. (Note: this activity works best on a sunny day.)
4. After 5 minutes, record temperatures.
5. Provide each group with light green leaves of plants from a dry, hot, sunny environment and dark green leaves of plants 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.
6. 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.
7. Take leaves outside in the full sun. Using the Plant Light Intensity Meter, measure the ambient (surrounding) light level by holding the probe at the leaf's level, pointing toward the sun. Then point the probe toward a light-colored leaf (hold it about 2 inches above the leaf's surface with the probe pointing toward

the leaf), and measure reflected light level. Light level is measured in foot-candles, the amount of light a candle produces at a distance of one foot. Record your measurements. Next, repeat with a dark-colored leaf and record ambient and reflected light levels. Repeat for 6 leaves of each type. To determine reflectance, divide the reflected light measurement by the ambient light measurement.

VII. Discussion Questions

1. What was the difference in temperature (heat absorbed) between the different colored fabrics?
2. If you went to Death Valley when it was 130° F, would you rather be wearing a white shirt or a black shirt? Why?
3. What differences did you observe between the color of leaves from a hot, dry, sunny environment and those of a shady, moist environment?
4. Which color of leaf reflected the most light? In what environment might high reflectance be useful to a plant? How? In what environment might low reflectance be useful? How?
5. What environmental variables do you think affect leaf color in these two habitats?
6. What do you think the limiting factors are in each of these habitats?

VIII. Discussion Questions Related to *Reading Plants*

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

1. In which environment were high ambient light levels measured? Low levels?
2. What patterns can you see in leaf color in the Jungle Garden compared with the Desert Garden?
3. Do you think a plant with small, gray leaves could survive on the floor of a rain forest? Have you ever seen a photograph of a forest floor covered with gray-leaved plants?
4. Do you think a plant with large, green leaves could survive the summer in a desert?

IX. Extension Activities & Web Links

See the lesson plan **Learning From Leaves: A Look at Leaf Size**.

Photosynthesis: Don't "Leaf" Out Fall's Most Valuable Lesson:

Lesson Planning Center (Education World)

Lesson planning article with links to lessons and sites.

< http://www.educationworld.com/a_lesson/lesson024.shtml>

The Colors in White Light: Rain Forest Curriculum: (Rain Bird Corporation)

Activity in which students collect, observe, and describe leaves.

< http://www.rainbird.com/rainforest/rainbird_7.pdf>

Magic Cabbage: Science Arts: (Bright Ring Publishing)

Using pigments from a red cabbage to paint pictures.

< <http://teachers.net/gazette/JAN03/crafts.html>>

Vocabulary

<i>adaptation</i>	a change in plants and animals over many generations in response to environmental conditions
<i>chlorophyll</i>	the green pigment in plants that captures the energy of light and enables them to make sugars
<i>chloroplast</i>	an oval-shaped body in plant cells that contains chlorophyll and is the site where photosynthesis and starch formation occur
<i>environment</i>	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.
<i>limiting factor</i>	an environmental variable that limits the success of one or more organisms in a given community or ecosystem, acting to restrict one or more of its functions
<i>photosynthesis</i>	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 ₂ O) to make sugars (C ₆ H ₁₂ O ₆) and release oxygen (O ₂): $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
<i>respiration</i>	the process in living organisms by which sugars (C ₆ H ₁₂ O ₆) are combined with oxygen (O ₂) to form carbon dioxide (CO ₂) and water (H ₂ O), and to release energy for the organisms' use in growth, etc.: $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}$
<i>stoma (pl. stomata)</i>	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)
<i>transpiration</i>	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 Color

Name: _____

Date: _____

Temperature under white fabric: _____ (°F or °C, circle one)

Temperature under green fabric: _____ (°F or °C, circle one)

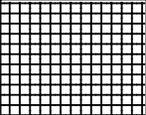
Temperature under black fabric: _____ (°F or °C, circle one)

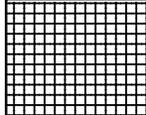
Plant name:

Plant name:

Habitat or plant community
you think it is from:

Habitat or plant community
you think it is from:

	Ambient light level (foot candles)	Reflected light level (foot candles)	% of light reflected
Leaf #1			
Leaf #2			
Leaf #3			
Leaf #4			
Leaf #5			
Leaf #6			
Average			

	Ambient light level (foot candles)	Reflected light level (foot candles)	% of light reflected
Leaf #1			
Leaf #2			
Leaf #3			
Leaf #4			
Leaf #5			
Leaf #6			
Average			