What Plants Need in Order to Survive and Grow: Air

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).

Students will conduct an experiment to evaluate whether plants need air in order to survive and grow.

II. Objectives

- Students will learn how to conduct an experiment and use this knowledge to gather data about how plants respond to being providedwith or deprived of air.
- After making observations and measurements, students will analyze their data to draw conclusions about basic plant needs.

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).
- Plants have structures for gas exchange (photosynthesis and respiration) and transport of materials (5.2.a).

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).

Grades 6–8

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).

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).

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.

This lesson focuses on air, the "A" in LAWN. Plants use carbon dioxide (CO_2) from the air in the process of photosynthesis. This energy is used by the plant to power the construction of living tissue so that the plant can grow and reproduce.

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.

Submerged aquatic plants obtain carbon dioxide and oxygen as gasses dissolved in water.

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, and oxygen and water out of the leaf. This latter process is called transpiration.

V. Materials for each activity (for each group of 3-4 students)

Looking at stomata

- 3 identical potted plants (*Philodendron* is good for this)—use the same plant for all groups in the class
- clear nail polish
- glass slides and cover slips
- eye dropper with water
- microscope (compound)
- data sheets

Looking at transpiration as evidence for gas exchange

- 3 identical potted plants (*Philodendron* is good for this)—use the same plant for all groups in the class
- sunny outdoor area, hot lamps, or a very sunny windowsill
- small plastic bags (sandwich size is good) and twist-ties (two for each student)
- data sheets
- marking pens
- petroleum jelly
- water

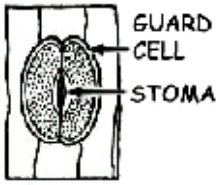
VI. Preparation

Guide your students through a discussion of the needs of living things, light, air, water, and nutrients (LAWN). When discussing each need, describe it as representing a natural resource. Then discuss underlying concepts related to the resource. Explain that air is made up of a number of basic components: carbon dioxide, oxygen, nitrogen, and water vapor as well other gases and molecules.

This would be a good time to begin exploring photosynthesis in the appropriate depth for your grade level. There are many lesson plans available on photosynthesis and respiration (see Extension Activities).

Looking at stomata.

Explain to the students that plants take in air through small openings in their leaves (and sometimes stems) called stoma that are surrounded by guard cells. Stomata look like a pair of lips and when they open, carbon dioxide moves into the leaf and oxygen and water tend to diffuse out of the leaf. (The loss of water from a plant when the stomata open is called transpiration.) Students will make some slides in order to observe stomata and then will gather evidence that plants absorb air (carbon dioxide) and give off water (transpire).



1. Divide the class into groups of 3–4 students.
2. Provide each group with a potted plant.
3. Brush the top and bottom of a leaf with nail polish and let dry.
4. At the edge of a leaf, gently pull up two strips of the dried nail polish—one from the top of the leaf and one from the bottom. The nail polish will adhere to the epidermal cells of the leaf, including the stomata.
5. Make glass slides of the strips of dried nail polish (called a "stomatal peel") by first placing them on a glass slide and then adding a drop of water. Add a small cover slip to the top
6. Using a compound microscope, place the first glass slide on the stage at the lowest power and then carefully bring it into focus. Previous practice using a compound microscope is helpful in order to avoid breaking the slides.
7. Observe the stomata and draw them on the data sheet. Repeat this for the second slide.
8. Count the number of stomata gathered from the top leaf surface.
9. Count the number of stomata gathered from the bottom leaf surface. Compare.

Looking at transpiration as evidence for gas exchange

1. Each student should label a plastic bag with their name and the word "air"; a second bag should include name and the words "no air."
2. Place the bag labeled "air" over a fresh leaf and tie the base securely.
3. Select a second leaf similar in size and orientation to the first leaf. Cover both surfaces of the leaf with petroleum jelly. Place the bag labeled "no air" over the leaf and tie the base securely.
4. Place the plants outside in full sun, under hot lamps, or on a very sunny windowsill.
5. Record on the data sheet which leaves have the most moisture on the inside of the bag after 5, 10, 15, or more minutes.

VII. Discussion Questions

1. Why do you think there might be a difference in the number of stomata on the top of the leaf and the bottom of the leaf? (*Dirt is more likely to clog stomata on the tops of leaves.*)
2. What differences did you observe between the leaves in bags exposed to air versus those that were prevented from receiving air due to the petroleum jelly covering?
3. What would happen to the plant if it could not receive any air?

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

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

1. Where do you think stomata are located on leaves of plants from the rain forest? (*Stomata are common on both leaf surfaces to maximize photosynthesis.*)
2. Where do you think stomata are located on leaves of plants from the desert? *(Stomata re often just on the bottom of leaves away from the hot sun's rays, or sunken into pits surrounded by moisture-trapping hairs.)*
3. Where do you think stomata are located on leaves of plants from the ponds and marshes? *(Stomata are on the tops of the leaves of water lilies, not the bottom—the upper surfaces of the leaves are exposed to air, the lower leaf surfaces to water; stomata may be on both leaf surfaces of plants with leaves above the water; stomata may be present on submerged leaves but are usually non-functional.)*

IX. Extension Activites & Web Links

Do stomatal peels on a variety of plants from different habitats such as those on the Reading Plants tours. Patterns may become evident, such as no stomata on upper leaf surfaces of plants from dry areas (to decrease transpiration rates where water is in short supply), or fewer stomata may be present. On the other hand, water plants such as water lilies will only have stomata on the upper leaf surfaces, which are the only ones exposed to air!

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

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

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.:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

stoma (pl. ***stomata***) — a very small hole 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

Do Plants Need Air?

Name:_____ Date:_____

Looking at stomata

Draw stomata

Top Leaf Surface

Bottom Leaf Surface

Number of stomata on top of leaf?

Number of stomata on underside of leaf?

Looking for transpiration:

Air		No air	
Time:	Moisture:	Time:	Moisture:
Time:	Moisture:	Time:	Moisture:
Time:	Moisture:	Time:	Moisture:
Time:	Moisture:	Time:	Moisture:

Results and conclusions: