 Huntington Library, Art Collections, and Botanical Gardens

Reading Plants

Overview

Students learn to "read" plants: by studying a plant's physical traits, they will be able to extrapolate facts about the environment in which the plant evolved.

Introduction:

Plants depend on their physical environment to obtain what they need to live and grow. Their requirements can be summarized with the acronym L.A.W.N., which stands for light, air, water, and nutrients. If the plant does not receive the proper amount of each (too little, but in some cases too much), the individual plant will eventually die. The requirement that is outside of the zone of tolerance limits the growth of the plant, and is called the limiting factor.

The limiting factor in an environment can be a driving force for evolution. For example, in a desert where water is a limiting factor, plants that thrive have adaptations to conserve water, such as light color or succulent leaves. These traits originated in mutations that were selected for in a population over time. The individuals with beneficial mutations that helped overcome the limitations in the environment lived to reproduce and pass on their genetics. Eventually the population changed as well.

Each environment has its own set of limiting factors. By visiting (either physically or hypothetically) desert, aquatic, bog, jungle, or other environments, one can make predictions about the limiting factors. A study of the plants in that environment, then, should reveal traits that are adaptations to mitigate the environment's limitations.

Motivation:

Bring a Venus fly trap or a sundew to class. Have the students examine it and ask a series of questions to focus their examination: What do you notice about this plant? How is it different or the same to other plants? What is unique about it? How do plants get food? How does *this* plant get food? How do plants get nutrients? How does *this* plant get nutrients? Why don't other plants "eat" bugs? (discussion should include adaptations to the environment in which they evolved).

Ask the students if it is possible to describe the environment from which this plant comes when we are only observing it in the classroom? Could they do that with other plants?

Objectives:

Upon completion of the lab, students should be able to

1. List four environmental factors on which plants depend for survival.
2. Define and discuss the relationships among *limiting factors, evolution, adaptation,* and *natural selection*.
3. Make predictions about the environment in which a plant evolved from a study of the plant's physical traits.

Materials:

- Plants from different environments (at least one from each chosen environment), such as
    i. Desert or arid environments: cacti, succulents (ice plant, jade plant, agave, etc)
    ii. Aquatic: water hyacinth, *Elodea*, water lilies
    iii. Bog: sundews, Venus' fly traps, pitcher plants
    iv. Rainforest: philodendron, *Monstera*, *Zebrina* ('wandering Jew')
- Squirt bottles (optional)
- Either a place to visit example environments (such as a botanical garden) or pictures of example environments

Associated California Biology Standards:

7a. Students know why natural selection acts on phenotype rather than the genotype of an organism.
7d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.
8a. Students know how natural selection determines the differential survival of groups of organisms.

Procedure:

1. In each case, students will think about key abiotic aspects of an environment, and then try to predict what those conditions mean for the plants that grow there—how they will get what they need to survive. If you can take a field trip to a park or botanic garden, you may be able to find two or more areas that will serve as different "environments". If so, conduct the activity outside in those areas. If travel is not possible, have pictures of different environments and each time you present a new one, have the students picture the environment, look at the photos, and discuss the conditions. You may choose to compare as many or as few of the four example environments as you wish, in the order you choose.
2. Have the students generate a list of what plants need to obtain to survive. The answers should include light, air, water, and nutrients (L.A.W.N.). How does a plant obtain these things from its environment?
3. Next ask them to consider how their answers vary when considering plants in different environments. For instance, how does a plant in the Mojave Desert obtain water from its environment; how does an aquatic plant in a lake do the same? If the environment varies around the world, and every place does not have the same amount of rainfall, sunlight, heat, or wind, then how do plants live just about everywhere on the planet? How do they manage to live in all these different environments? Your students should begin to identify elements of evolution and adaptation.
4. Now begin a journey through different environments (starting at Step 5), and ask the students to consider which environmental factors will pose the most problems for plants in obtaining LAWN. The condition in an environment that poses the highest restrictions for growth, which has a critical point over or under which the plant will die, is called a limiting factor. For instance, the limiting factor in a desert is often the lack of water. But there can be more than one limiting factor (high light, for instance).

In each environment, after they consider the nature of the environment, they should predict the limiting factors. The can write these down as they go in the table in their student sheet. Finally, they should then study the plants and look for physical clues that show them how the plant obtains LAWN even amongst limiting factors. What traits of the plant were adaptations to the limiting factors of that environment? They may also track these in the second table on their student sheet. Put another way, what factors of that environment provided the driving force for natural selection, and what traits were the results of that? Natural selection selects for the traits, but your students should also consider in each case how the traits first arise. In every case, the answer is through random mutations.

5. In a bog, what is the environment like? Ask your students to consider each aspect of LAWN, is it high or low in this environment? In a bog, light and air are at fairly normal levels (though air to the roots can be very low, see below), while water is very high and nutrients very low. The reasons for this are largely due to the material in which bog plants grow: sphagnum moss and peat. Bog soils are largely a special moss—sphagnum—and when it decays it is called peat. Both hold massive amounts of water, like a sponge. They also lower the pH of the bog so that most things won't quickly decompose. Therefore, nutrients are low. Ask you students to consider each of these factors: if there is a lot of water, how will that affect the plant? (The plant's roots will have to adapt to having low oxygen available). If there is low nutrients, how can a plant obtain what it needs? Have them look at a bog plant like a flytrap or a sundew. What do they notice about the plant? How might what they notice be an adaptation to the bog environment? (Carnivorous plants catch and digest insects to obtain the nitrogen which is otherwise very low or unavailable in the sphagnum-heavy soil).
6. Ask your student to describe a desert environment. How does it compare to a bog? How are the elements of LAWN different? (High light and heat, available air, low water, and low nutrients because there isn't an abundance of living material to break down in the soil). Ask the students to then predict traits of desert plants that help them deal with high light but low water. Next, bring out an example desert plant and ask the students to study it and list details that are adaptations to the desert environment. Examples might include photosynthetic stems and/or small leaves (reduces surface area exposed to sun and evaporation); light colors (reflects light); shading from spines or fur; succulence (water storage); and rosette growth forms (funnels available water to roots). You may use a squirt bottle on the plant to demonstrate how many desert plants have growth forms that help them funnel water to the roots.
7. Have your students describe life in an aquatic environment, like a lake. How does it compare to a desert? Have students list the characteristics of LAWN in a lake. (Low available air, high water, low light below surface, usually available nutrients). Have students predicts traits of aquatic plants that help them obtain air when it is in short supply and deal with life surrounded by water. Show an example of an aquatic plant, like a water hyacinth. Ask the students to study it and list details that are adaptations to the aquatic environment. Examples might include the feathery roots that increase the surface area in contact with air and nutrients in the water, air bladders to help with flotation, waxy leaves to channel water off the leaf surface (so the plant doesn't sink), and stomata on the upper side of the leaf (normally the holes for gas exchange are on

the lower side of the leaf, for an aquatic plant that would be in water instead of to the air).

8. Finally, ask the students to consider life in a rainforest environment. What is it like? How does it compare to a desert or a bog? Describe the characteristics of the environment in terms of LAWN (low light, high water, available air, but low nutrients because the abundance of life uses soil nutrients as soon as they become available.) How do rainforest plants deal with high water but low light? The students should predict traits of the plants based on these limitations. Answers include big, dark leaves to increase the amount of light the plant can "catch"; waxy leaves and drip tips on the ends of leaves that funnel off excess water (test with a squirt bottle); and climbing/vining habits that allow them to reach light. Show them an example rainforest plant and have them name some of the traits that are adaptations to that environment.
9. Summarize the lesson by showing students that by "reading" a plant's physical adaptations, one can predict something about the nature of the environment in which it evolved.

Evaluation:

The following questions are listed under the Analysis section of the student handout and may be used as part of a report, class discussion, or assessment. You will need to provide a plant not used in class for them to use in their answers.

1. What do you notice about this plant? Describe its physical features.
2. How might key physical features of this plant be involved in obtaining light, air, water, and nutrients?
3. What might be a limiting factor to survival in the environment in which this plant evolved? What makes you say that?
4. Describe the environment in which this plant might have evolved. Defend your hypothesis.

Extension Activities:

1. Plant a terrarium for tropical and bog plants as outline in the lesson plan at http://www.huntington.org/Education/lessons/BG-RP-mini-ecosystems.pdf . Ask students what kind of environment they need to create? Why? How will they do it?
2. Assign readings about individual carnivorous plants from The Savage Garden by Peter D'Amato. Students can present a short summary description of the plant to the class in the form of a brief oral report.

Test Preparation:

1. Which statement about the rates of evolution for different species is in agreement with the theory of evolution?
   - (A) They are identical, since the species live on the same planet.
   - (B) They are identical, since each species is at risk of becoming extinct.
   - **(C) They are different, since each species has different adaptations that function within a changing environment.**
   - (D) They are different, since each species has access to unlimited resources.

2. Which concept is not a part of the theory of evolution?
    (A) Present- day species developed from earlier species.
    (B) Some species die out when environmental changes occur.
    (C) Complex organisms develop from simple organisms over time.
    (D) Changes occur according to the needs of an individual organism to survive.

3. Which situation would most likely result in the highest rate of natural selection?
    (A) reproduction of organisms by an asexual method in an unchanging environment
    (B) reproduction of a species having a very low mutation rate in a changing environment
    (C) reproduction of organisms in an unchanging environment with little competition and few predators.
    (D) reproduction of organisms exhibiting genetic differences due to mutations and genetic recombination in a changing environment.

4. In his theory, Lamarck suggested that organisms will develop and pass on to offspring variations that they need in order to survive in a particular environment. In a later theory, Darwin proposed that changing environmental conditions favor certain variations that promote the survival of organisms. Which statement is best illustrated by this information?
    (A) Scientific theories that have been changed are the only ones supported by scientists.
    (B) All scientific theories are subject to change and improvement.
    (C) Most scientific theories are the outcome of a single hypothesis.
    (D) Scientific theories are not subjected to change.