

## **Ideas for Discovery Activities for the TOPS Photosynthesis Lab**

### **BACKGROUND INFORMATION:**

The TOPS lab has been modified to accommodate a discovery approach. A prelab scenario has been provided which can be changed to fit any classroom situation. This particular scenario, which deals with the identification of a plant of unknown origin, has been designed to include several prelab and postlab activities. Teachers should allow students to generate their own labs in this identification process or guide students to choose a prepared lab.

The TOPS lab has been edited to a more inquiry oriented format. The title is now the major question of the lab. The background reveals less information and includes questions to think about while performing the lab. An application and synthesis section has been added to aid the student in determining relevance.

### **GOAL:**

Students will identify the origin of a mystery organism of extraterrestrial origin using the scientific method. In this process they will be using the following TOPS lab.

### **MOTIVATION:**

Bring in many exotic plants--especially CAM plants, to pique their interest. A partial list of CAM plants is included with this reference page.

### **POSSIBLE PERFORMANCE OBJECTIVES:**

The students will, after reading and discussing the scenario:

1. Discover some important plant processes which can lead to biochemical testing.

Suggested activities: Brainstorming, students design experiments

2. Inspect macro- and micro-scopically two CAM plants, one with stomata open and one with stomata closed.

Suggested activities.: Student generated investigations, any plant anatomy lab, a stomata lab, or microscope lab.

3. Measure the pH values of two succulents, one with the stomata closed and one with the stomata open.

Suggested activity: TOPS lab How Do Some Plants Differ In their Photosynthetic Pathways?

4. Discover the factors in plant metabolism which may affect pH, thereby inferring the conditions that created the results.

Suggested activity: TOPS lab application and synthesis sections in How Do Some Plants Differ In their Photosynthetic Pathways?

5. Separate photosynthetic pigments using TLC chromatography on a mystery CAM plant or any other plants as a comparison.

Suggested activities: TOPS lab How Can Plant Pigments be Analyzed Using Thin Layer Chromatography?

6. Design their own investigation on the mystery plant and write it up formally.

Suggested activities: library research, computer search, cross curriculum writing assignment.

---

## TOP SECRET: From the X Files

On July 10, 1995, possibly the first specimen of extra-terrestrial origin was isolated in an unidentified flying object which crashed into a remote Arizona desert area close to the community of Sedona. A few local residents witnessed the 2:00 a.m. event from a distance, and reported to FBI investigators a "flash" and a "sonic boom explosion", during a harmonic convergence ritual. The witnesses were not eager to report this event to authorities due to their belief that they conjured up the UFO during their ceremony.

Investigators recovered a spacecraft of unknown origin with unfamiliar devices and equipment. The Arabic letters of CAM were inscribed into the twisted hull. A computer screen endlessly displayed the numbers 700 and 680. Metallurgists determined the spacecraft to be composed of a metal not known on earth. After the impact there were no engines, motors, or circuits in working order. There was no evidence at the scene of animal or humanoid life aboard the craft. It has been speculated that this ship may have been a robot ship.

One awesome find was a ceramic-like container with an organism resembling, according to FBI scientists, a common terrestrial plant. Experts at this time have incomplete or inconclusive biochemical results. What is known is that this strange organism has openings which permit CO<sub>2</sub> from its environment to enter cells only in the evening. It is assumed that since this organism is taking in CO<sub>2</sub> and is green, photosynthesis is occurring. There appears to be no nervous system.

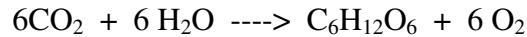
The government has officially denied collecting extra-terrestrial flora from any source. All research has halted due to the intense media attention.

*BUT THE TRUTH IS OUT THERE*

*AND SO IS THE NEED TO KNOW!  
HOW DO SOME PLANTS DIFFER IN THEIR PHOTOSYNTHETIC  
PATHWAYS?*

**BACKGROUND INFORMATION:**

Photosynthesis is the process that plants use to convert CO<sub>2</sub> into carbohydrates (sugar). These carbohydrates are stored (as starch) and are used by the plant for food. The basic formula for photosynthesis is



Generally a plant takes advantage of the light during daytime hours to undergo photosynthesis. Carbon dioxide enters the leaf cells through openings called stoma. Light energy drives a series of reactions to produce glucose and oxygen. Water is needed in this reaction, but water can also be lost through the stoma, as the day progresses.

However, what might happen to a plant if the outside temperature was very hot and arid? What adaptations might a plant make to survive?

**OBJECTIVE:**

In this investigation, you will discover that there is an alternate pathway of photosynthesis which depends on environmental factors such as lightness and darkness.

**EQUIPMENT:**

Electronic balance and a pH meter

**SUPPLIES:**

2 succulent plants (1 in sun for 24 hours and 1 in the dark for 24 hours), scissors, mortar and pestle, sand, distilled water, 10 mL pipette, pipette pump, wash bottle (distilled water), beaker to wash pH meter electrode, 30 mL beakers, stirring rod, grease pencil.

**PROCEDURE:**

1. Remove leaf from unknown succulent plant A.
2. Wash leaf, blot dry with a paper towel.
3. Weigh approximately 0.5 g. of leaf (use scissors to cut pieces of leaf) to 0.01 g.
4. Grind in mortar and pestle with sand and 3.0 mL distilled water.
5. When the leaf material is a homogenous mixture, put into a 30 mL beaker, add 10.0 mL of distilled water and mix thoroughly with a stirring rod.

6. Determine pH of solution with pH meter.
7. Repeat steps 1-6 with unknown succulent plant B.
8. Collect data in a table.

### **ANALYSIS:**

1. Which plant had the lowest pH?
2. Which plant had the highest pH?
3. What might account for the difference in pH values?

### **APPLICATION:**

Succulents and some cacti open their stomata at night to allow CO<sub>2</sub> to enter. At this time, instead of glucose being produced, CO<sub>2</sub> is converted to malic acid and stored for the night. During the day CO<sub>2</sub> is released from malic acid, and proceeds to produce sugar and oxygen. Plants which use this biochemical route are called CAM plants.

1. From your data collected, which plant was left in the dark for 24 hours?
2. Which plant was left in the light for 24 hours?
3. Explain how you determined the answer to Questions 1 and 2.
4. What environmental conditions would force a plant to take in CO<sub>2</sub> only at night rather than during the day?
5. From an evolutionary viewpoint, how has the above adaptation helped CAM plants survive under these conditions?
6. Would you find CAM plants in North America? If so where would you find them growing naturally?

### **SYNTHESIS:**

Not all succulents and cacti use the CAM metabolic pathway for photosynthesis. Examine a non-CAM plant and propose a hypothesis on how they can adapt to the same environmental conditions as a CAM plant, without using the CAM metabolic pathway for photosynthesis.

### **CAM Plants**

CAM stands for Crassulacean Acid Metabolism. Plants in the Crassulaceae family are succulent plants that are adapted to hot climates. Here is a partial list of these types of plants.

Crassula - succulents:

Crassula arborescens  
C. argentea - Jade Plant, also  
C. portulacea  
C. corymubulosa  
C. falcata  
C. lactea  
C. lycopodioides  
C. 'Morgan's Pink'  
C. multicava  
C. pyramidalis  
C. schmidtii  
C. tetragona

Kalanchoe - Succulents

Kalanchoe beharensis - Felt  
Plant, also Kitchingia  
mandrakensis  
K. blossfeldiana  
K. daigremontiana -  
Maternity Plant  
K. manginii  
K. pinnata - Air Plant, also  
Bryophyllum pinnatum  
K. tomentosa - Panda Plant  
K. uniflora

Sempervivum - Houseleeks:

Sempervivum arachnoideum  
- Cobweb Houseleek  
S. tectorum - Hen and  
Chickens

Sedum - Stonecrops:

Sedum acre Goldmoss  
Sedum  
S. album also - S.  
brevifolium  
S. anglicum  
S. confusum  
S. dendroideum  
S. lineare also S.  
sarmentosum  
S. morganianum - Donkey  
Tail or Burro Tail  
S. oxypetalum  
S. reflexum  
S. rubrotinctum -Pork and  
Beans, also S.  
guatemalense  
S. sediforme  
S. sieboldii  
S. spathulifolium  
S. spectabile  
S. spurium  
S. telephium

Echeveria - Succulents

Echeveria agavoides also  
Urbinia agavoides  
E. crenulata  
E. elegans - Hen and Chicks  
E. hybrids  
E. imbricata - Hen and  
Chicks  
E. secunda - Hen and  
Chicks  
E. setosa

Reference: Sunset Western Garden Books, 6th Ed.; 1995 Sunset Publishing Corp; Menlo  
Park, CA