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 CO₂ from its environment to enter cells only in the evening. It is assumed that since this organism is taking in CO₂ 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 CO₂ into carbohydrates (sugar). These carbohydrates are stored (as starch) and are used by the plant for food. The basic formula for photosynthesis is

\[ 6\text{CO}_2 + 6\text{H}_2\text{O} \longrightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]

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-succulents (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 somata at night to allow CO₂ to enter. At this time, instead of glucose being produced, CO₂ is converted to malic acid and stored for the night. During the day CO₂ 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 CO₂ 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. corymbulosa
- C. falcata
- C. lactea
- C. lycopodioides
- C. 'Morgan's Pink'
- C. multicava
- C. pyramidalis
- C. schmidtii
- C. tetragona

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

Sempervivum - Houseleeks:
- **Sempervivum arachnoideum** - Cobweb Houseleek
- S. tectorum - Hen and Chickens

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

Kalanchoe - Succulents
Kalanchoe beharenis - 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

Reference: