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Fascinating Education Script
Introduction to Science Lessons

Lesson 4: Plants

Slide 1: Introduction

Slide 2: What kind of experiment would help us decide whether a plant's leaves or its roots make oxygen?

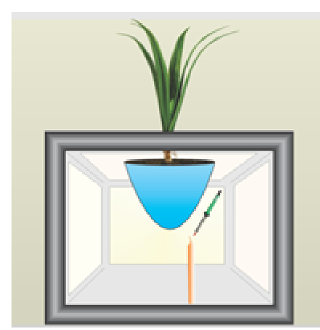
Before we started talking about candle flames, we had pretty good evidence that plants make oxygen.

What part of the plant could be making oxygen? I guess the two choices are the leaves and the roots.

What kind of experiment would help us decide whether a plant's leaves or its roots make oxygen?

We need a way to separate the roots from the leaves when a plant grows. How could we do that?

Slide 3: How will we detect whether the roots are making any oxygen?



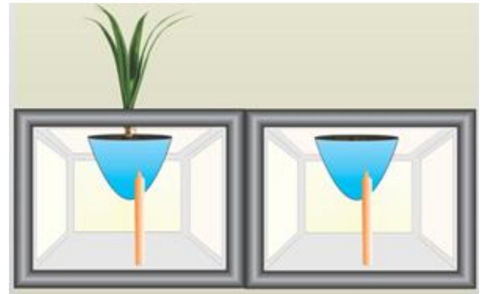
How about if we grow the plant in an airtight glass box with a hole at the top, and let the stem and the leaves stick up out the top through the hole, while the roots remain in the jar embedded in some soil?

To prevent any air from getting into the box, we could pack bee's wax around the hole.

How will we detect whether the roots are making any oxygen?

We already have a way of detecting oxygen. Let the plant grow for a few days and light an experimental candle inside the box. If there is extra oxygen inside the box, the experimental candle flame will burn brighter than the control candle outside the box.

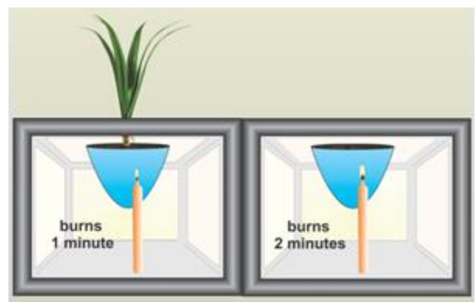
Slide 4: Let's introduce a control in your experiment.



This plant has been growing for a few days now, so let's see what happens when we light the candle.

Before we do that, though, we need a control candle. Remember, we are looking at two things in the experimental candle. One is how bright the candle burns, and the other is how long the candle burns. Where should we place the control candle?

Sure. We need to put the control candle inside the airtight glass box without the plant. That way, the only thing different about the two candles is that one is exposed to the roots of the plant and the other is not. Both candles have the same amount of air to burn.



When we now light the candles, the experimental candle burns dimmer than the control candle, and the experimental candle burns only 1 minute while the control candle burns 2 minutes.

What do these results suggest?

I agree. They suggest that the roots must have used up much of the oxygen inside the glass box.

It certainly does not appear that the roots made extra oxygen.

Slide 5: Let's set up your experiment.

Okay. Now let's reverse the set up and leave the roots outside the jar and let the stem and the leaves stick up through a hole into the glass box.

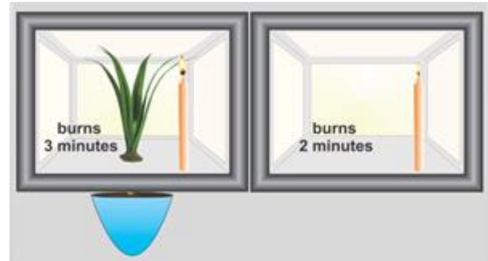
We'll place the roots in a glass bowl to make sure the plant doesn't get dried out.

Slide 6: What did we learn?

The plant has been growing for a few days now. Time to light the candle.

The flame in the left hand box is much brighter than the flame in the right hand box. And it burns a full minute longer.

We now have evidence that the oxygen being produced by plants is coming from its leaves.



So what do we know so far about plants?

Their leaves make oxygen and their roots use oxygen.

If leaves make oxygen, how does oxygen get out of the leaves?

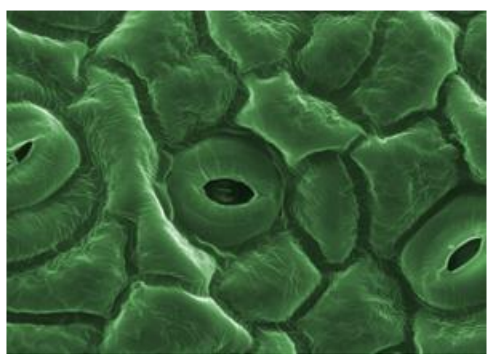
Slide 7: The underside of a leaf

Feel the surface of a leaf. It's kind of waxy, and we just used wax to prevent air from getting in or out of a glass box.

Let's look at a leaf under a microscope. Do you see the waxy surface of the leaf? That waxy coating keeps the inside of the leaf dry when it rains.

Now let's flip the leaf over and look at the undersurface.

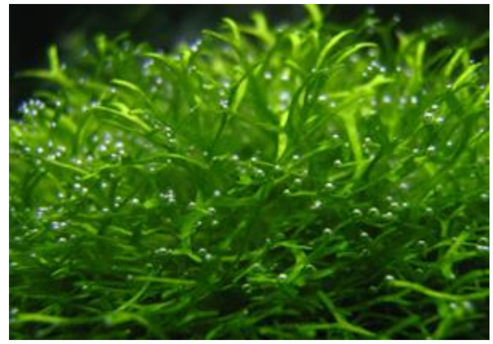
Whoa. What do you think these holes are for? Could they be the holes through which oxygen emerges from a leaf into the air?



How would you design an experiment to support that hypothesis?

How about if we design an experiment that allows us to see the oxygen leaving the leaf? How could we do that?

Slide 8: How do you support for your hypothesis.



How about if we grow a plant underwater?
What would we look for that would suggest that the plant is making oxygen and releasing the oxygen though holes along the undersurface of the leaf?
Sure. We could look for bubbles forming on the leaves.

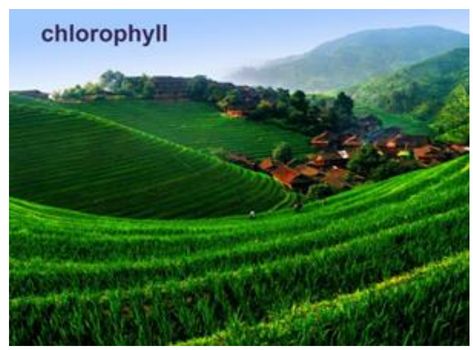
These bubbles support your hypothesis that leaves make oxygen and release it through holes along the undersurface of the leaf.

These holes are called stomas. Stoma means "mouth" in Latin, which was a language spoken thousands of years ago by the Romans.

A lot of scientific terms use ancient Latin. The Latin word "stoma" is how the stomach got its name.

Slide 9: How a plant makes oxygen?

How do you think plant leaves make oxygen?



What's the first thing you notice about leaves?

Sure. They're green. What is inside a leaf that makes a plant green?

Chlorophyll.

We now have a new hypothesis, that chlorophyll makes oxygen. How can we test this hypothesis?

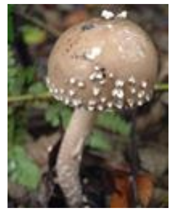
What does our hypothesis predict? Once we answer that question, we can design an experiment to look for that prediction.

Slide 10: Chlorophyll

If chlorophyll makes oxygen, then a plant that doesn't have chlorophyll won't make oxygen. In fact, if it isn't making oxygen, it must be acting like an animal and using oxygen.

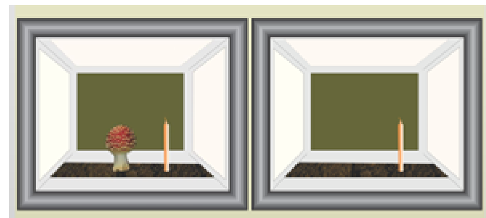
So let's look for a plant that's not green and let's see whether it makes oxygen or uses oxygen.

What plant did you find?



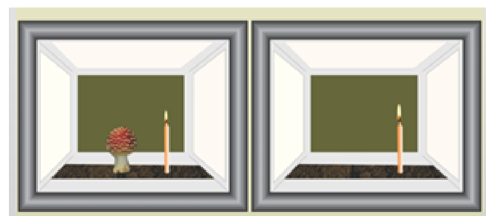
Great. A mushroom. A mushroom is not green but it lives in the soil like a plant. Does it make oxygen, or use oxygen? So what's our experiment?

Slide 11: What's our conclusion?



We'll grow these mushrooms inside our airtight glass box for a week, and then compare how bright the flame is and how long it lasts with a control candle in another glass box.

It's now a week later. Let's light the candles.



The experiment candle lights, but, compared to the control candle, the flame on the experimental candle is dimmer than the control candle, and it doesn't last as long as the control candle. What's the conclusion?

The mushrooms must have used up some of the oxygen inside the glass box.

Slide 12: Mushrooms must not be plants.

What's the other conclusion?

If we said that all plants make oxygen, and a mushroom does not make oxygen, what does that say about mushrooms?

Right! Mushrooms must not be plants. And they're not, because they don't have what?

Chlorophyll.

What do you think chlorophyll does inside a leaf? What's your hypothesis?

So your hypothesis is that chlorophyll is what makes oxygen inside a plant. That seems to make sense because things that don't aren't green, like animals and mushrooms, don't make oxygen. They use oxygen.

Slide 13: Everything needs energy.

We said at the very beginning of these lessons that everything needs energy. Animals eat their energy.



Where do plants get their energy?

What's your hypothesis?

Your hypothesis is that plants capture the energy in sunlight and use it to grow, right?

What kind of experiment would show that plants need sunlight to grow?

Slide 14: Answers often bring more questions!


We'll place this plant in sunlight and this plant in the dark.

A week later, the plant growing in sunlight is doing fine, but the plant growing in the dark is clearly failing.

It looks like plants are capturing the energy in sunlight.

Wait a minute. If animals eat food to get energy, and plants capture their energy from the sun, where do mushrooms get their energy?

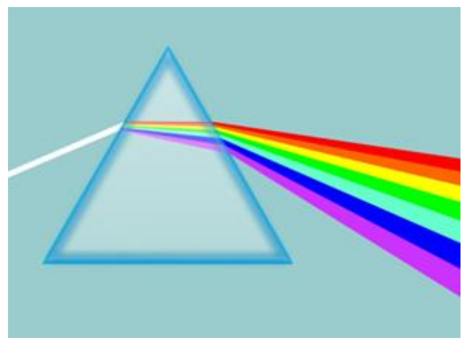
Slide 15: How do mushrooms get their energy?

Back to the forest, or your back yard. Dig underneath a mushroom and what do you find?

Usually you'll find some kind of dead wood. Mushrooms get their energy by digesting some plant or tree that has already died.


Slide 16: What is a prism?

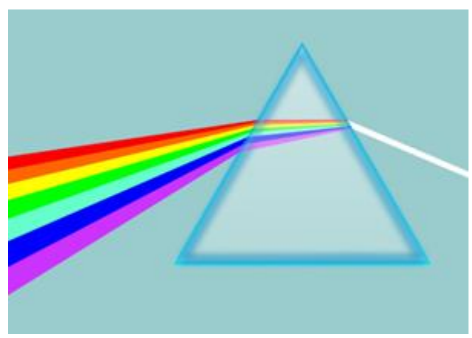
So plants need sunlight. How many different colors of light are coming from the sun?



How do you know?

Sure. We can break up sunlight into all its colors by bending sunlight with this triangular piece of glass, called a "prism."

How would you show that when you combine all these colors back together, you get sunlight again?



Use a second prism and flip it around. Do you see how all the colors have come back together again and formed white sunlight?

Slide 17: What happened to all the colors?

Okay, so all the colors in sunlight strike a leaf, but the leaf is green. What happened to all the other colors? Where are they?

What's your hypothesis?

Let's think about this. If a leaf looks green to you, then the green light in sunlight must have bounced off the leaf and is now entering your eye. Where did the other colors go? What's your hypothesis?

Maybe the other colors entered the leaf and provided chlorophyll with the energy it needed to make oxygen.

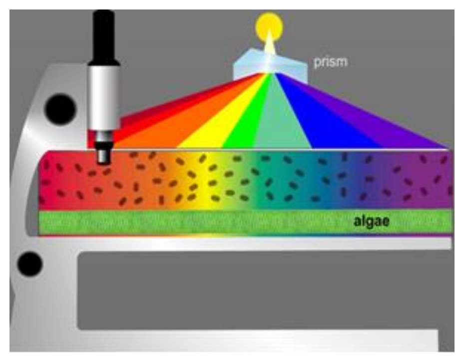
How would you test this hypothesis -- that plant leaves reflect away green light instead of absorbing it and using it make energy for the plant?

How about if we try to grow a plant in green light? What does your hypothesis predict?

And how would that compare to growing a plant in red, orange, yellow, and blue light?

Slide 18: Who is Theodor Englemann?

This experiment was carried out back in 1881 by Theodor Engelmann. Instead of leafy plants,



Engelmann grew green algae in a thin layer of water on a microscope slide. He then shined a rainbow of light onto the microscope slide. He created the rainbow by passing sunlight through a prism.

The algae that grew the fastest would supposedly produce the most oxygen. How, though, could you detect that oxygen on a microscope slide?

What Engelmann did was add bacteria to the water. The bacteria were special in two ways.

First, they always wanted to be near oxygen. Second, they were capable of wiggling toward areas rich in oxygen.

What do you think Engelmann saw when he viewed the bacteria?

The bacteria were grouped around the algae growing in the red and orange light, and also in the blue and violet light, but not around the algae growing in the green light.

What conclusion did Engelmann draw?

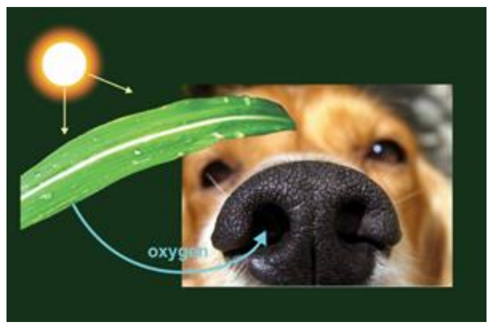
Engelmann concluded that green light is not very good at helping plants grow.

That's quite a coincidence. Plants don't need green light to grow and they reflect green light away from themselves. How did those two things happen to occur together? Did plants decide that since their chlorophyll can't use green light, there was no point in even letting green light enter the plant? Or were plants always unable to absorb green light, and so they made chlorophyll incapable of using green light?

My guess is that chlorophyll was never able to use green light, and plants developed a way to keep green light from entering the plants. Why plants should want to keep green light from entering doesn't make a lot of sense. Even if green light brings in only a little energy, some energy is better than no energy, so why prevent green light from entering a plant at all?

Slide 19: Animals need oxygen to live.

Something else doesn't make sense. If a plant needs sunlight to grow, and it uses sunlight to make oxygen, and the plant then dumps the oxygen it just made out into the air, how does sunlight make a plant grow? The plant must be doing something else with the sunlight besides making oxygen. The oxygen must be some kind of garbage for the plant, something the plant doesn't need and just gets rid of by spitting it out through the leaf's stomas.



But for animals, oxygen is anything but garbage. Animals desperately need oxygen to live.
What would the world be like if we didn't have plants?

Not only would be not have any vegetables or fruits to eat, we'd have no oxygen to breathe.
That's why plants are so important. Without plants there would be no oxygen in the air for us to breathe.

We have to do everything we can to make sure our rain forests are not destroyed, and that we protect all our other forests.

Slide 20: How do fish breathe?

We breathe oxygen into our bodies, but how do fish breathe when they are under water?

Gills. As water flows over the gills, the gills remove the oxygen dissolved in the water.

How does oxygen in our lungs, or in a fish's gills, get to the brain or the muscles far away from the lungs?

Slide 21: Blood carries oxygen to the rest of the body.

The oxygen we breathe in attaches to the blood passing through our lungs. The blood then carries the oxygen to the rest of the body.

What causes the blood to move?
Our heart. Our heart pumps the blood to everywhere in our body.

How do you know you have a heart?

You can hear your heart pumping by listening through a stethoscope, or even through a cardboard paper towel roll.

You can also feel each time your heart pumps by feeling the artery in your wrist. Feel for the pulse of blood by gently pressing between the bone and the tendon just above the hand.

Slide 22: Blood returns to the heart in veins.

Once the blood releases oxygen into the brain, or the eye, or the muscles, the blood returns to the heart and is then pumped to the lungs to pick up more blood.

Blood returns to the heart in veins, those blue lines you can see and touch under the skin in your hands and arms.

You can make your veins stand out by holding your arms at your side. When you raise your arms to the level of the heart or above, the blood in the veins drains downhill, into the heart, and the veins collapse.

Slide 23: What is oxygen?

So what is oxygen, and why do we need it? What does oxygen do, that if we don’t have it, we die? The answer to these and other questions can be found in Fascinating Chemistry and Fascinating Biology.