Lesson: “What do plants eat?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! If you're someone who likes to eat bacon at breakfast, but you aren't always a fan of eating your vegetables at dinner, here's an idea for you to try out on your parents. You could tell them, I'm always eating vegetables. There's a way in which that's true. I mean, think about the food chain that's involved. Bacon is meat that comes from a pig. What do pigs eat in order to grow big? Well, maybe you don't know what pigs eat, so you look it up, and you find out that pigs on a farm eat mostly corn and soybeans. Corn and soybeans. Those are plants. So pig meat somehow comes from the plants that the pigs ate. So there you go. In a way, eating bacon is really like having a helping of vegetables. Now what if you don't eat bacon? Say that you prefer hamburger instead. Well, no worries. Again, think about the food chain. Hamburger is meat from a cow. What do cows eat? They graze on grass. Plants again. Not a fan of hamburgers? OK, so let's consider chicken. What do chickens eat? They eat seeds. Again, that's plants. But now, just for fun, let's say your chickens are wild chickens. So they're not just eating seeds. They're also eating the occasional little beetle. But then, what do those beetles eat? They eat plants. So you can get the idea. Everything comes down to plants every time when you follow the food chain. And not just for human beings who eat meat, but for any animal that eats any other kind of animal. When you ask the question, “What does it eat?” and you keep asking that question, you always wind up back at plants. So if all these things in the end are just eating things that eat things that eat things that eat plants, it makes you wonder: so what do plants eat then? Well, let's consider that today. But let's not think about just any little plant. If we're going to talk about what plants eat, we might as well talk about the king kahuna of all the plants—the largest plant in the world. It's this. It's actually the largest living thing in the world. Larger even than any animal. It's a tree. If we're looking up, looking up, keep going, keep going. I'll wait for it here. This kind of tree is called a sequoia. All sequoia trees are massive like this, but this particular one I'm showing you is the biggest of them all. It's an individual tree growing in eastern California. It's so large that it's even got its own name. People call it General Sherman. General Sherman weighs, are you ready for this, four million pounds. That's the same weight as about 300 elephants. But where does all that four million pounds of tree come from? It's tempting to think that sequoia trees like this are just always huge. They just exist. But walking around on the forest floor, you can find these. It's a sequoia cone. It's like a pine cone. And if you shake it, you'll find that inside are the seeds of a sequoia tree. Even General Sherman started out once as just a little seed like this, no bigger than a grain of oats from your oatmeal. How did he get so big? How does any plant gain weight? If we were talking about a person or an elephant instead of a tree, then you'd have some easier guesses. You'd say, well, living things like animals and human beings, they gain weight because they eat food. But plants? What do plants eat? Do they even eat? What is a plant's food?

EXPLORATION VIDEO 2

So you might be thinking that plants eat dirt, right? That's what lots of people assume is true. And that's a perfectly logical thing to think. I mean, plants grow in dirt. Or what in scientific language we often call "soil" instead. So that's what I'll call it from now on. Plants have their roots in the soil. So maybe the roots are eating that soil. For hundreds of years, this is even what scientists assumed to be true. Plants must be eating soil, they thought. They assumed that soil was where plants get their weight from. But no one had ever actually checked to see if this was true. Eventually, one scientist—this guy—got really curious about this. He wondered, are we sure the plants eat soil? And he came up with a very clever experiment, which he hoped would help him solve the mystery. Here was his idea. He decided that he would plant a young tree in a pot. Now, before doing that, he would carefully weigh the tree and the soil that he was going to place into the pot. The tree weighed about two pounds, the soil about 200 pounds. After weighing and planting the tree, he wanted it and made sure that it got all the sunlight it needed, too. A few years later, once the tree had grown to be bigger, like this, he took it out of the pot again and measured the weight of the tree, and then the weight of the soil. Do you see his idea here? Remember, the original weight of the tree was about two pounds, and the original weight of the soil about 200 pounds. After the tree had grown, the tree now weighed about 160 pounds. So the tree had gained a huge amount of weight. But now what about the soil? If the tree had been eating the soil, if soil is a tree's food, then what do you think he would discover when he went to weigh the soil?

EXPLORATION VIDEO 3

So where did General Sherman get all the material that it's made of? All that bark, all the wood inside the tree, how did a tree get to weigh four million pounds? Was it all from eating soil? Let's look back at that scientist's experiment. After five years, once his small tree had grown and gained weight, he carefully took it out of the pot. He weighed the tree, and he weighed the soil. The tree weighed 160 pounds. It had gained a lot of weight compared to the two pounds it started at. But to his amazement, the soil had barely changed in weight. It started at 200 pounds, and now was only just 199.8 pounds. It lost almost nothing—just the tiniest amount. So that 158 pounds of new tree—it couldn't have come from the soil. The scientist Van Helmont was convinced plants don't get most of their weight from soil. His experiment showed it. Mystery solved—sort of. Because think about it, if plants aren't getting the weight from soil, we still haven't solved where they *do* get their weight from. Van Helmont thought about this. Now, the only things he knew he'd added to his young tree during those five years of its growth were sunlight and water. Now, he knew that even though all plants need sunlight, sunlight itself wasn't adding any weight to the plant. Sunlight's a form of energy. It's not a material. Scientists today know that plants use sunlight for their energy, but they're not made of sunlight. Sunlight doesn't weigh anything. So that just leaves water. If you cut open a plant—even if you cut open a tree—you can feel some wetness. So there's evidence that water is part of a plant. The scientists who did this thought, well, maybe plants somehow create their weight just from the water they take in. Or to put it another way, he thought—ah-ha, so maybe plants don't eat, they just drink. But Van Helmont could only think this, because there was something he didn't know yet. He didn't know that there's another material that plants take in besides just water. Much later than his lifetime, scientists using microscopes discovered something very interesting on the underside of a plant's leaves. It looks like this. They look like little microscopic mouths. And they act like them too. They're even able to open and close. Scientists decided to call them stomata, from the Greek word for mouth. But what on earth are these little mouths on the underside of leaves doing? Could they be taking something in, adding weight to the plant? In fact, scientists were able to figure out that the stomata are taking in air from around the plant. And not just some air, lots of air, all day long. So some scientists did experiments trying to stop the plant from getting air by covering up the stomata. And they found out that when they did this, the plant would die in a matter of days. So it must have been that the plants were doing something with that air that was coming in through the stomata. Could it be that air is an important food used by plants in order to help them grow? The problem is, air is about as light a thing as you can imagine. Is there really any way that plants like General Sherman—which weighs 4 million pounds—could be gaining in weight because of air it's taking in through its leaves? What do you think? I mean, does air even weigh anything at all?

ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to do an investigation to figure out whether air weighs anything. Did you come up with some ideas on how to weigh air? It's a fairly tough challenge. I mean, air is all around us all the time, but we can't even see it. We can't grab a handful of it. So how can we possibly weigh it? Here at Mystery Science, we decided the first thing we had to do was get a whole bunch of air and stuff it into a container so that we can weigh it. Now luckily, people play with containers of air all the time. Instead of a basketball or a beach ball, you're going to use a balloon to hold the air you're going to weigh. You probably already know the tool that people use to measure weight. It's a scale, like this type of scale that you might have in your bathroom. In this activity, we're going to use a much simpler scale. It's called a balance scale. This kind of scale doesn't tell you a weight in pounds, or ounces, or grams. Instead, it just lets you compare two things and find out which one weighs more. You'll use a balance scale that looks like this. It's made from a yardstick and a couple of binder clips. Now, if you hang stuff of equal weight from both ends of the yardstick, like these two empty buckets that we're hanging on either side here, the yardstick will stay level. It'll stay straight like this. But now, suppose one end of the scale is heavier, like if we pour water into one side, like this. So you see what happens. The heavy end goes down, and the light end goes up. That's how your balance scale will work. So now, what do you think? How could you use a balance scale and a bunch of balloons to figure out whether or not air weighs anything? You're going to discuss this question in the first step, and then I'll show you step by step one way that we thought to do this.

ACTIVITY STEP 1

Discuss this question as a group. When you're done with this step, click the arrow on the right.

ACTIVITY STEP 2

Here's an idea we had. We'll put balloons filled with air on each end of the balance scale. And we'll make sure that we have the same number on each end. Then, we'll let air out of all the balloons on one end and see what happens. Are you ready? If you're going to do the experiment our way, go to the next step.

ACTIVITY STEP 3

Find a partner. Decide who'll be Balloon Master, and who will be Measure Master.

ACTIVITY STEP 4

Get your supplies. Each group needs these.

ACTIVITY STEP 5

Balloon master: Stretch the balloon, then blow it up. Don't tie it, just hold it closed. Make sure to blow it up big.

ACTIVITY STEP 6

Discuss as a group.

ACTIVITY STEP 7

Let's make the balloons the same size. Balloon Master: hold the balloon. Measure Master: wrap the string around the middle of the balloon. You want the string ends to just meet, like this. If the string ends overlap like this or if they're far apart like this, then you'll need to either let some air out or blow more air in until the string ends touch. Since everyone's string is the same length, this will make the balloons the same size.

ACTIVITY STEP 8

We're gonna show you a quick way to tie a balloon. Ballon Master, twist the balloon's neck, like you see here, and fold it over like this. Then, Measure Master, clamp the clip on the fold. Now it's tied.

ACTIVITY STEP 9

Now you'll come up and hang your balloons on the scale, like this. Hang three balloons on each end of the scale. Put any extra balloons aside. You may want to use them later.

ACTIVITY STEP 10

After all the balloons are on the scale, check to make sure the yardstick is still level. Adjust the scale until it is.

ACTIVITY STEP 11

In just a moment, have someone let all the air out of the balloons on just one side of the balance scale. Now to get ready for that step, do questions number one and number two on your experiment sheet.

ACTIVITY STEP 12

Talk about your answers as a group. Is there any disagreement about what will happen?

ACTIVITY STEP 13

In just a moment, one person is going to purposely let out all of the air out of the balloons on one end of the balance scale. Whoever does this job, close the paperclip to keep everything in place as you work. Once you do that, you're ready for the moment of truth. Go to the next step.

ACTIVITY STEP 14

Watch this whole step before you do anything. Whoever's in charge, hold one balloon's neck. Then open the binder clip, and clamp it on that little plastic ring part of the balloon, like that. Unwind the neck, and keep unwinding it until you hear air escaping from it. Then, let go. Do this to all three balloons immediately, one after the other. Then you'll find out what happens when all the air is let out on one side of the balance scale. This is the exciting part. Go.

ACTIVITY STEP 15

How did it go? If something went wrong, that's OK. Back up to the last step and try again with your extra balloons. Sometimes it takes practice to get experiments to work smoothly, and this could be one of those times. It actually took us a couple of tries to get it right.

ACTIVITY STEP 16

After all of the balloons on one side are deflated, do number three on your handout and discuss.

WRAP-UP VIDEO

So you saw in the activity when you let out all of the air from one side of the balance scale, the balloons with the air still in them dropped down. They were heavier. So air does weigh something. Today, scientists are able to measure exactly how much air a plant takes in, and they figured out that a tree as massive as General Sherman is taking in as much as four pounds of air per day. That's the equivalent of 700 balloons worth of air. Now still, air is very light weight. But just consider how long trees like this live for. We don't know for sure how old General Sherman is, but similar sized sequoias that have died or fallen over, like this one here, if you count the rings, you find out that a tree General Sherman's size is probably 2,000 years old. So do the math. General Sherman takes in four pounds of air per day. Multiply that four pounds by 365 days per year. And then multiply that by 2,000 years that General Sherman has probably been alive. That's nearly three million pounds of air that General Sherman has taken in over its whole lifetime. Its total weight is 4 million pounds. So whoa, air makes up most of a plant's weight. Three million pounds of General Sherman has come from air alone. So what do plants eat? Mystery solved. Or almost at least, because you could wonder, well, why didn't all of

General Sherman's weight come from air? What's the other one million pounds of weight coming from? But don't forget. Not only are trees taking in air, they're also taking in water through their roots. So now, what do plants eat? Where do they get their weight from? You can answer it. The weight comes from air and water. Now you know. OK, now remember when I said at the beginning, if you're eating bacon, you could argue to your parents that you're actually eating your vegetables since bacon comes from an animal and whenever you trace the food chain backwards you always wind back up at plants? You could try out that idea on your parents. See if they're convinced. But if your parents know the answer to the mystery of what do plants eat, then one morning, don't be surprised if you show up at breakfast and find this. Here's your breakfast, your mom says. And you'll say, what? There's nothing here but an empty plate and a glass of water. But your parents can argue, well, if you're going to claim that bacon is a vegetable, then we get to claim that vegetables are just air and water. So enjoy your breakfast. I'm sure you realize I'm being slightly silly with all this because obviously if you just ate air and water for breakfast, you'd starve. But there is a sense in which you do eat air and water for breakfast. It is true that when you eat bacon, you're eating something which originally came from air and water. There's something that plants are doing with air and water. Plants somehow transform air and water into the nutrients eaten by animals and eaten by us. Now what is this transformation? It seems almost magical. I mean, think about it. How could two substances like air and water, both of which are clear and neither of them are solid, and yet they could be transformed into wood or leaves, materials that are definitely solid and definitely not clear? That's a whole other set of mysteries. That's a whole part of science called chemistry. It's the study of materials and how they can be transformed into new materials with totally different properties. Now there's so many awesome things you'll get to learn when you study chemistry.

Chemistry really is almost like magic. We have some Mysteries to help you explore that if that interests you. For now, I hope you'll stay curious, and see you next Mystery!