mystery science

Lesson: “Can we make it rain?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! You might know that I live in the US state of California. Now, California's a big state, and not just in terms of the land size. There are 37 million people living here. That's more people than any other state in the United States. And yet what's surprising, given that it's the most populated state in America, is that California actually doesn't have a lot of fresh water. There aren't a lot of lakes. There aren't a lot of rivers. There aren't that many aquifers. California's a pretty dry state. Parts of it are even desert. So it's not unusual, at least in some parts of California, for there to be little rain for months on end. For Californians who live in those driest parts of the state, sometimes things can even get scary. My friend Pat tells a true story that one day in 2015 her brother went to turn on his faucet and nothing came out. The town he lives in sits on an aquifer. There's normally some ground water down there, but the aquifer had run dry. Now, at first, that might just seem like it would be kind of weird or maybe a slight inconvenience. Oh man, I can't shower this morning. But think about it. What if this lack of water from his faucet was something that lasted for days? Remember, people can only live about three days without water. If you ran out of water on a Monday, by Wednesday you could be dead. What should Pat's brother do in a situation like this? Just pack his bags and move? He can't do that. He's got a home there. It's where he lives. Surely, there's some way to solve a problem like this. If this were your town, what would you do?

EXPLORATION VIDEO 2

I'll point out something that makes things even more frustrating for Pat's brother. Here is California, and here is the largest body of water on Earth, the Pacific Ocean. It's right there. Now that just seems crazy. How could you run out of water if you live in California? But remember, ocean water is salt water. You can't drink salt water, and it turns out that getting the salt out of the water is really hard to do and also incredibly expensive. Now, I guess the town could buy tons of bottled water and then have it delivered to everyone's homes. But the town has thousands of people. They couldn't do that forever. What the town really needs is for its aquifer to be full again. In other words, the key to all this is going to be rain. Rain is what fills aquifers up to begin with. It's the reason why aquifers have water in them. And by the way, not having enough rain isn't just a problem that can happen in California. There are other places in the world that have dry climates, places where people run into similar problems, like Australia, the Middle East, parts of India. And yet lots of other places on Earth don't have these problems. Many places get plenty of rain. Rain is a pretty simple thing, right? It's just drops of water that fall from the sky, specifically from clouds. Isn't there something we could do to make it rain a little more in the drier places, like where Pat's brother lives? To figure something like this out, really the question we need to ask ourselves is: What makes it rain in the first place? How does water get up into the clouds, and why does it fall out of them?

EXPLORATION VIDEO 3

So what do you think? How does rain get up in the clouds? Well, this is what I drew. You can see here I've got the ocean down here. Maybe you drew a lake or a pond or a puddle. As long as you have any water on the ground, that's good. And I've got arrows going upwards where I've

written “evaporation.” Now, maybe you didn't write that on your drawing. That's fine. But I'm guessing you've heard of this idea before. Evaporation is the name for the process when water goes from being a liquid to a gas. Now, here is maybe the most familiar example of evaporation: It's a boiling pot of water on a stove. The heat of the stove is causing water to be converted from its liquid phase in the pot to its gas phase above. You could call this stuff up here water gas. Scientists and most people tend to call it by an older name: water vapor. So I'll call it that, too. But even if the water isn't boiling—for example, this puddle of water on the ground—as long as there's some heat around, like the heat of the sun's rays hitting this puddle, some of that water is still turning into water vapor. Watch as this video is sped up. See how the liquid water evaporates? It didn't disappear, it just became water vapor. It's going into the air. This is surprising, but you can see it for yourself right at home. Like, check out this other example. This is a glass of water left sitting out in a warm room. Let's go ahead and mark where the water level is at. And now watch as the video gets sped up. Whoa, are you seeing that? The water level's going down. If you watch again, you can even see something escaping the glass. That's liquid water as it's becoming water vapor. So as long as there's some heat around, some liquid water will evaporate. It will turn into water vapor and rise up into the air. So that's why I've got the sun and evaporation drawn on here. The heat of the sun alone is enough to cause some of the water in puddles, in lakes, in rivers, and the ocean to evaporate and enter the air around us. That's evaporation. Now, it might be tempting to think that maybe clouds are made of water vapor that's risen up into the atmosphere. After all, clouds seemed to float up there in the Earth's atmosphere. That's what you'd expect a gas to do, float around up there in the air above us. But it's possible to actually jump through a cloud and find out exactly what it's made of. That's what these skydivers are about to do. Watch. Right there, you notice that? Right there. Clouds, including rain clouds, are actually made of tiny droplets of liquid water. Why would there

be liquid water up there? Well, it would seem that water vapor—that's water in its gas form—rises up into the air around us and then somehow gets converted from a gas back into liquid water. What might cause water in its gas form to start forming droplets of liquid water? You don't have to go up to the clouds to collect clues. You can find evidence right here in your everyday life, right here on Earth's surface. Have you ever noticed that droplets of water formed on something?

ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to figure out what makes it rain. And you'll do that by doing some experiments. Now, it's tough to experiment with something as big as a rainstorm. You can't fit a rain cloud or an ocean of water in your room. So, rather than sending you up into the clouds to figure out what's going on, we're going to make a model. Maybe you think of a model as a miniature version of something that looks like the real thing, like a model airplane looks like a real plane. But in science, people often make models that don't necessarily look like the real thing. Instead, they act like the real thing. That's the kind of model you're going to make today. Let's walk through what your model will look like. You'll have a small cup of water to provide water vapor. That's going to be your ocean. It's a small ocean, but that's fine. Then you'll have a clear plastic cup you'll put over that. That's going to be your sky, the atmosphere, the place where clouds form. Now, remember, a rain cloud is just a bunch of tiny water drops. Those drops join together to make big drops that fall as rain. So your goal is to get water vapor to rise up from the ocean—that's the water in this cup—and turn into a cloud in the sky. Or. in other words, you want a bunch of water drops to form on the clear cup. Those tiny water drops will look like fog or rain on the clear cup. Can you figure out how to make the most rain in the sky? See if you can. I'll walk you through the set-up, step by step.

ACTIVITY STEP 1

If you're working in a group, form a team of four. If you're working alone, that's fine too. You'll just get to do more experiments. When you're done with this step, click the arrow on the right.

ACTIVITY STEP 2

Here are three people who have ideas about what it's like up in the atmosphere where the clouds are. Discuss. Who do you think is right? Why?

ACTIVITY STEP 3

To figure out what makes the most water vapor on the sky cup, you'll experiment with the temperature of the ocean and the sky. We'll show you the set-up, but don't do anything yet. Just watch for now. You'll start with a plate—that's the ground. For your ocean cup, you can either choose cold water, which is colored blue, or warm water, which is colored red. Pick one and put it on a plate to represent your ocean. Then, put a clear cup over it to represent your sky, like this. You can change the temperature of the sky by putting a cold bottle or a warm bottle on top of the cup. So you'll be putting water in two different places. And you can choose between making them hot or cold. Now that you know this, go to the next step.

ACTIVITY STEP 4

Get a worksheet for each member of your team. As a team, make a plan. Decide on four set-ups to try. For each setup, decide whether the sky is warm or cold and whether the ocean is warm or cold. Then write that on your worksheet. Everyone writes down the same plan, but each person needs their own worksheet so they can write down their own observations.

ACTIVITY STEP 5

Discuss and predict.

ACTIVITY STEP 6

Get your supplies. Each group needs these things.

ACTIVITY STEP 7

If you're on a team, have each person choose one set-up: A, B, C, or D. Take about ten seconds to decide who has which one. If you're working alone, you'll do all of them. Are you ready? Here are your ten seconds. Okay, go to the next slide.

ACTIVITY STEP 8

Write the letter of your set-up on a plate. For example, I picked set-up A, so I'm going to write that down right here. Then, on the worksheet, look at what water to use for the ocean and the sky. In this example, I chose a cold ocean and a cold sky. Okay, go to the next step.

ACTIVITY STEP 9

Set up your experiment like this. Put a small cup on a plate and add the type of ocean you chose. In this example, I chose a cold ocean so I'm pouring blue water. Then cover it with the sky cup and put the bottle you chose on top. I chose a cold sky in my example, too. Okay, go ahead and do this now using the colors and temperatures on your worksheet.

ACTIVITY STEP 10

For the next two minutes, observe all four experiments. You're looking for differences. Is there something different happening in the different set-ups? When the timer stops, record your observations in questions number one through three on your worksheet. I'll let you know when the timer stops. You ready? Go! Okay, you've been watching for two minutes. Now fill in questions number one through three on your worksheet.

ACTIVITY STEP 11

There's one more thing to observe about your experiments. You can't see what's going on under the bottle that's on top of your sky cup. Lift all the bottles off and check underneath. Are the experiments different from each other? Compare them. Then draw what you see on question number four.

ACTIVITY STEP 12

Tap on the sky cups in the experiments. Can you make it rain?

ACTIVITY STEP 13

Discuss.

ACTIVITY STEP 14

Earlier, you did a drawing of how you thought water gets up into the sky. But now that you've done this investigation, you might have new ideas. So it's time to consider revising your

drawing. Draw any new ideas you have about what the ocean and the sky need to be like to make raindrops. Make sure to include words like warm and cold when you label your drawings.

WRAP-UP VIDEO

Here's what we noticed when we did this activity. We decided to do our four set-ups like this. We had two set-ups that had cold oceans. In one of them, we had a cold sky. And then the other one, a warm sky. Then we had two set-ups that had warm oceans. And in one of them a warm sky, and the other a cold sky. So, which one of these set-ups made the most water drops on the sky cup? Definitely the two set-ups that had the warm ocean. Why would that be? Well, actually, that makes a lot of sense based on what you know, doesn't it? The warmer that water is, the more of it evaporates, or turns from liquid water to water vapor. The warmer the ocean, the more water vapor you get that rises up into the air. But now notice something else if you pay close attention: Of these two warm ocean set-ups, one of them had more water droplets than the other. When we lifted the bottle off the cups and looked below them, we saw lots more water on the one with the cold sky. Interesting. Where the sky cup was coldest, the most water drops formed. If you tap it, you can even make it rain. So, let's summarize. What does all this mean? The water needs to be warm in order for there to be much water vapor in the air. You hopefully already knew that, even before you did the activity. But what is it that turns water vapor back into liquid water? In other words, what might cause water vapor rising off of oceans and lakes and rivers to become rain? To become liquid water again? The answer is the cold sky. It took something cold to turn water vapor back into water liquid. So in order to make it rain, you really just need the opposite of evaporation. With evaporation, you take a liquid, you get it warm, and that turns it into a gas. With the opposite of evaporation, you take a gas, get it cold, and that turns it back into a liquid. This process has a name: condensation. And it is the opposite of

evaporation. To make rain, you need condensation to happen. Something cold has to chill the water vapor in the air around us, causing that to become droplets of liquid water, that then can fall from the sky as rain. What you made in the activity is actually a model of how rain works in the real world. Sunlight heats up the liquid water of lakes, rivers, and oceans, causing some of it to become water vapor. Then, as some of that water vapor floats around and makes its way up into the atmosphere, well, guess what the temperature is like up there? It's cold. Does that surprise you? Sure, you probably know that hot air rises. But as it does, hot air doesn't stay hot forever. It cools off. And yes, you are technically closer to the sun when you're up there. But the sun is 93 million miles away from us, so you're not closer to the sun in any real meaningful way. If you've been on an airplane, you might have seen for yourself just how cold it is up in the atmosphere. Ice crystals form on the outside of airplane windows. Or you might have noticed that lots of mountains have snow on top of them, often even when it's warm on the ground at the base of the mountain. That's because it's cold up in the atmosphere. But now wait a second. Let's go back to a question we asked before we did our experiment. Why wasn't Pat's brother getting any rain? He lives in California. Sunny, warm California, right next to an ocean. Shouldn't there be plenty of water vapor rising up, hitting the cold atmosphere, and turning to liquid water? Shouldn't he be getting plenty of rain? Well, you'd think so, wouldn't you? But there's one piece of information you're missing And that's what the ocean temperature is like off the coast of California. If you're from California, or if you ever get to visit there, pay attention to the beaches. Sure, California is famous all over the world for being a land of sunshine and palm trees. But surprisingly, if you visit the beach and you dip your toes in the ocean water, you'll find out ocean water off the coast of California is pretty chilly, usually around 60 degrees Fahrenheit. That's 16 degrees Celsius. It's cold enough that surfers in California have to wear wetsuits in order to keep warm. So, the problem in California is that there isn't enough water vapor being created by

the heat of the sun. The ocean is just too chilly there. Because of this, California tends to be a pretty dry place. If you wanted to make it rain more in California, one way to do it for sure would be to heat up the ocean. That would create a lot of water vapor. And then when some of that water vapor hit the cold atmosphere, it would condense and form rain droplets. So why don't people do this? Well, heating up a whole section of the ocean, that would be very hard to do. That's a huge space. And even if there were a way to do it, creating that much heat is going to require a lot of energy, and that costs money. So far an idea like this just wouldn't make sense. Now, fortunately, it's pretty rare that anyone in California would run out of water. And that's because every few years water vapor does arrive in California from air currents that blow over from the warm waters of the South Pacific. And that did finally happen again. So Pat's brother is okay for now. His town's aquifer is full again with rain water. That said, it is always in danger of running dry during years when there isn't enough rain. But imagine if you could heat up the ocean cheaply and easily, or if you could figure out some cheap and easy way to remove salt from ocean water. Then no place on earth would ever run out of fresh water. Is there a way to do that? We'll explore that in a future Mystery. Have fun and stay curious!