# The Water Cycle
# Lesson 6a: Conservation of Water in a Closed System

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| **Grade 5** | **Length of lesson:** 58 minutes | **Placement of lesson in unit:** 6a of 6 two-part lessons on the water cycle |
| **Unit central questions:** How does water change in the world around us? Does Earth ever run out of water? | | **Lesson focus question:** Does Earth ever run out of water? Support your answer with evidence and reasoning. |
| **Main learning goal:** As water changes state (liquid, solid, or gas), its mass is always conserved, which can be demonstrated mathematically. | | |
| **Science content storyline:** The motion and arrangement of water molecules change as molecules move back and forth between liquid, solid, and gaseous states, but their mass never changes. By measuring the mass of three closed bottles of water, we showed that it remained constant even though one bottle was put in the freezer and the water turned to ice; one bottle was heated, causing evaporation; and one bottle remained at room temperature. Like the bottles, Earth is a closed system for water, so Earth never runs out of water. Water molecules are never lost from Earth and Earth's atmosphere, so the total mass of water molecules on Earth never changes. Even though water exists in and changes between liquid, solid, and gas forms, the total mass of water on Earth remains constant over time. | | |
| **Ideal student response to the focus question:** The total amount of water on Earth never changes. Water changes forms (liquid, solid, or gas), like in evaporation and condensation, but it doesn't disappear, and its total mass never changes. It stays the same over time because Earth is a closed system for water. | | |

## Preparation

**Materials**
- Science notebooks
- Water-changes-system setup (from lesson 4b)
- 3 identical clear plastic bottles with tight caps (8-oz clear water bottles work well, labels removed)
- 4 extra clear plastic bottles (same as above)—3 for practicing the activity in advance, and 1 to fill and freeze overnight as a substitute for the first freezer bottle at the end of the experiment (see Ahead of Time for instructions)
- 1 permanent marker to label the bottles
- 1 heat-lamp setup (see photo)
- 1 heat-lamp bulb: Exo Terra Sun Glo Basking Spot Lamp, 150 watts
- 1 digital scale
- 1 graduated cylinder (25 ml)
- Water—20 ml in each bottle
- Access to a freezer
- Oven mitt (for handling the heated bottle)

**Student Handouts**
- 4.2 Water-Changes System (from lesson 4b)

**Ahead of Time**
- Review the Water Cycle Content Background Document: part 2.
- Review the PowerPoint slides and modify them as you wish.
- Set up your water-changes system. If the water from the test tube wasn't poured back into the flask during lesson 4b, turn on the hot plate and heat the system well before the activity-setup discussion in this lesson. If the water was previously poured back into the flask, just show the setup without turning on the system.
- The word bank should include these words: *closed system*, *open system*, *molecules*, *mass*, *solid*, *liquid*, *gas*, *water vapor*, *condensation*, *evaporation*, *gain energy*, *lose energy*.
- Perform a test run of the three-bottles experiment:
  - Number and label three bottles so you can easily reference them: (1) Freezer, (2) Room Temp, (3) Heated. **Important:** The night before the lesson, fill an extra bottle with 20 ml of water, screw on the cap tightly, label the bottle "Freezer," record the starting mass, and place the bottle in the freezer overnight. This bottle will replace the first freezer bottle at the end of the experiment so that students can weigh it and record the ending mass after freezing. Make sure the two freezer bottles are identical so the switch will work!
  - Practice setting up the heat lamp and bottle to be heated. Lay the bottle on its side and position the bulb approximately 3 inches from the side of the bottle (not toward the cap). Signs of evaporation should appear after about 10 minutes. Small drops of condensation should form on the side of the bottle opposite the heat source. When this happens, the bottle may become unstable, so make sure it doesn't roll around . Don't leave the bottle unattended while heating. As evaporation continues, the heated bottle will likely expand. Stop heating the bottle if it becomes deformed, and don't heat it for longer than 20 minutes. **Handle the heated bottle with an oven mitt!**

## Lesson 6a General Outline

| Time | Phase of Lesson | How the Science Content Storyline Develops |
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| 5 min | **Link to previous lessons:** The teacher links this lesson to previous lessons and addresses the first unit central question by having the class look at a drawing of a mountain scene and talk about all the changes water might undergo in such an environment. | • Through evaporation, condensation, freezing, and melting, water continually changes state and moves from place to place in our environment.<br>• Scientists describe this constant change and movement as the *water cycle*.<br>• In the water cycle, water can change from a liquid to a gas through evaporation, from a gas to a liquid through condensation, from a liquid to a solid by freezing, and from a solid to a liquid by melting.<br>• These changes of state occur because of changes in the movement and arrangement of water molecules as they gain or lose energy. |
| 3 min | **Lesson focus question:** The teacher introduces and elicits student ideas about the focus question, *Does Earth ever run out of water? Support your answer with evidence and reasoning.* | |
| 7 min | **Setup for activity:** Students revisit the water-changes system from lesson 4b and explain the changes they observed in terms of molecules, evaporation, and condensation. The teacher asks students whether the mass of water changed in this system and then introduces the concepts of open and closed systems. | • Evaporation, condensation, and precipitation can occur in one system.<br>• Some systems are closed so that matter (such as water molecules) can't escape; other systems are open so that matter can escape. |
| 30 min | **Activity:** The teacher sets up an experiment with three bottles of water to explore whether mass is lost during evaporation, condensation, or freezing in a closed system. Students record the beginning mass of all three bottles and make predictions about the ending mass using mathematical equations. Then they analyze sample data from another class that conducted the experiment and weigh their own bottles again at the end of the experiment. | • In a closed system, the total mass of the water doesn't change regardless of changes in state. |
| 5 min | **Follow-up to activity:** Students share their equations representing the results of the three-bottles experiment. Then they come up with explanations for the results (claims, evidence, reasoning). The teacher highlights key science ideas related to the experiment. | |
| 7 min | **Synthesize/summarize today's lesson:** Students answer the focus question in their science notebooks. *Optional:* Students share and critique their summaries. | • Water changes state through evaporation, condensation, and freezing because of changes in the movement and arrangement of water molecules as they gain or lose energy.<br>• In a closed system, the total mass of the water (and the number of water molecules) doesn't change regardless of changes in state.<br>• Earth is a closed system for water molecules, so it never runs out of water. |
| 1 min | **Link to next lesson:** The teacher summarizes key science ideas and links them to the next lesson. | |

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| 5 min | **Link to Previous Lessons**<br><br>**Synopsis:** The teacher links this lesson to previous lessons and addresses the first unit central question by having the class look at a drawing of a mountain scene and talk about all the changes water might undergo in such an environment.<br><br>**Main science idea(s):**<br>• Through evaporation, condensation, freezing, and melting, water continually changes state and moves from place to place in our environment.<br>• Scientists describe this constant change and movement as the *water cycle*.<br>• In the water cycle, water can change from a liquid to a gas through evaporation, from a gas to a liquid through condensation, from a liquid to a solid by freezing, and from a solid to a liquid by | Link science ideas to other science ideas. | **NOTE TO TEACHER:** *If the water from the test tube wasn't poured back into the flask during lesson 4b, turn on the hot plate now to allow enough time for the system to heat before the activity setup.*<br><br>**Show slides 1 and 2.**<br><br>In this unit, we've been studying changes of state in water to help us answer these unit central questions, *How does water change in the world around us? Does Earth ever run out of water?*<br><br>**Show slide 3.**<br><br>What have we learned so far about the first question?<br><br>Look at the diagram on this slide for a moment and think about all the water changes you could describe. Everyone should be prepared to share an idea.<br><br>**Individual think time (1 min).**<br><br>**Whole-class share-out:** What water changes can you imagine happening in this diagram? I'll call on you to share your ideas using the equity sticks.<br><br>**NOTE TO TEACHER**: *During this discussion, challenge students to include the idea of molecules in their statements. Make sure they're communicating science ideas* | Evaporation.<br><br>Evaporation from the river happens | Put that in a complete sentence, please. |

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| | melting.<br>• These changes of state occur because of changes in the movement and arrangement of water molecules as they gain or lose energy. | | *accurately. If students make inaccurate statements, ask them challenge questions (or ask other students whether they agree or disagree with the statement and why).*<br><br>*Make sure students talk about evaporation, condensation, precipitation, molecules, and energy. Freezing and melting would be nice additions, but they're not essential.* | when water molecules gain heat energy from the Sun and start moving so fast that they escape into the air.<br><br>Precipitation is happening when liquid water falls from the clouds.<br><br>Clouds are made of liquid-water drops.<br><br>Water evaporates from Earth and rises into the air, and when it gets high enough, it cools off. So the water molecules lose heat energy, slow down, and come together to form liquid-water drops on pieces of dust in the air. That's a cloud. | Tell us more about the water in the clouds.<br><br>Where did those liquid-water drops in the clouds come from? |
| | | Highlight key science ideas | So we know that through evaporation, condensation, freezing, and melting, water is | | |

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| | | and focus question throughout. | constantly changing states and moving from place to place in our environment. Scientists describe this constant change and movement as the *water cycle*.<br><br>In this cycle, water can change from a liquid to a gas through evaporation, and from a gas to a liquid through condensation. It can also change from a liquid to a solid by freezing, and from a solid to a liquid by melting. These changes of state occur because of changes in the energy, movement, and arrangement of water molecules. | | |
| 3 min | **Lesson Focus Question**<br><br>**Synopsis:** The teacher introduces and elicits student ideas about the focus question, *Does Earth run out of water? Support your answer with evidence and reasoning.* | Set the purpose with a <u>focus question</u> or goal statement.<br><br>Ask questions to elicit student ideas and predictions.<br><br>Ask questions to probe student | **Show slide 4.**<br><br>Our focus question today is related to the second unit central question: *Does Earth ever run out of water? Support your answer with evidence and reasoning.*<br><br>Write this question in your science notebooks and draw a box around it. Then think about it silently for a moment and be ready to share your ideas with the class.<br><br>**Individual think time (1 min).**<br><br>**Whole-class share-out:** Do you think Earth ever runs out of water? What ideas and reasons do you have? | No, I don't think so, because if Earth was running out of water, we'd all be dead by now. | Say more about that. |

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| | | ideas and predictions. | | I think it *is* running out of water. My evidence is that sometimes it doesn't rain for a long time, so we have a drought.<br><br>I think it is because some of the water probably goes out into space. So eventually Earth will run out of water.<br><br>By evaporating.<br><br>I think that just like the Sun will eventually run out, I think in, like, a billion years, the water will run out. | How do you think water would get into space?<br><br>Say more about the Sun and water running out. |
| 7 min | **Setup for Activity**<br><br>**Synopsis:** Students revisit the water-changes system from | Make explicit links between science ideas | **Show slide 5.**<br><br>**NOTE TO TEACHER:** *Display the water-changes-system setup from lesson 4b. You may also want to have students locate handout 4.2* | | |

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| | lesson 4b and explain the changes they observed in terms of molecules, evaporation, and condensation. The teacher asks students whether the mass of water changed in this system and then introduces the concepts of open and closed systems.<br><br>**Main science idea(s):**<br>• Evaporation, condensation, and precipitation can occur in one system.<br>• Some systems are closed so that matter (such as water molecules) can't escape; other systems are open so that matter can escape. | and activities **before** the activity. | *from that lesson and refer to it as needed throughout the discussion.*<br><br>Let's start by thinking about the water-changes system from lesson 4. What changes did you observe in this system?<br><br>How did water in the flask change when it was heated?<br><br>What changes did you observe in the tubing?<br><br>What processes did you observe in this experiment? | The water in the flask evaporated.<br><br>The liquid water changed to water vapor when it was heated.<br><br>We saw droplets of liquid water in the tubing.<br><br>We saw water vapor change back to liquid water in the tubing.<br><br>We saw the water evaporate and then condense. | What happened with the water molecules during these changes [*evaporation and condensation*]?<br><br>What did you actually see, and what was going on that you couldn't actually see? |

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| | | | | We could only see when the water condensed as liquid water.<br><br>We also saw precipitation when the water rolled down the tubing into the test tube. | |
| | | Engage students in analyzing and interpreting data and observations. | **Show slide 6.**<br><br>Let's consider some data to help us think about our focus question. Look again at the diagram of the water-changes system.<br><br>**NOTE TO TEACHER:** *If the water from the test tube was poured back into the flask during lesson 4b, just point to the actual setup throughout this discussion, as well as the diagram on the PowerPoint slide. If you didn't have time to pour water from the test tube back into the flask during that lesson, do it now. (Make sure to turn off the hot plate!)*<br><br>In the demonstration during lesson 4, we marked the starting line of the water on the flask. Then when we poured the water from the test tube back into the flask, we discovered that that it didn't return to the original starting line.<br><br>Why didn't we have the same amount of water | | |

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| | | | in the flask at the end of the experiment as we did at the beginning? Did some of it disappear, change, get destroyed, or get lost?<br><br>**Turn and Talk (1 min):** Talk about these questions with a partner.<br><br>**Whole-class share-out:** So why didn't we have the same amount of water in the flask at the end of the experiment? What happened to the water? Did it disappear? | It didn't disappear, but not all of it ended up in the test tube. Some of the water was still in the tubing.<br><br>I agree, and we saw some of the water escape out the top of the test tube as steam.<br><br>It went into the air as water vapor (gas), but the cooler air hit the water-vapor molecules, and they lost energy, slowed down, and came together to form liquid-water drops. | Tell me more about what was happening when the water escaped from the top of the test tube. |

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| | | <br><br><br><br><br><br>Link science ideas to other science ideas.<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>Ask questions to elicit student ideas and predictions. | **Show slide 7.**<br><br>**NOTE TO TEACHER:** *Explain to students why the water-changes system is an open system.*<br><br>The water we poured back into the flask at the end of our experiment didn't return to the starting line because some water was still in the tubing, and some escaped into the air. We call this an *open system* because the water molecules could escape out of the system through the test-tube opening.<br><br>What if we changed the setup so that no water could escape into the air? Any ideas about how we could do that? This would make our system a *closed system*.<br><br>**Show slide 8.**<br><br>**NOTE TO TEACHER:** *Make sure students can imagine this setup as a closed system.*<br><br>What do you think about this *closed system*? If we poured the water from the test tube back into the flask in this system, would the water level in the flask be the same as when we started?<br><br>**Turn and Talk (1 min):** Work with a partner to come up with a prediction and reasoning to support your prediction.<br><br>**Whole-class share-out:** Let's hear your ideas. Do you think the water level in the closed system | <br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>Maybe cover the top of the test tube? | |

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| | | | would be the same as the level in the open system? | The water level would be the same because no water would escape through the opening at the top of the test tube. | Anyone agree or disagree with this idea? Anything you want to add on or ask? |
| | | | | I disagree, because there would still be some water in the tubing.<br><br>But if you could get all the water out of the tubing, it would come back to the starting line, like maybe if you blew it out of the tubing and back into the flask. | |
| | | | Do you think all of the water molecules that started in the flask are somewhere in the system?<br><br>Raise your hand if you think the answer is yes.<br><br>**NOTE TO TEACHER:** *If time allows, ask students to share their reasoning.* | | |

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| | | | **Show slide 9.**<br><br>We've heard some different ideas about what happens to water in a closed system, but we don't have enough evidence to answer our focus question. So let's gather more data! | | |
| 30 min | **Activity**<br><br>**Synopsis:** The teacher sets up an experiment with three bottles of water to explore whether mass is lost during evaporation, condensation, or freezing in a closed system. Students record the beginning mass of all three bottles and make predictions about ending mass using mathematical equations. Then they analyze sample data from another class that conducted the experiment and weigh their own bottles again at the end of the experiment.<br>**Main science idea(s):**<br>• In a closed system, the total mass of the water doesn't change | Make explicit links between science ideas and activities **during** the activity. | **NOTE TO TEACHER**: *This experiment should be set up so the whole class is looking at the same bottles and the same data. However, you can involve students in helping you measure, label, and weigh the three bottles as you set them up. Only the substitute freezer bottle will be filled, measured, and labeled in advance. Don't bring out this bottle until the end of the experiment.*<br><br>**Show slide 10.**<br><br>To investigate our focus question, we're going to collect some data in an experiment with three bottles.<br><br>Each bottle is the same size, shape, and material. And each has a cap to make it a *closed system.* That means any air or water inside each bottle can't get out unless we remove the cap. [*Show students the bottles*.]<br><br>Let's add 20 milliliters of water to each bottle and then put the caps on nice and tight.<br><br>What do you think happens to the mass of water when it changes states in a closed system? Let's find out! | | |

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| | regardless of changes in state. | | **NOTE TO TEACHER:** *Make sure the bottles are clearly labeled 1 Freezer, 2 Room Temp, and 3 Heated. Measure the water carefully and add it to each bottle. Make sure the caps are screwed on tightly*.<br><br>**Show slide 11.**<br><br>First, we're going to weigh each of the three bottles and record their mass at the beginning of the experiment on a chart like the one on this slide.<br><br>**NOTE TO TEACHER:** *Have students help you weigh each bottle and record the data on a class chart. Ask students to create a similar data table in their science notebooks, where they'll record data from the beginning and the end of the experiment. They should create a table that looks like the model on the slide.* | | |
| | | | How can we express our results about the mass of the bottles in words? | They have the same mass.<br><br>They're equal. | What's a mathematical way of saying that?<br><br>What is equal? What do you mean by "they"?<br><br>Does everyone agree |

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| | | | How could we express this idea using a mathematical equation and symbols, such as the equals sign and the less-than or more-than signs?<br><br>**NOTE TO TEACHER:** *The bottles will likely all have the same mass. But it's OK if they don't. Students should describe their results accurately using mathematical language and symbols, such as equals (=), less than (<), and greater than (>).*<br><br>*Help students come up with an equation similar to the following:*<br><br>Mass Bottle 1 = Mass Bottle 2 = Mass Bottle 3<br><br>OR<br><br>Mass Bottle 1 < Mass Bottle 2 = Mass Bottle 3<br><br>*Instruct students to write the equation in their science notebooks, making sure to label it "Start of experiment."*<br><br>Now let's place bottle 3 near the heat lamp, turn on the lamp, and watch what happens.<br><br>**NOTE TO TEACHER:** *As the bottle heats, it may expand or become deformed. If this happens, turn off the heat lamp and allow the bottle to cool. If you handle the bottle while it's still hot, use an oven mitt!* | *Acceptable equations*:<br><br>Bottle 1 = Bottle 2 = Bottle 3<br><br>15.2 g < 15.3 g = 15.3 g | that this is accurate? |

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| | | Ask questions to elicit student ideas and predictions.<br><br>Ask questions to probe student ideas and predictions. | What do you think will happen as the water in this bottle heats up?<br><br>**NOTE TO TEACHER:** *Signs of evaporation should appear in the bottle after about 10 minutes of heating. You may want to have students work on the following equation task for 5–8 minutes as the bottle begins heating and then have them start observing the bottle at around 8 minutes into the heating phase so they can see condensation begin to form.*<br><br>**Show slide 12.**<br><br>How do you think the mass of each bottle will change at the end of the experiment? Write your predictions in one or more equations using a combination of words and mathematical symbols. Be ready to give the reasons for your predictions.<br><br>**Students work on prediction equations (5 min).** | The water will evaporate.<br><br>The liquid will change into a gas.<br><br>The liquid water molecules will gain heat energy and move farther apart into the air. | Tell me what will happen to the water molecules. |

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| | | | **NOTES TO TEACHER:** *Students can work with a partner on their predictions. Have them express their predictions as mathematical equations in their science notebooks. For example: Bottle 1 start < Bottle 1 end.*<br><br>*Reminders for students:*<br>• *Use the symbols less than (<), greater than (>), or equal to (=).*<br>• *Indicate which bottle you're talking about (1, 2, or 3)*<br>• *Indicate which condition you're predicting (start or end).*<br>• *You can write more than one equation.*<br><br>**Whole-class discussion (3 min):** What are your predictions? What do you think will happen to the mass of each bottle after the experiment? | Bottle 1 (freezer) will weigh the most, and bottle 3 (heated) will weigh the least (e.g., Bottle 1 > Bottle 2 > Bottle 3).<br><br>Because gas is lighter than liquid water or ice, and there will be more gas in bottle 3 because of evaporation. [*Misconception*] | Why do you think that?<br><br>Does anyone agree, disagree, or want to |

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| | | | | And ice is heavier than liquid water. [*Misconception*]<br><br>I disagree because I think ice is lighter than liquid water because ice floats on water. So I think the freezer bottle will weigh less at the end than at the start (e.g., Bottle 1 start > Bottle 1 end).<br><br>The bottles will all weigh the same at the end as they did at the beginning because it's the same amount of stuff; it's just changing form (e.g., Bottle 1 start = Bottle 1 end; Bottle 2 start = Bottle 2 end; and Bottle 3 start = Bottle 3 end). [*This is the desired/ expected finding.*]<br><br>I think bottle 3 will weigh less at the end than at the beginning | add on?<br><br>What do the rest of you think? |

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| | | | | (e.g., Bottle 3 start > Bottle 3 end). [*Not expected. The student may be thinking incorrectly that water vapor has less mass than water in its liquid state.*]<br><br>I think all the bottles will have the same mass at the end (e.g., Bottle 1 end = Bottle 2 end = Bottle 3 end). [*This may or may not happen; it's a reasonable prediction, but the analysis should focus on the comparisons between starting and ending masses.]* | |
| | | | **NOTE TO TEACHER:** *After heating the bottle for 20 minutes, turn off the heat lamp and allow the bottle to cool while students examine the following sample data.*<br><br>**Show slide 13.** | | |
| | | Engage students in analyzing and interpreting data | Before we finish our three bottles experiment, let's look at some sample data collected from another class that performed this experiment. | | |

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| | | and observations.<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>Ask questions to probe student ideas and predictions.<br><br>Ask questions to challenge student thinking. | Then we'll see how our data compares with theirs.<br><br>**Students examine sample data.**<br><br>**NOTE TO TEACHER:** *Briefly review the format of the data chart so students understand which data are in each row and column.*<br><br>What can you say about the results of this experiment from the sample data? What pattern do you notice in the data between the start of the experiment and the end?<br><br>**Small groups:** Talk about these questions in your small groups. Then try to use equations with mathematical symbols to represent the pattern in writing. When you're finished, have one group member write your equation on the board.<br>**Small groups work on equations.**<br><br>**NOTE TO TEACHER:** *While students are working on their equations, move from group to group and ask, "What pattern do you see in the results?" Also ask questions that probe and challenge student thinking.*<br><br>*If students have difficulty coming up with ideas for representing the pattern mathematically, direct their attention to the <, +, and > symbols on slide 13 and ask, "Might any of these symbols be useful in showing the pattern of change from the beginning to the end of this experiment?"* | | *Possible probe and challenge questions*:<br><br>What do you mean when you say "it" never changes?<br><br>Can you use mathematical terms or symbols to describe the pattern |

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| | | | **Show slide 14.**<br><br>Before we share our equations, let's finish our three-bottles experiment and see if our results match the sample data. First, we need to replace our freezer bottle with an identical bottle of water that was frozen overnight.<br><br>Now let's weigh our three bottles again and record the ending mass for each bottle on our class data chart.<br><br>**Whole-class discussion:** What do you notice when you compare our results with the results from the sample data? Is the pattern the same or different? | | you see? |
| 5 min | **Follow-Up to Activity**<br><br>**Synopsis:** Students share their equations representing the results of the three-bottles experiment. Then they come up with explanations for the results (claim, evidence, reasoning). The teacher highlights key science ideas related to the experiment.<br>**Main science idea(s):**<br>• In a closed system, the total mass of the water doesn't change regardless of changes | Make explicit links between science ideas and activities **after** the activity. | **Show slide 15.**<br><br>OK, let's look at the equations you came up with to represent the pattern you observed in the experiment results. We'll start with Group 1.<br><br>Be thinking of questions to ask Group 1. Do you understand what their equation is saying? Do you think it accurately describes the data?<br><br>**NOTE TO TEACHER:** *Follow the same process for each group. (If groups come up with the same pattern, quickly move on to the next group.)*<br><br>*Encourage students to ask each other probe and challenge questions, and agree, disagree, or add on to each other's ideas.* | *Accurate equations*:<br><br>• Bottle 1 start = Bottle 1 end; Bottle 2 start = Bottle 2 end; Bottle 3 start = Bottle 3 end<br><br>• Bottle 1 start < Bottle 2 start < | |

| Time | Phase of Lesson and How the Science Content Storyline Develops | STeLLA Strategy | Teacher Talk and Questions | Anticipated Student Responses | Possible Probe/Challenge Questions |
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| | in state. | Engage students in constructing explanations and arguments.<br><br>Engage students in communicating in scientific ways. | **Show slide 16.**<br><br>**NOTE TO TEACHER**: *Have students work with a partner to construct* ***oral*** *explanations for the results of the three-bottles experiment (including the sample data). They'll work individually on written explanations during the synthesize/summarize activity*.<br><br>What do the results of this experiment tell us? What does the pattern mean?<br><br>**Turn and Talk (about 3 min):** Talk about this with a partner and come up with a claim, evidence, and reasoning that answers the question on the slide: *As water changes states, does its mass change? Support your answer with evidence and reasoning.*<br><br>**Whole-class discussion:** Do you think the mass of water changes when it changes states? Let's hear your claims, evidence, and reasoning. What claims can be supported by our evidence?<br><br>Everyone listen and be ready to ask questions, add on, and agree or disagree with what you hear. Let's think like scientists! | Bottle 3 start<br><br>• Bottle 1 end < Bottle 2 end < Bottle 3 end<br><br>The mass doesn't change as water changes states, because none of the bottles changed in mass even after they | |

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| | | | | were heated or cooled.<br><br>I agree. Even though the water froze in bottle 1 and evaporated in bottle 3, the mass of the water didn't change.<br><br>As water changes states, its mass changes only when it freezes. The frozen water weighs less than room-temperature and heated water. I think this is because ice is lighter than liquid water; it floats. [*Make sure this claim is challenged. Students might see that the freezer bottle had less mass than the other two and draw the wrong conclusion.*] | Does anyone agree or disagree? Any questions or add ons?<br><br>Does that surprise you? Why or why not?<br><br>You're noticing that |

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| | | | How did the results of this experiment compare with your predictions? Why do you think your predictions were correct or incorrect? | We thought the heated bottle would weigh less, but it doesn't.<br><br>I thought liquid-water molecules would weigh more than molecules in the gaseous state, but I think I was wrong.<br><br>I thought the ice would be more packed together and weigh more than liquid water.<br><br>I guess the water molecules weigh the same whether they're | the frozen water has less mass than the water in the other two bottles. Does the data show that water has less mass when it's frozen? |

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| | | | **Show slide 17.**<br><br>**NOTE TO TEACHER:** *Reveal the questions and answers on the slide one at a time.*<br><br>So we found that the *mass* of the bottles didn't change when the water was frozen or heated.<br><br>Did the *amount* of water in the bottles change?<br><br>Do you think the *number of water molecules* in each bottle changed when the water froze and became a solid or evaporated and became a gas? | frozen or liquid.<br><br>No, the water just changed state.<br><br>No, the number of molecules was the same; they were just in a different state.<br><br>Probably there is the same number of molecules because where could they escape to?<br><br>Maybe they could escape if the cap wasn't on really, really tight. | More accurately, we say they have the same mass. |

| Time | Phase of Lesson and How the Science Content Storyline Develops | STeLLA Strategy | Teacher Talk and Questions | Anticipated Student Responses | Possible Probe/Challenge Questions |
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| | | Highlight key science ideas and focus question throughout. | In a *closed system* like our bottles, the mass of the water will always be the same. The water molecules may move faster or slower as they gain or lose energy, but the water molecules don't disappear or lose mass. There will always be the same number of molecules, and they'll always have the same mass whether they're in the liquid, solid, or gaseous state.<br><br>**Show slide 18.**<br><br>This slide shows what water molecules **can** and **cannot** do when they change states in a closed system.<br><br>They **can** gain or lose energy, speed up or slow down, and change how they're arranged in relationship to other water molecules.<br><br>They **cannot** gain or lose mass, be destroyed, or disappear into nothingness.<br><br>**CONTENT NOTE TO TEACHER:**<br>*Conservation of matter holds true if the system is closed. Water molecules can't escape a* | I think there would be fewer molecules when the bottle was heated, because they would be more spread out and less crowded. | |

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| | | | *closed system. In the three-bottles experiment, the tight caps on the bottles modeled a closed system where no matter or molecules could enter or leave. The water-changes system in lesson 4b was an open system, with some molecules escaping as water vapor from the open end of the test tube. Earth and its surrounding atmosphere are a closed system for water. So Earth never runs out of water. Water molecules may change states, but they never disappear or escape the system.* | | |
| 10 min | **Synthesize/Summarize Today's Lesson**<br><br>**Synopsis:** Students answer the focus question in their science notebooks. *Optional:* Students share and critique their summaries.<br><br>**Main science idea(s):**<br>• Water changes state through evaporation, condensation, and freezing because of changes in the movement and arrangement of water molecules as they gain or lose energy.<br>• In a closed system, the total mass of the water (and the number of | Highlight key science ideas and focus question throughout. | **Show slide 19.**<br><br>Let's return to our focus question: *Does Earth ever run out of water? Support your answer with evidence and reasoning.*<br><br>**Show slide 20.**<br><br>Like our bottles, **Earth is a closed system for water**. The air around Earth (the atmosphere) is like a cap on a bottle. Gravity is also a force that pulls water molecules toward Earth. Gravity and Earth's atmosphere keep water molecules from escaping into space.<br><br>So let's use what we learned from our experiment today to answer today's focus question.<br><br>***Embedded Assessment Task***<br><br>**Show slide 21.** | | |

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| | water molecules) doesn't change regardless of changes in state.<br>• Earth is a closed system for water molecules, so it never runs out of water. | Engage students in making connections by synthesizing and summarizing key science ideas. | In your science notebooks, try to answer our focus question using both mathematical evidence from our experiment and words that describe what happens to molecules as they change states. Write down your claim and provide evidence and reasoning to support it.<br><br>Use words like *open system, closed system*, *molecules*, *mass*, *evaporation*, *condensation*, *solid*, *liquid*, *water vapor* or *gas*, and *gain* or *lose energy*. You may also want to draw pictures that help you express your ideas.<br><br>***Optional:*** *Allow a few students to read their summaries aloud and receive feedback/critiques from you and other classmates. If there isn't enough time, start the next lesson with this activity.* | *Strong answer:*<br><br>**Claim:** Earth does not run out of water.<br><br>**Evidence:** My mathematical evidence is our experiment. The water in a closed system changed state, but the mass didn't change.<br><br>**Reasoning:** My reasoning is that water molecules can't get out of those bottles, so they can't be lost. They're still in the bottles. The same thing is true of Earth and its atmosphere. The water molecules can't escape because Earth is a closed | |

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| | | | | system for water. | |
| 1 min | **Link to Next Lesson**<br><br>**Synopsis:** The teacher summarizes key science ideas and links them to the next lesson. | Summarize key science ideas.<br><br>Link science ideas to other science ideas. | In past lessons, we learned how water changes form through evaporation and condensation. We also learned how the energy water molecules contain can explain their arrangement and how they move when they change forms.<br><br>**Show slide 22**.<br><br>Today we learned that in a closed system, the amount of water (its mass and the number of molecules) doesn't change. Water constantly changes states from a liquid to a solid or a gas, but it never disappears or is lost. Earth is a closed system for water, so the water on Earth never runs out!<br><br>**Show slide 23.**<br><br>Tomorrow we'll use everything we've learned about the water cycle to answer our central unit questions, *How does water change in the world around us? Does Earth ever run out of water?* | | |