Water Cycle Lessons: Scope and Sequence

Lesson Number	Focus Question(s)	Main Learning Goal	Science Content Storyline
1a	Does liquid water ever disappear? Explain your thinking.	Scientific explanations can be constructed by (1) stating a claim that answers the question being studied, (2) identifying evidence that supports the claim, and (3) including logical reasoning that uses science ideas and principles to show how the evidence supports the claim.	Water undergoes changes we can observe, and it sometimes seems to disappear, such as when water boils away from inside a beaker. We observed that the water level in the beaker went down as the water boiled. Did some of the water disappear? Why did the water level go down? To explain this scientifically, we need a claim that proposes an answer to the question, observable evidence to support the claim, and reasoning that uses science ideas and principles to show how the evidence supports the claim. We came up with claims and evidence about the boiling water, but we need some science ideas that we can use in our reasoning to build a stronger scientific explanation.
1b	Does liquid water ever disappear? Explain your thinking.	When liquid water is heated, it changes to a gas (water vapor) that isn't visible. This process is called *evaporation*.	Water sometimes seems to disappear, such as when it boils away from inside a beaker. But the water still exists and is changing state from a liquid to a gas called *water vapor* that we can't see. The process of water changing from a liquid to a gas is called *evaporation*. Evaporation happens faster if heat is added.
2a	Can you make water vapor in the air "reappear" as liquid water? Explain your thinking.	Observations of the formation of liquid-water droplets on the outside of a cup of water with ice can provide evidence to support claims about whether water vapor in the air can "reappear" as liquid water.	We know that water can change from a liquid to a gas (water vapor) when heat is added. The water seems to disappear, but it's actually rising into the air as a gas called *water vapor*. Can gaseous water vapor reappear as liquid water? To answer this question, we observed liquid water appear on the outside of a cup of water with ice, but not on the outside of a cup of water at room temperature. We're working to explain where the liquid water came from. We considered different claims and the evidence that does or does not support them. Now we need some new science ideas to help with our reasoning.
2b	Can you make water vapor in the air "reappear" as liquid water? Explain your thinking.	Water changes state from a gas (water vapor) to a liquid when water vapor in the air loses energy (cools). This process is called *condensation*.	We know that water can change from a liquid to a gas (water vapor) when heat is added. Water can also change from a gas to a liquid when water vapor in the air loses energy (cools). This process is called *condensation*.

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3a	Why is water sometimes a liquid, sometimes a solid, and sometimes a gas?	Water is made up of tiny molecules we can't see. In the liquid state, these molecules are always moving around and sliding past one another.	Why does adding heat help change liquid water to water vapor? And why does cooling help change water vapor to liquid water? To answer these questions, we need to know about water molecules. A water molecule is the tiniest part of water that is still water. It can't be seen, even under a powerful microscope. We can see water only when very large numbers of water molecules cluster together. Water molecules are clustered together in the liquid and solid forms, so we can see liquid water and ice. But water molecules in the gaseous state are so spread out that we can't see them. Even though we can't see individual water molecules, we have evidence from our food-coloring experiment that water molecules in the liquid state move. To answer our focus question, we need to find out whether water molecules in the solid and gaseous states move in the same way.
3b	Why is water sometimes a liquid, sometimes a solid, and sometimes a gas?	Water is made up of molecules that move differently when water is in liquid, solid, or gaseous states.	Water is sometimes in a liquid state that we can see, sometimes in a solid state (ice) that we can see, and sometimes in a gaseous state that is spread out in the air and we can't see. Why is water sometimes a liquid, sometimes a solid, and sometimes a gas? Last time, we started thinking about what water molecules might have to do with these changes of state. We learned that water is made up of tiny molecules, and when these molecules are in the liquid state, they're always moving around, even when the water appears to us to be very still. Liquid-water molecules are loosely attracted to each other, allowing individual molecules to slip or slide past one another. Molecules of liquid water have more energy than molecules of solid water (ice) and less energy than molecules of gaseous water (water vapor). Molecules in the solid state behave very differently. They line up next to each other in a rigid, lattice-like formation that prevents them from moving away from each other. In the solid state, water molecules slowly vibrate in place. In the gaseous state, water molecules move apart and are not attracted to one another. The individual water molecules in a gaseous state move very fast and spread throughout the air in different directions.

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4a	How can ideas about water molecules help us explain evaporation and condensation?	Changes in the energy (motion) of molecules help explain how water changes state during evaporation and condensation.	Water molecules move differently when they're in different states (liquid, solid, and gas). We can use this idea to explain what is happening during phase changes like evaporation and condensation. In a liquid state, water molecules are loosely attracted to each other and can slip and slide past one another. As water molecules in the liquid state absorb energy, they move faster, break away from other molecules, escape the surface of the water (a phase change), and spread throughout the air as individual gas molecules called *water vapor*. This process of liquid water absorbing heat, increasing its molecular motion, and changing from a liquid to a gas is called *evaporation*. Boiling water in lesson 1a is an example of evaporation: When the water boils, the molecules gain energy, move faster, and break away from each other to form water vapor in the bubbles and at the surface of the water. When water-vapor molecules in the air lose heat energy (cool), they slow down and are attracted to each other to form liquid-water droplets. This process is called *condensation*. An example of condensation is the water that formed on the cup of ice water in lesson 2a.
4b	How can ideas about water molecules help us explain evaporation and condensation in a system?	Changes in the energy (motion) of molecules help explain how water changes states during evaporation and condensation within an open system.	Water molecules move differently when they're in different states (liquid, solid, and gas). We can use this idea to explain what is happening during the processes of evaporation and condensation in an open distillation system. In a liquid state, water molecules in a flask sitting on a hot plate are loosely attracted to each other and can slip and slide past one another. As these water molecules absorb energy from the hot plate, they move faster. Fast-moving water molecules at the surface of the liquid can escape into the air (evaporation) and spread out in the flask as individual gas molecules (water vapor). As the water-vapor molecules move to the top of the flask and into the tubing, the surrounding air is much cooler. The fast-moving water-vapor molecules lose heat energy to the cooler air and slow down. As they slow, they're attracted to other slower-moving water molecules to form droplets of liquid water near the top of the flask and in the tubing (condensation). Some of the droplets of condensed water slide down the tubing into the test tube

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			(precipitation). Some of the fast-moving water molecules in the gaseous state escape out of the system through the opening at the top of the test tube. In this system, molecules move back and forth between liquid and gaseous states through evaporation and condensation. Some of the water in the flask ends up in the test tube, and some of it ends up escaping into the air (out of the system).
5a	How can ideas about water molecules, evaporation, and condensation help us explain everyday situations?	Changes in the motion and arrangement of water molecules during evaporation and condensation are involved in forming clouds, steam above a teakettle spout, and "fog" on bathroom mirrors.	Many everyday situations can be explained in terms of changes in the arrangement and motion of water molecules as they move from the liquid state to the gaseous state (evaporation) and back again (condensation). We know that evaporation occurs when water boils and molecules in the liquid state move faster, break away from other molecules, and rise into the air as water vapor. We also know that condensation occurs when water-vapor molecules in the air lose heat energy (cool), slow down, and join together to form liquid-water droplets when they come near a cold glass of ice water. Today we found out that some everyday situations involve both evaporation and condensation. For example, clouds form when liquid water on Earth is heated and the molecules evaporate, spreading throughout the air as water vapor. When these water-vapor molecules rise high up in the sky, they cool, lose energy, slow down, and condense on dust particles in the air, forming tiny droplets of liquid water that we see as a cloud. Other examples of everyday situations that involve both evaporation and condensation are the steam above a teakettle spout and a foggy bathroom mirror.
5b	How can ideas about water molecules, evaporation, and condensation help us explain the water cycle in the world around us?	Driven by energy from the Sun, water molecules are constantly changing states and cycling from Earth to the atmosphere and back to Earth through the processes of evaporation, condensation, and precipitation. [**Note:** Conservation and recycling of water molecules in	Water molecules are constantly changing states and cycling from Earth to the atmosphere and back to Earth through the processes of evaporation, condensation, and precipitation. Energy from the Sun drives this water cycle. Evaporation from lakes, oceans, rivers, plants, and even our skin occurs when water molecules in the liquid state gain heat energy from the Sun and move faster. Fast-moving water molecules break away from other molecules, escape the surface of the water, and spread out into the air as individual water-vapor (gas) molecules. Condensation occurs when water-vapor molecules lose

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		the water cycle will be addressed in the next lesson.]	heat energy (cool), slow down, and join together to form tiny droplets of liquid water (condensation). This is how clouds are formed—water-vapor molecules move high into the air, where they lose heat energy and condense onto dust particles in the atmosphere. Precipitation occurs when the liquid-water droplets that make up the clouds get heavy enough to fall to Earth as rain, hail, sleet, or snow. Each water molecule changes from one state to another over and over again.
6a	Does Earth ever run out of water? Support your answer with evidence and reasoning.	As water changes state (liquid, solid, or gas), its mass is always conserved, which can be demonstrated mathematically.	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 or 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.
6b	Could you be drinking the same water that George Washington used to wash his boots? Explain your thinking.	Energy from the Sun drives the water cycle, which includes the processes of evaporation, condensation, and precipitation that allow water molecules to move around the world without ever disappearing, being destroyed, or being used up. The total mass of water molecules on Earth doesn't change.	Evaporation, condensation, and precipitation are processes that allow water to be continually recycled on Earth. In the water cycle, water molecules are constantly changing states and moving around on Earth and in its atmosphere. Since Earth is a closed system for water molecules, Earth never runs out of water. Although water molecules change states, they never disappear from Earth, lose mass, or are destroyed. Water molecules evaporate when heat is added to liquid water (as when the Sun's energy heats rivers, lakes, and oceans), causing the molecules to gain energy, move faster, break away from other molecules, escape the surface of the water, and spread out into the air as individual water-vapor (gas) molecules. Water-vapor molecules condense when they lose energy in cooler air, slow down, and join together to form tiny droplets of liquid water. Clouds are tiny droplets of liquid (or frozen) water that have condensed onto dust

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			particles in the air. Precipitation occurs when liquid-water droplets in the clouds fall to Earth as rain, hail, sleet, or snow. Each molecule of water changes from one state to another over and over again without ever disappearing or getting used up.