Lesson Plan: Water Wonderland

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Target Grade: 6th

Teacher Prep Time: 30 minutes

Lesson Time: 6 hours (We recommend doing this lesson over 6 days, 1 part per day.)

- Part 1:
  - 20 min - Beginning Thoughts
  - 40 min - How do Water Sources Interact?
- Part 2:
  - 60 min - Why Does Water Flow? (Part A)
- Part 3:
  - 60 min - Why Does Water Flow? (Part B)
- Part 4:
  - 10 min - Phase Changes Review
  - 25 min - Roles of Plants in the Water Cycle
  - 25 min - Roles of Animals in the Water Cycle
- Part 5:
  - 20 min - Applying our Model
  - 40 min - Verifying our Model
- Part 6:
  - 25 min - Checking Our Predictions
  - 35 min - Final Water Cycle Model

Where This Lesson Fits in:

From earth science lessons in previous grades, students will know different types of water sources (ex: river), as well as weather conditions (ex: rain). This lesson sequence would take place at the beginning of the 6th grade earth science unit. During the lesson, students will explore the water cycle and the roles of gravity and energy within the cycle. Students will be introduced to air masses and learn that they are different temperatures and humidities. They will further explore these later in the unit, when they learn how air mass interactions affect weather conditions (MS-ESS2-5). This will lead students to further explore how atmospheric and ocean circulations are uneven across the planet, which causes different locations to have different climates (MS-ESS2-6).

Lesson Overview:

In this lesson, students will develop a model of the water cycle. Part 1 of the lesson starts with students thinking about why water is important to us, where we find water in the environment, and how water enters and leaves these water sources. Groups then generate an initial model containing the names of the water sources (ex: lake), arrows showing the flow of water, and at least the following scientific terms: **precipitation, evaporation, solid, liquid, gas,** and **condensation**. In Part 2 of the lesson, students watch two demonstrations that allows them to explore gravity and what happens when rain lands on a slope. They are introduced to ground water and the at least the following scientific terms: **gravity**, **percolation**, **infiltration,** and **runoff**. These ideas and terms are added to their models in addition, students highlight arrows in green in which gravity plays a role in the transportation of the water. Part 3 of the lesson, student watch another demonstration that allows them to explore the role of heat sources and sinks in the water cycle. Groups revise their model by adding orange arrows to show energy

transfer during the water cycle. In addition, they add at least the following scientific terms to their model: **humidity, melting, freezing, heat sources,** and **heat sinks.** Part 4 of the lesson allows students to revisit the role of phase changes in the water cycle. Then they explore the role of plants and animals in the water cycle. Groups then add at least the following scientific terms to their model: **transpiration** and **respiration.** For Part 5 of the activity, students use their model to make a prediction to explain what happens when we pump groundwater. As a class, students complete a reading that allows them to learn about the local water system, verify their model, and check their prediction about pumping groundwater. This reading introduces the following scientific terms that students will add to their final model: **watershed**, **sea level, aquifer, water table, sublimation, photosynthesis** and **deposition.** The lesson concludes with groups adding the additional terms to their models and sharing their completed water cycle models with the class.

Learning Objective:

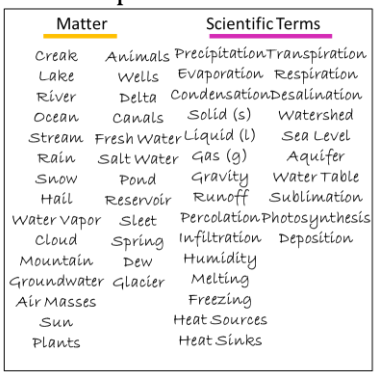
- Students will develop a model that shows both the flow of water and energy in the water cycle.

NGSS:

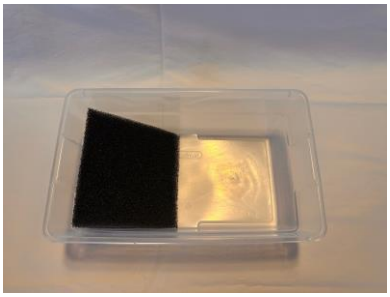
- **Performance Expectation**
  - MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- **Science and Engineering Practice**
  - #2 - Developing and Using Models
    - Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
      - Develop or modify a model - based on evidence – to match what happens if a variable or component of a system is changed.
      - Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
      - Develop and/or use a model to predict and/or describe phenomena.
      - Develop a model to describe unobservable mechanisms.
- **Disciplinary Core Idea**
  - ESS2. C: The Role of Water in Earth Surface Processes
    - Water cycles through land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.
- **Cross Cutting Concept**
  - #5 - Energy and Matter
    - In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.
- **Common Core State Standard**
  - RI.6.2 - Reading Informational Text
    - Determine a central idea of text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgements.

Materials Needed (see start of lessons sequence for suggested students per group)**:**

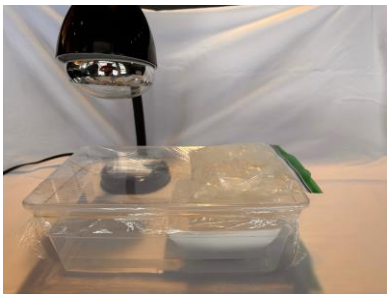
- (1 per student + 1 for the example worksheet [filled out by teacher]) *Water Wonderland* Worksheet
- (1 per student + 1 for the example reading) *Walking in a Water Wonderland* Reading
- (20 per group) Yellow and pink post-it notes (0.76" x 3" and 3" x 3")
- *Matter and Scientific Terms* Poster - Poster (27" x 34") with the words "Matter" and "Scientific Terms" written at the top. There will be approximately 20 terms written under each of these headings by the end of the activity. The final poster will look similar to the one below. It is possible that students generate other terms as well such as: snow pack, waterfall, slough, dam, pipe, etc. that can also be added to the poster.



- (At least 1 per group; some groups might ask for additional paper) Poster paper (27" x 34")
- An object that can be dropped (ex: pen)
- Groundwater demonstration
  - Plastic transparent container:
    - I used a plastic shoe box that was made by Sterilite that was $13\frac{5}{8}$ x $8\frac{1}{4}$x $4\frac{7}{8}$ (Home Depot)
  - Angled sponge
    - I used a gutter foam filter insert (right) that I cut to fit into my box (Home Depot)
  - Catchment system.
    - It is important that this not be more than ¾" tall and that it does not float (made of ceramic). I used a 60 mm x 15 mm glass petri dish (Amazon)
  - (~1 tsp) Food coloring
    - any color works; you will need about 1 tsp
  - Measuring cup or pitcher with water (~4 cups)
    - I would suggest using a 4-cup measuring cup.



- Heat demonstration
  - Heat lamp indoor bulb - Incandescent 250 W BR40 Infrared Reflector (Amazon or hardware store)
  - Gooseneck desk lamp that fits bulb (Amazon or hardware store)
    - You need to be able to bend the lamp, so that the bulb is about 3 inches above the plastic wrap.



  - Plastic transparent container
    - I used a plastic shoe box that was made by Sterilite that was $13\frac{5}{8}$ x $8\frac{1}{4}$x $4\frac{7}{8}$ (Home Depot)

- Plastic wrap (2 ft)
- Ice (1 Ziplock sandwich bag full)
- Rubber band (7”x1/8”; file bands)

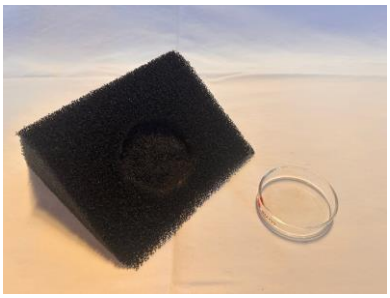
- Transportation demonstration
  - Ziplock sandwich bag
  - Plant
    - You need to be able to put the bag over the plant as seen in the picture on the right.
- Respiration demonstration
  - (1 per student) Plastic sandwich bag
- (1 per student) Highlighter or yellow crayon

Teacher Prep:

Part 1:

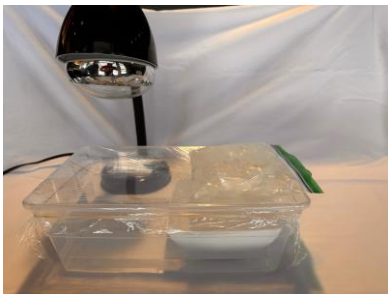
- Print out the *Water Wonderland* Worksheet.
- Have yellow and pink post-it notes ready to give groups.
- Have poster paper ready to give groups.

Part 2:



- Have the *Matter and Scientific Terms* poster easily available to put up on the front board.
- Have yellow and pink post-it notes ready to give groups.
- If needed, make the groundwater demonstration
  - Cut the sponge to fit into the plastic tub. Cut a hole in the bottom of the sponge to hold the catchment basement. Students should not be able to see the catchment basement when the sponge is over it in the tub. Have food coloring and ~4 cups of water ready to use when you do the demonstration.
- Test the groundwater demonstration so that you know how much water to pour to allow water to cover the bottom of the box, but not overflow the catchment system.

Part 3:



- Have the *Matter and Scientific Terms* poster on the front board.
- Have yellow and pink post-it notes ready to give groups.
- Set up heat demonstration
  - Pour 3 cups of water into the bottom of the plastic tub. Put the bowl in the plastic tub off to one side. Cover the tub with plastic wrap and then secure plastic wrap with a rubber band. Set up light so that it is positioned on the opposite side of the box from the bowl, about 3 inches from the plastic wrap. When ready to start the demonstration, turn on the light and set a bag of ice on the plastic wrap over the bowl.
- 30 minutes before starting the activity, have students look at the heat demonstration. Take a photo of the system and turn on the heat lamp and place ice, in a sandwich bag, over the bowl.

Part 4:

- Have the *Matter and Scientific Terms* poster on the front board.
- Have yellow and pink post-it notes ready to give groups.
- Test out the transportation demonstration. Put a sandwich bag over a broad-leafed plant (I bought a basil plant from the grocery store and that worked well) and see how long it takes to form water in the bag for the conditions at your school. This could be anywhere from a few

minutes to hours.
- Have a bag ready for the transpiration demonstration.
- Have a plastic sandwich bag ready to give to students for the respiration demonstration.

Part 5:
- Have the *Matter and Scientific Terms* poster on the front board.
- Print out the *Walking in* a *Water Wonderland* Reading.
- Have yellow and pink post-it notes ready to give groups.

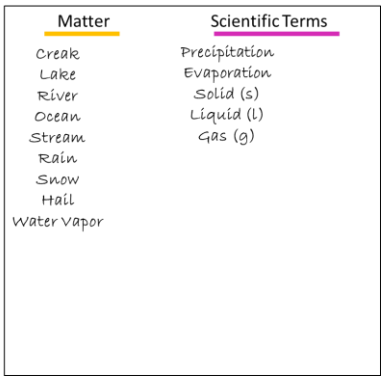
Part 6:
- Have the *Matter and Scientific Terms* poster on the front board.
- Write the following on the board: *If the water does not runoff, it can be absorbed into the soil.*
- Write the following on the board leaving room to list terms by "matter," and "scientific terms:"
    - Different water sources
        - Matter:
        - Scientific Terms:
    - How water enters into water sources
        - Matter:
        - Scientific Terms:
    - Groundwater
        - Matter:
        - Scientific Terms:
    - How water leaves water sources
        - Matter:
        - Scientific:
    - Phase changes in the water cycle
        - Matter:
        - Scientific Terms:
    - Role of living things in the water cycle
        - Matter:
        - Scientific Terms:

Lesson Sequence:

* For this activity we recommend that students work in groups of five. Do not have more than six groups per class.

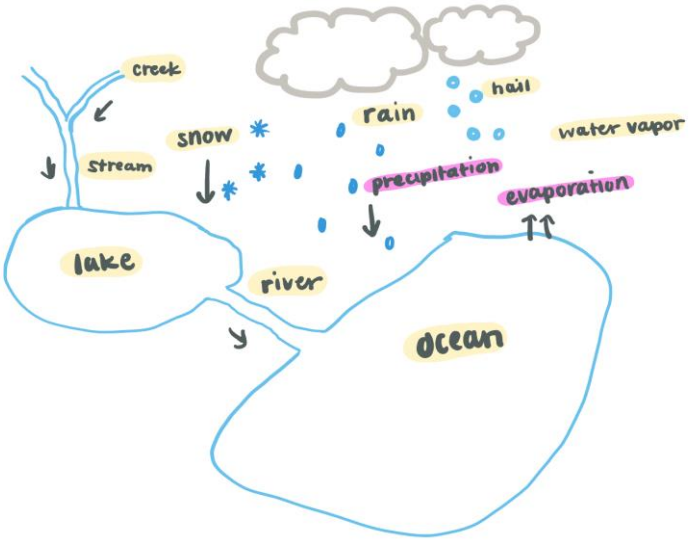
Part 1:	
20 minutes	**Beginning Thoughts** • Pass out a *Water Wonderland* worksheet to each student. • Tell students, "We are going to start a unit that focuses on water. Before we start, I want to know why you think water is important to us?" • Have students independently fill out **question 1**, then discuss the importance of water. Make sure students understand without water there would be no life on Earth. Record the class consensus answer on the example worksheet under the document camera. • Tell students, "Direct uses of water are ways that we use or interact with water in our lives." Have students independently fill out **question 2**. Then, have students share the direct uses of water they generated (ex: drinking, bathing, watering plants, swimming, etc.) and record some of these on the example worksheet. • Tell students, "Indirect uses of water are products that we use that need water

	to be made." Have students independently fill out **question 3**. Then, have students share the indirect uses of water that they generated (ex: food that we eat, wood in our houses, the paper that we are writing on, the electricity that we use [water is used to convert natural gas into electricity]) and record some of these on the example worksheet. • As a class, fill out **question 4**, make sure students know water can be present in solid form which we call ice, liquid form which we call water, and gas form which we call gaseous water. • As a class, fill out **question 5**. Make sure students know the names of solid, liquid, and gas water in the environment. ○ Students may not know that gas water is called water vapor in the atmosphere. Give them this term, if needed. ○ If sleet comes up, add a line below gas that says solid and liquid: and write sleet next to it. If this term does not come up, do not prompt students to say it. This will come up later in the reading. • Have students list where water can be found in the environment (**question 6**). Then have them share their answers, and record these on the example worksheet. • As a class, discuss if all the water sources are a form of matter. Lead students to understand that they are, because they take up space and have mass. Record this on the class worksheet (**question 7**), while students do the same on their worksheet. • Have students fill out **questions 8** and **9** with how water enters and leaves these locations. • Discuss how water enters these systems. Make sure students generate rain and snow. If they do not generate other ways, do not press them on this now. Record these on the example worksheet. ○ Make sure students know that the scientific word for water coming from the sky is precipitation. • Discuss how water leaves these systems. Make sure students generate flow out of a water source and evaporation. If they do not generate other ways, do not press them on this now. Record these on the example worksheet.
40 minutes	**How do Water Sources Interact?** • Tell students, "We are now going to make a model of the water cycle." • Ask students, "What is a model?" By the end of the conversation, make sure students understand a model is a representation of a person's current understanding of an event, system, or process. Record this for **question 10** on the example worksheet, while students do the same on their worksheets. • Place the *Matter and Scientific Terms* poster on the board, if it is not already there. • Ask students, "What bodies of water or water sources should be included in our model?" ○ Expected Student Response (ESR): **Ocean**, **lake**, **river**, **stream**, **creek**, **rain**, **snow**, and **water vapor**. ○ As students generate these, write them on a poster under the word matter. ○ Students may generate terms that are not above (ex: slough) add these to the poster as well. • Tell students, "Yellow post-it notes will contain different forms of matter that

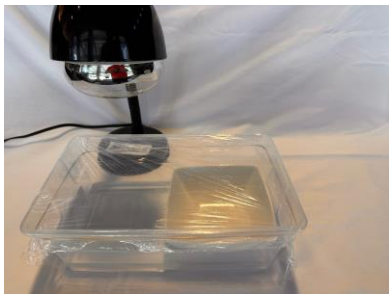
	are important to the water cycle which we should include in our model."
	• Pass out yellow post-it notes to each group. Have groups write each of the water sources that were generated on post-it notes.
	• Ask students, "What scientific terms should we include in our model?"
	  ○ ESR: **Precipitation**, **evaporation, solid, liquid,** and **gas**.
	  ○ Make sure that students generate both of these. If they generate others (ex: condensation) that is fine, but do not push other terms.
	• The *Matter and Scientific Terms* poster should currently look like the one below. It is ok if not all of the forms of matter are on the poster but make sure that the two scientific terms are there. It is ok to have extra matter and scientific terms on the poster.
	 
	
	• Tell students, "Pink post-it notes will contain scientific terms that are relevant to the water cycle that we should include in our model."
	• Pass out pink post-it notes to each group. Have groups write each of the scientific terms that were generated on post-it notes.
	• Tell students, "You are now going to draw a model of the water cycle for **question 11**. You should include the matter and scientific terms that we generated. In addition, you will use black arrows to show the flow of water from one location to another."
	• Give students approximately 5 minutes to draw their water cycle model.
	• Have students share their water cycle model with their group.
	• As a group, have them draw a water cycle. Make sure they place their yellow and pink post-it notes in the appropriate location on their group model.
	• Have one groups share their water cycle models with the class.
	• Ask groups, "Does anyone else have anything different than what was already shared on their model?" If so, let these groups share what else they included on the model.
	  ○ If the word condensation is not already on the *Matter and Scientific Terms* poster make sure this term is discussed.
	• Ask students, "Is there any other form of matter or scientific term that we saw in the model that we should add to our *Matter and Scientific Terms* poster?" Oftentimes **condensation** and **clouds** come up. If needed, add these terms to the *Matter and Scientific Terms* poster and have students write it on the appropriate colored post-it note.

Matter	Scientific Terms
Creak	Precipitation
Lake	Evaporation
River	Solid (s)
Ocean	Liquid (l)
Stream	Gas (g)
Rain	Condensation
Snow	
Hail	
Water Vapor	
Cloud	

- Allow groups a few minutes to modify their models, if desired.

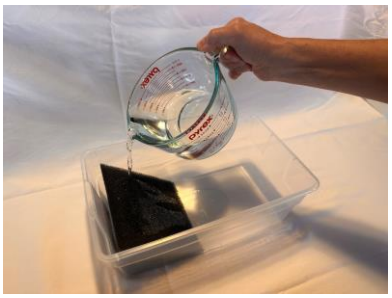


- As a class, discuss if the amount of water in the system (Earth) changes. By the end of the conversation, make sure students understand the amount of water on Earth is essentially constant, but it is transferring between solid, liquid, and gas forms. Fill out **question 12** on the example worksheet, while students do the same on their worksheets.
- Have students fill out **question 13** on their own. Then, have a few students share an example of water transfer in which the state of matter did not change. While they share, have them point to where on their model this transfer is shown. This question does not need to be filled out on the example worksheet.
- Have students fill out **question 14** on their own. Then, have a few students share an example of water transfer in which the state of matter did change. While they share, have them point to where on their model this transfer is shown. This question does not need to be filled out on the example worksheet.
- Tell students, "Next session we will learn more about the water cycle and see if we can continue to improve our models."

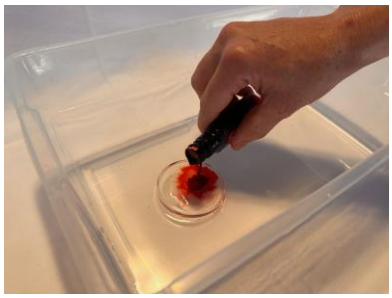
Part 2:	
60 minutes	**Why Does Water Flow? (Part A)**  • Tell students, "We were starting to construct a model of the water cycle from last session." Ask students, "What were some of the scientific terms that we included in the model and how do these apply to the water cycle?" ○ ESR: We included precipitation, evaporation, and condensation. Precipitation is when water falls from the sky and evaporation is when water goes from a liquid to a gas phase. Condensation is when water goes from a gas to a liquid phase. • Put the *Matter and Scientific Terms* poster back on the board. • Tell students, "I am going to do a demonstration for you. Then, you are going to record observations, what happened, and why, for **question 15** on your worksheet." • Take a pen (or other object) and drop it. Then, have students independently fill out question 15, after which, have one of them share their answer with the class. Record the class consensus answer on the example worksheet. Make sure by the end of the conversation students know that the object fell to the ground because of gravity, and all things that have mass (matter) will be pulled towards the center of the Earth. • Ask students, "What does the demonstration I just showed you have to do with the water cycle?" ○ ESR: Gravity is what causes the water to flow in the water cycle. • Record the class consensus answer for **question 16** on the example worksheet, while students do the same on their worksheets. • Have students answer **question 17** about how they could show this phenomenon in their model. Then as a class, discuss and record the class consensus response on the example worksheet. • Ask students, "Are there any new physical things, matter, that should be included in a model of the water cycle?" ○ ESR: **Mountains**. ○ If this term was not already written on the *Matter and Scientific Terms* poster, add it. Then, have students write it on a yellow post-it note. • Ask students, "Are there any new scientific terms that should be included in a model of the water cycle?" ○ ESR: **Gravity**. ○ If this term was not already written on the poster, add it. Then have students write it on a pink post-it note.

Matter	Scientific Terms
Creak	Precipitation
Lake	Evaporation
River	Solid (s)
Ocean	Liquid (l)
Stream	Gas (g)
Rain	Condensation
Snow	Gravity
Hail	
Water Vapor	
Cloud	
Mountain	

- Tell students "I am going to do another demonstration for you. After the demonstration, you are going to record observations, what happened, and why."



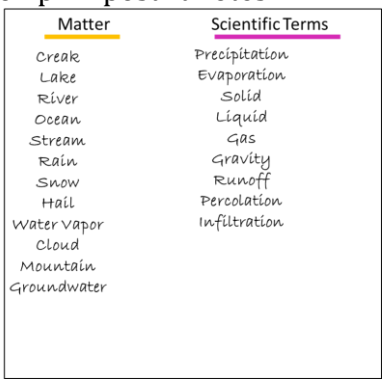
- Have students stand around the groundwater demonstration. Pour approximately 1 cup of water over the sponge. Have students tell you what they observe.
  - ESR: Some of the water is running off into the lake and some is being absorbed into the ground.
  - Make sure you pour enough water to get some in the catchment system but not enough for it to overflow.
- Ask students, "Does gravity play a role in this process?"
  - ESR: Yes, because whether the water is absorbing into the ground or running off into the lake, the water starts at a higher elevation and is pulled downward towards the center of the Earth.
- Tell students, "We are now going to verify that water was in fact absorbed into the ground." Remove the sponge and reveal the groundwater catchment system with water in it.



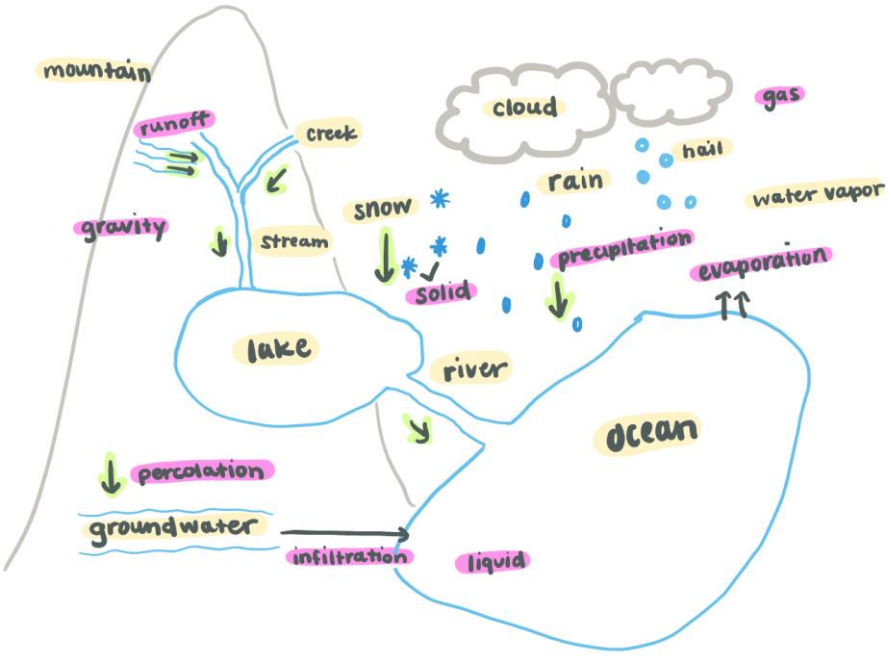
- Tell students, "The process by which water flows through small cracks in the ground is called percolation. 29% of the freshwater on Earth is in the form of groundwater."
- Tell students, "We are now going to do the demonstration again, and this time we are going to put dye into the groundwater catchment system to see how groundwater interacts with other water sources."
  - Note: If the catchment system is full, make sure to dump a little water out of it before you add the food coloring.

- Put approximately a teaspoon of food coloring into the groundwater catchment system. Then return it to under the sponge and pour approximately 1 cup water over the system. Have students describe what they see.

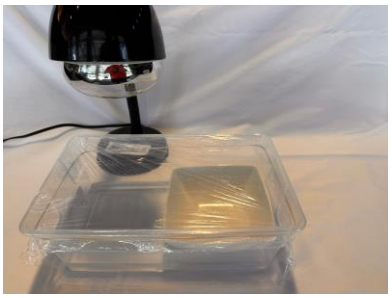
- ESR: Some of the water from the groundwater is seeping into the lake.
- Tell students, "The process in which groundwater latterly flows through rocks and sediment is called infiltration."
- Have students fill out **question 18** in their worksheet and then allow a few to share their answers. You do not need to record this on the example worksheet.
- As a class, fill out **question 19** about what happens to water that does not fall in a body of water. Make sure the words runoff, percolation, and infiltration are in the answer.
- Ask students, "Are there any new physical things, matter, that should be included in a model of the water cycle?"
  - ESR: **Groundwater.**
  - If this term was not already written on the poster, add it. Then, have groups write it on a yellow post-it note.
- Ask students, "Are there any new scientific terms that should be included in a model of the water cycle?"
  - ESR: **Runoff**, **percolation,** and **infiltration**.
  - If these terms were not already written on the poster, add them. Then, have groups write them on pink post-it notes.

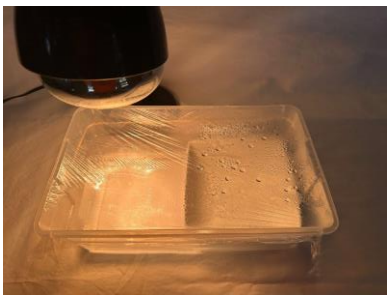


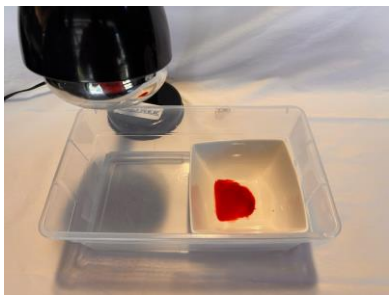
- Tell students, "You are now going to revise your model. If needed, you can have a new piece of poster paper or you can revise the model you made in Part 1. You can also use the larger sticky notes to write on important facts about either matter or scientific terms. For instance, you might want to add 29% of fresh water is in the form of groundwater to a yellow stick. Currently you have arrows showing the direction of water flow. If gravity plays a role in the motion of the flow, you are going to highlight the arrow in green."
- Give groups approximately 8 minutes to revise their models.
- Have a group share their model focusing on the modifications they made.
- Ask groups, "Does anyone else have anything different than was already shared on your models?" If so, let these groups share what else they included on the model.
- Ask students, "Is there any other form of matter or scientific term that we saw in the models that we should add to our *Matter and Scientific Terms* poster?" If needed, add the term(s) to the *Matter and Scientific Terms* poster and have students write it on the appropriate colored post-it note.
- Allow groups a few minutes to modify their models, if desired.

	 • Tell students, "Next session we will continue to explore additional way that water flows in the water cycle."
Part 3:	
60 minutes	**Why Does Water Flow? (Part B)** 30 minutes before you want to start the activity, tell students, "Today we are going to continue learning about the water cycle. To help us we are going to use this demonstration. Since it takes a little bit of time, we are going to start it now and come back to it later in the activity." Show students the heat demonstration set up, and take a picture of it before you turn on the light and place the ice on the plastic wrap above the bowl. Tell students, "We will check back on this demonstration later in the lesson." • Ask students, "What have we been learning about? And what are some key things that we have learned last session?" ○ ESR: We are learning about the water cycle. Last session we learning the water can absorb/percolate into the ground as groundwater or run off. Once there it can infiltrate, or flow sideways into other water sources like lakes. • Tell students, "We are now going to go back to the demonstration that we started earlier. Before we observe it again, we need to record observations from when we took the photo." Display the photo from the beginning of the session and have students fill out **question 20**. Then, have a few students share their answers with the class. You do not need to record this on the example worksheet." • Tell students, "We will now observe the demonstration again." Have students gather around the demonstration and have them try to explain what is happening. Make sure in their explanation they use the words evaporate and condense (or condensation). It is helpful to pick up the bag of ice and show the water drops on the plastic wrap under it. They should see at least one drop fall into the bowl. You can then remove the plastic wrap and show them how much water has accumulated in the bowl. Then fill out **question 21** on the example worksheet, while students do the same on their worksheet.

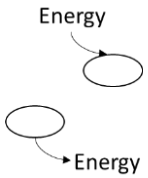
- The pictures show 1) the start of the demonstration before the lamp is turned on and ice is put over the bowl, 2) the amount of condensation under the ice 30 minutes after the demonstration has started, and 3) the water in the bowl (with food coloring add to make it easier to see) after 30 minutes.







- As a class, discuss the difference between the start and end of the demonstration. Make sure students identify that at the end of the demonstration there was ice, which was cold, and a lamp, which was hot. Introduce the terms energy/heat source and energy/heat sink and have students identify what was the energy source and sink in the demonstration. Record this on the example worksheet for **questions 22** and **23**, while students do the same on their worksheets.
- Have students tell you the two scientific phenomena that were seen in the demonstration (evaporation and condensation). Lead the class to understand that for evaporation, energy enters into the water, and for condensation, energy leaves the water. Then fill out **question 24** on the example worksheet, while students do the same.
- Tell students, "When a substance changes state, this is known as a phase change." Have students look at the reactions and identify that both reactions have energy in them. Explain that all phase changes either need energy to enter or leave the substance and the energy either comes from or is emitted into the surroundings. Fill out **question 25** on the example worksheet, while students do the same on their worksheets.
- As a class, go over the energy sources and sinks in the environment. You will need to introduce the idea that not all air is the same temperature and air that is at the same temperature and humidity is called an air mass. Fill out **questions 26** and **27** in the example worksheet, while students do the same on their worksheets.
- Have students tell you the terms that go in the blanks for **questions 28** and **29**. Then review evaporation and condensation, the roles of energy in these processes, and how they can show how energy is entering a system (top) and leaving a system (bottom) in their model. Fill these in on the example worksheet, while students do the same in their worksheets.

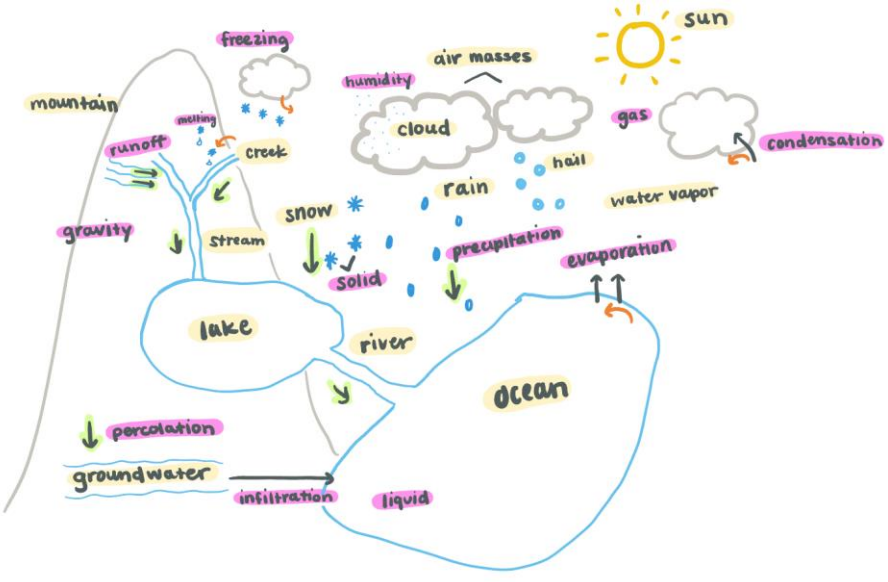


- Ask students, "Are there any other phase changes that happen in the water cycle?" If they are not able to give you melting and freezing, give them these phase changes. Record their definitions and reactions in the example worksheet for **question 30**, while students do the same in their worksheets.
- Ask students, "Are there any new physical things, matter, that should be

included in a model of the water cycle?"
    - ESR: **Air masses** and **sun**.
    - If these terms were not already written on the poster, add them. Then have groups write them on yellow post-it notes.
- Ask students, "Are there any new scientific terms that should be included in a model of the water cycle?"
    - ESR: **Heat sources, heat sinks, evaporation**, **condensation**, **melting**, **freezing,** and **humidity**.
    - If these terms were not already written on the poster, add them. Then have groups write them on pink post-it notes.

Matter	Scientific Terms
Creak	Precipitation
Lake	Evaporation
River	Solid (s)
Ocean	Liquid (l)
Stream	Gas (g)
Rain	Condensation
Snow	Gravity
Hail	Runoff
Water Vapor	Percolation
Cloud	Infiltration
Mountain	Heat Sources
Groundwater	Heat Sinks
Air Masses	Humidity
Sun	Melting
	Freezing

- Tell students, "You are now going to revise your model. We are now going to use orange arrows to show energy flow in our models."
- Give groups approximately 8 minutes to revise their models.
- Have a group share their model, focusing on the modifications they made.
- Ask groups, "Does anyone else have anything different than was already shared in the model?" If so, let these groups share what else they included in their models.
- Ask students, "Is there any other form of matter or scientific term that we saw in the models that we should add to our *Matter and Scientific Terms* poster?" If needed, add the term to the *Matter and Scientific Terms* poster and have students write it on the appropriate colored post-it note.
- Allow groups a few minutes to modify their models, if desired.

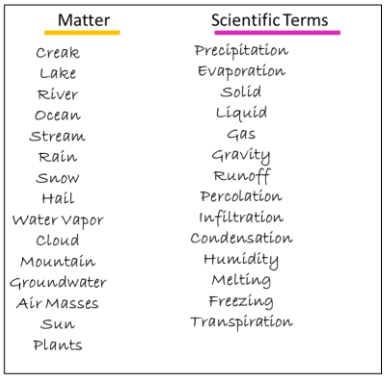


	• Tell students, "Next time we will continue to explore other factors that might affect the water cycle."
Part 4:	
10 minutes	**Phase Change Review** The transpiration demonstration can vary in time widely from a few minutes to up to an hour. It works best when the ground is wet and it is hot outside. (Another option is to get a broad leave plant (ex: basil) that is in a pot. Make sure that you only cover the leaves and not the entire pot while doing the demonstration.) Make sure that you test this demonstration the day before, to know the amount of time it will take for your conditions. Use this information to start the demonstration when needed. When you start the demonstration, tell students, "Later today, we are going to work on our water cycle models and explore if plants and animals have a role in the water cycle. To get ready for this, we are going to put a plastic bag over some leaves. We will then come back later to see what happens." Put the plastic bag over some of the plant's leaves. Make sure to seal the Ziplock as best you can around the stem of the plant. Take a picture, so students will remember what it looks like. • Tell students, "Last session we learned about phase changed and their role in the water cycle." Ask students, "What is a phase change?" ○ ESR: A phase change is when a substance changes state, for instance from a sold to a gas. • Ask students, "What is needed or released during a phase change?" ○ ESR: Energy. • Have students fill out **question 31** on their own. Then, have a few students share an example of energy transferring into water. While they share, have them point to where on their group model this transfer is shown. Make sure they also understand that energy was not created or destroyed, just transferred from one thing into another. You do not need to fill in this question on the example worksheet. • Have students fill out **question 32** on their own. Then, have a few students share an example of energy transfer from water. While they share, have them point to where on their group model this transfer is shown. Make sure they also understand that energy was not created or destroyed, just transferred from one thing into another. You do not need to fill in this question on the example worksheet. • Ask students, "How might desert plants get water if it does not rain?" ESR: If the plant leaves are colder than the air, water could condense on the leaves and then fall to the ground. Make sure students discuss both the phases of water and the energy transfers. Record the class consensus answer for **question 33** on the example worksheet, while students do the same on their worksheets.
25 minutes	**Roles of Plants in the Water Cycle** • Tell students "The two phenomena that we have seen so far that drive the water cycle are gravity and energy. We are now going to explore the role of plants and animals in the water cycle. We will first focus on plants. Before we go and check in on our demonstration, I would like you to fill out question 34 about whether

you think plants play a role in the water cycle, and if so what role."

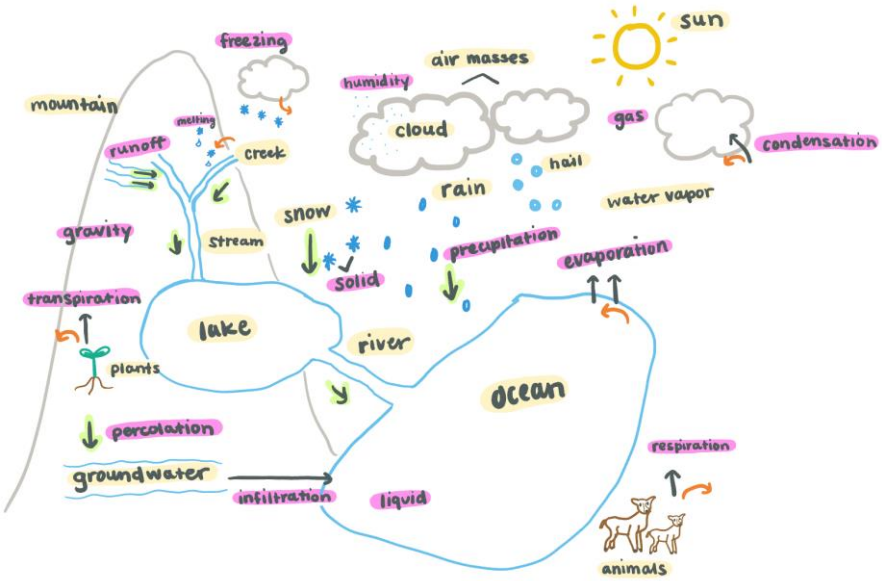
- Have students fill out **question 34** and then share their ideas. At this point, most students will only generate the idea that plants take in water through their roots. Do not correct them or do any formal teaching at this point. This question does not need to be filled out in the example worksheet.
- Show students the picture from the morning when they started demonstration 4 and have students record their observations for **question 35**. Have students share their answers and record the class consensus answer on the example worksheet.

- Go outside and look at the bag. Students should notice that the inside of the bag is now filled with water vapor.
- Have students go back inside and fill in **question 36**. Have students share their answers and record the class consensus answer on the example worksheet.
- Tell students, "Plants take water in through their roots. But approximately 95% of the water that a plant takes in is given off through its leaves by a process called transpiration. A large oak tree can take in 100 gallons of water in one day. Through transpiration approximately 95 gallons of that water is put back into the air as water vapor."
- As a class, discuss the role of plants in the water cycle. Record this for **question 37** on the example worksheet, while students do the same on their worksheets.
- As a class, discuss the energy associated with transpiration. Make sure students draw the connection between transpiration and evaporation. Fill out the class consensus answer for **question 38** in the example worksheet, while students do the same on their worksheets.
- Ask students, "Are there any new physical things, matter, that should be included in a model of the water cycle?"
  - ESR: **Plants**. If this term is not already written on the poster, add it. Then, have groups write it on a yellow post-it note.
- Ask students, "Are there any new scientific terms that should be included in a model of the water cycle?"
  - ESR: **Transpiration**.
  - If this term is not already written on the poster, add it. Then, have groups write it on a pink post-it note.
- Tell students, "Now that we know plants play an important role in the water cycle, let's explore the role of animals."

	
25 minutes	**Roles of Animals in the Water Cycle** • Tell students, "We have just explored the role that plants have in the water cycle. Before we continue to collect data, fill out **question 39** from your worksheet about if animals play a role in the water cycle and if so, what their role is." • Have students share their ideas. They may generate things like drinking water, using it for household reasons, or growing plants. Do not correct them at this point. This question does not need to be filled out on the example worksheet. • Tell students "We observed the process of transpiration in the last demonstration where water left the leaves of the plant and collected inside the bag." Distribute a plastic bag to each student and instruct them to breathe **out** into the bag with it closed around their mouths. After a few breaths, stop and have them observe the bag. • Have students answer **question 40** on their worksheet. Then have a few students share their answers. Record the class consensus answer on the example worksheet. • Tell students "Similar to plants, animals also release water into the atmosphere. This water is released when they breathe out through a process called respiration. Humans lose about one cup of water per day through respiration." • Discuss the energy associated with respiration and fill in **question 41** on the example worksheet, while students do the same on their worksheets. • Ask students, "Are there any new physical things, matter, that should be included in a model of the water cycle?" ○ ESR: **Animals**. ○ If this term is not already written on the poster, add it. Then, have groups write it on a yellow post-it note. • Ask students, "Are there any new scientific terms that should be included in a model of the water cycle?" ○ ESR: **Respiration.** ○ If this term is not already written on the poster, add it. Then have groups write it on a pink post-it note.

Matter	Scientific Terms
Creak	Precipitation
Lake	Evaporation
River	Solid (s)
Ocean	Liquid (l)
Stream	Gas (g)
Rain	Condensation
Snow	Gravity
Hail	Runoff
Water Vapor	Percolation
Cloud	Infiltration
Mountain	Heat Sources
Groundwater	Heat Sinks
Air Masses	Humidity
Sun	Melting
Plants	Freezing
Animals	Transpiration
	Respiration

- Tell students, "You will now revise your group model to include the new information that we found."
- Have a group share their model focusing on the modifications they made.
- Ask groups, "Does anyone else have anything different than was already shared on the models?" If so, let these groups share what else they included on their models.
- Ask students, "Is there any other form of matter or scientific term that we saw in the models that we should add to our *Matter and Scientific Terms* poster?" If needed, add the term to the *Matter and Scientific Terms* poster and have students write it on the appropriate colored post-it note.
- Allow groups a few minutes to modify their models, if desired.



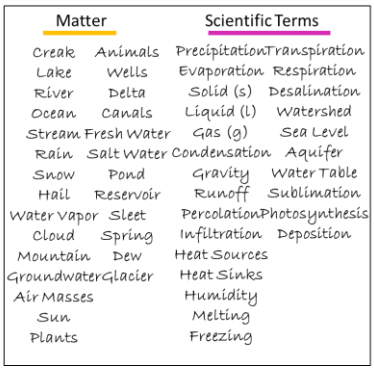
- Tell students, "Next session we will use our models to make some predictions and then we will check our predictions."

Part 5:	

30 minutes	**Applying our Model of the Water Cycle**
	• Tell students, "We have been exploring the water cycle." Ask students, "What are the key scientific ideas that drive the water cycle?"
	  ○ ESR: Gravity and energy.
	• Tell students, "Last time we looked at living factors that affected the water cycle." Ask students, "What are these and how do they affect the water cycle?"
	  ○ ESR: We learned that plants affect the water cycle through transpiration and animals affect the water cycle through respiration.
	• Tell students, "Today we are going to apply our model to predict how humans can continually remove groundwater for use in their everyday lives. You are going to answer this question in pairs. First, I want you to discuss how this is possible. Then you are going to need to incorporate five of the scientific terms that we have generated on the *Matter and Scientific Terms* poster. Once you have decided on these terms you will record them on question 42 of your worksheet. After which you will write your answer."
	• Allow students ~15 minutes to work together and answer **question 42**.
	• Have a few groups share their answers with the class. As they are sharing, each time they say a scientific term, point to it on the poster.

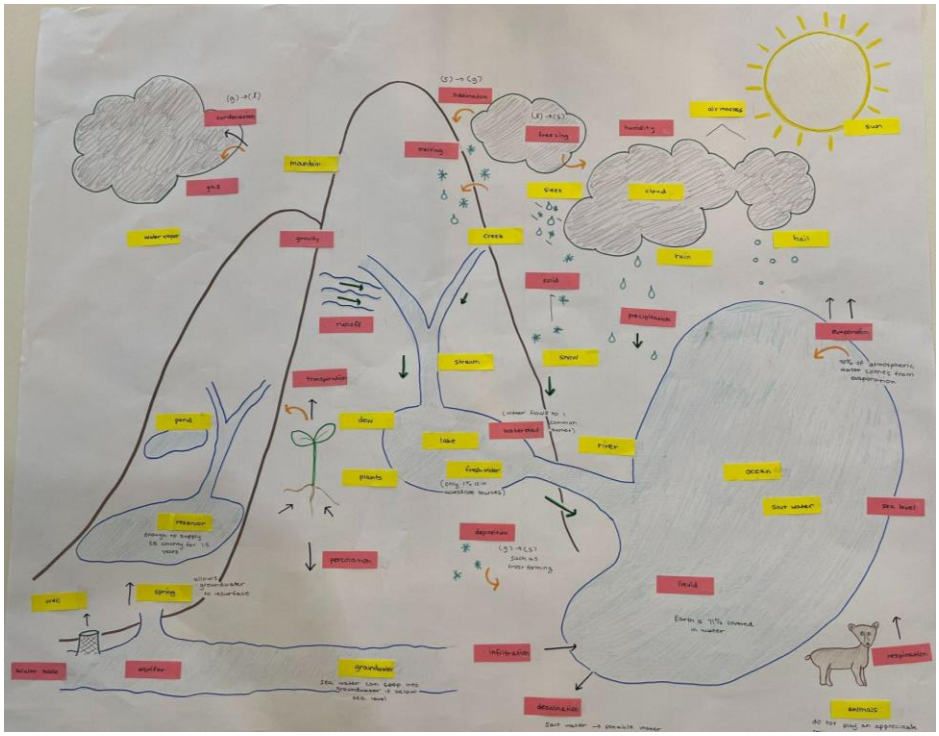
30 minutes	**Verifying our Model**
	• Pass out a *Walking in a Water Wonderland* reading to each student.
	• Tell students, "We are now going to do a reading about the water in our area and the water cycle."
	  ○ Note: If you are not from Santa Barbara, you can remove the section about water in the Santa Barbara area if you would like.
	• Tell students, "As we go through the reading, we are going to circle any matter terms and box any scientific terms that we find that are not already on our *Matter and Scientific Terms* poster. In addition, we will discuss what in the reading agrees with our model and if we find anything that we think might be important to include in our model we will underline it."
	• As a class, do the reading together and annotate the article as you go while students do the same. Once you get through page 2 of the article, after each paragraph, stop and discuss what in that paragraph has already been integrated into their models.
	  ○ When you circle a matter term, write it on the chart. The following words will most likely need to be added to the chart:
	  ▪ **Well** (pg 2)
	  ▪ **Delta** (pg 3)
	  ▪ **Canals** (pg 3)
	  ▪ **Salt water** (pg 3)
	  ▪ **Fresh water** (pg 3)
	  ▪ **Pond** (pg 3)
	  ▪ **Reservoir** (pg. 3)
	  ▪ **Sleet** (pg. 3)
	  ▪ **Spring** (pg 5)
	  ▪ **Dew** (pg 6)
	  ○ When you box a scientific term, write it on the chart. The following words

will most likely need to be added to the chart:
    - **Desalination** (pg 2)
    - **Watershed** (pg 4)
    - **Sea level** (pg 4)
    - **Aquifer** (pg 4)
    - **Water table** (pg 4)
    - **Sublimation** (pg 5)
    - **Deposition** (pg 6)
  - The following are the main passages that contain information that students will want to underline and then add to their models:
    - Saltwater makes up 97% of the water on Earth (pg 3)
    - Earth is 71% covered in water (pg 3)
    - Ground water makes up 29% of the freshwater on Earth (pg 4)
    - If people remove too much groundwater, it will cause the water table to be below sea level. If this happens, it causes salt water to seep into groundwater sources making them unusable (pg 4)
    - Approximately 30% of the water that we use in California comes from melting snowpack. (pg 5)
    - Springs allow groundwater to resurface … slowly feed rivers and creeks all year round (pg 5)
    - 90% of the water in the atmosphere comes from evaporation (pg 5)
    - Sublimation is much less than 1% (pg 5)
    - Dust particles act as a starting site for the water to condense on (pg 7)
    - Therefore, animals do not play an appreciable role in the water cycle through respiration (pg 7)
    - Humans can influence the water cycle by extracting groundwater, seeding clouds (putting substance in the atmosphere to make it rain), as well as changing where water is located. (pg 7)
    - Only 1% of the world's freshwater is in accessible sources. The other 99% is in the form of groundwater (29%) and ice caps/glaciers (70%). (pg 7)
- Have students write down the forms of matter that were written on *Matter and Scientific Terms* poster during the reading on yellow post-it notes.
- Have students write down the scientific terms that were written on the *Matter and Scientific Terms* poster during the reading on pick post-it notes
  - Group will put the yellow and pink post-it notes on their poster but not place them in the correct place or revise their model. This will be done next session.



- Have students individually fill out **question 43** about what they learned

	regarding water in the Santa Barbara area. Then, have them share these with the rest of the class. You do not need to record these on the example worksheet. • Tell students, "Next session we will use the reading to check our predictions about pumping groundwater and make the final version of our model."
Part 6:	
25 minutes	**Checking our Predictions** • Tell students, "We have been learning about the water cycle. So far, we have made our own models of the water cycle, and then we did a reading to see what other scientists know about the water cycle. Today we are going to use the reading to confirm or refute the predictions we made about what happens when humans extract groundwater. Then we will do the last revision of our model." • Tell students, "You are going to get back together with the person that you answered question 42 with. Together, you are going to evaluate if the reading supported your answers, refuted your answers, or includes more information that you could have included in your answer. I am going to show you how to do this for question 44. For example, let's say as part of my answer I wrote: If the water does not run off, it can be absorbed into the soil." If it is not already there, write this on the board. Tell students, "I was making a claim about runoff, therefore I need to find in the reading where it talks about runoff." Ask students, "What page do you see runoff in bold?" ○ ESR: Page 4. • Tell students, "I will then read part of the paragraph that the word is in to see if the reading is supporting my claim." Read the following section to them. ○ Even though the majority of the Earth's surface is water, not all water falls into a water source. Some of the water falls onto land. When this happens, the water can either be absorbed into the soil or if the soil is already waterlogged, it can be pulled by gravity into another water source at a lower elevation, which is referred to as runoff. Even the process of absorbing water into the Earth is driven by gravity. • Tell students, "I will then highlight the part that supports or refutes my claim. If it refutes my claim, I will use it for question 45. If it supports my claim, I will use it for question 44." Tell students, "I think the following statement supports my claim, so I will highlight it." Highlight the sentence below. ○ When this happens, the water can either be absorbed into the soil or if the soil is already waterlogged, it can be pulled by gravity into another water source at a lower elevation which is referred to as runoff. • Tell students, "Now I will fill out part of question 44 as an example of what you will do." For question 44 circle "yes" indicating the reading backs up at least part of your answer. Then fill in: On page <u>4</u> it says <u>that if the soil is waterlogged the water will runoff</u>. • Tell students, "You will now work with your partner to answer **questions 44-46**. • Give students about 10 minutes to work together. Then allow a few of them to share their answers. These do not need to be recorded in the example worksheet.

35 minutes	**Final Water Cycle Model** • Tell students. "You will now get 10 minutes to put the final touches on your water cycle model. While you are doing this, make sure to include the post-it notes of terms that we identified from the reading. In addition, look back at the reading at the parts that we underlined. You might want to write summaries of those ideas on the larger post it notes to add to you model." • Give students time to revise their models.  • Tell students, "We are now going to present our model of the water cycle. Each group is going to present one aspect of the water cycle model. These aspects will be: different water sources, how water enters into water sources, groundwater, how water leaves water sources, phase changes in the water cycle, and the role of living things in the water cycle." If these are not already written on the board, write them there with the terms "matter" and "scientific terms" written under each of them. Tell students, "Before, I assign which part your group will do, we will decide which matter and scientific terms each group will talk about. It is ok if multiple groups talk about the same terms but each term has to be discussed by at least one group." • Go through each term on the *Matter and Scientific Terms Chart*, and have students suggest which term should go with which presentation and write them under that presentation. It is ok if a term is in two presentations. ○ Below is the list of the presentations that will be given, along with the suggested word to go with each presentation. If students suggest words be paired with a different presentation, that is ok. ▪ Different water sources • Matter: creek, lake river, ocean, stream, water vapor, cloud, groundwater, fresh water, salt water, delta, canals, pond, reservoir, dew, glacier • Scientific Terms: solid, liquid, gas, watershed, sea level ▪ How water enters into water sources

	• Matter: rain, snow, hail, mountain, sleet • Scientific Terms: precipitation, gravity, runoff ▪ Groundwater • Matter: groundwater, well, spring, • Scientific Terms: gravity, percolation, infiltration, aquifer, water table ▪ How water leaves water sources • Matter: water vapor, well • Scientific Terms: gravity, evaporation, desalination ▪ Phase changes in the water cycle • Matter: sun, air masses, water vapor • Scientific Terms: evaporation, solid, liquid, gas, condensation, heat sources, heat sinks, humidity, melting, freezing, sublimation, deposition ▪ Role of living things in the water cycle • Matter: plants, animals • Scientific Terms: condensation, transpiration, respiration, photosynthesis • Assign each group their presentation part. • Tell groups, "You will now have 5 minutes to decide, the order you will present in and the terms each person will discuss. Each person must discuss at least 1 term. During this time, fill out **question 47** with your presentation topic, your order in the presentation, and the terms you will use." • Allow each group to present their section of the water cycle, while pointing to the relevant part of their model. • Tell students, "You have taught me a lot about the water cycle and how complex it is. Later this year we will learn about what causes the weather conditions that we have and understand the role of the water cycle in this."

Example Student Work:

Name: _____

Water Wonderland

Part 1:
Beginning Thoughts

1. Is water important to us? Water is needed for life, without it there would be no living things on Earth.

2. What are three ways that you use water directly?
   - drinking
   - bathing
   - brushing teeth

3. What are three ways that you use water indirectly?
   - Food we eat
   - Wood in our houses
   - paper we use

4. What are the states that water can be in and what are they called?

State of Water	Name
Solid (s)	Ice
Liquid (l)	Water
Gas (g)	Gaseous water

5. Give examples of solid, liquid, and gas water in the atmosphere.
   Solid: Snow and hail
   Liquid: Rain
   Gas: water vapor

6. Where can we find water in the environment? Ocean, streams, lakes, rivers, and creeks

7. Are water sources a form of matter? (circle one) (Yes) No
   Why or why not? Because they take up space and have mass.

8. How does the water enter these locations? Through rain (precipitation), snow melt, and runoff.

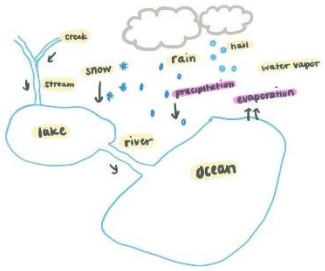
9. How does water leave these locations? Flowing out of the source, seeping into the ground, and evaporating.

2

How do Water Sources Interact?

10. What is a model? A representation of a person's understanding of an event, system, or process.

11. Draw a model that shows sources of water and how that water moves. Label bodies of water with their appropriate names. Use arrows to show the direction of water movement.



Make a group Model

3

12. Does the amount of water in the system (Earth) change? (circle one) Yes (No)
    Why or why not? Water does change locations and can change states but it still stays in the system.

13. Give one example of a transfer of water (mass) in your system in which the state of matter **did not** change. Make sure to include where the water came from, where the water went to. Liquid water flows from a river to a lake.
    Was matter created or destroyed during this process? (circle one) Yes (No)

14. Give one example of a transfer of water (mass) in your system in which the state of matter **did** change. Make sure to include where the water came from, where the water went to. Liquid water on the ground evaporates into water vapor.
    Was matter created or destroyed during this process? (circle one) Yes (No)

4

Part 2:

Why does water flow? (Part A)

15. Watch demonstration 1 and record observations, what happened, and why. The teacher held up a pen and released it which caused the pen to fall to the ground. This happened because gravity pulls matter towards the center of the Earth.

16. What does this demo have to do with the water cycle? Gravity makes water flow from higher to lower elevations

17. How could you show this phenomenon in your model? The rivers need to be in the mountains at an elevation above the lakes. The ocean needs to be at the lowest elevation.

18. Watch demonstration 2 and record observation, what happened, and why. Water was poured onto a slope, some of the water ran off into a lake and some of the water was absorbed by the ground and went into groundwater. Percolation happened because gravity was pulling the water closer to the center of the Earth. The simulation was repeated and this time food coloring was in the groundwater. This showed that the groundwater also flows into the lake through a process called infiltration.

19. What happens to water that does not fall in a body of water? The water either runs off until it hits a water source or is absorbed into the ground where it percolates into groundwater and then can infiltrate into other water sources.

Revise Model

Part 3:

Why does water flow? (Part 2)

20. Record observations from the start of demonstration 3 when the picture was taken. There was a tub of water covered with plastic wrap. In the water was a bowl that did not have water in it.

21. Describe what happened since the start of demonstration 3 and why this happened? The heat lamp caused the water to evaporate (turn from liquid into gas). When the gaseous water hit the cold ice, the water condensed (turned back into a liquid) which caused it to drip (rain) over the bowl.

22. What was different between the start and end of demonstration 3? Heat/energy sources and sinks were introduced.

23. In the demonstration the lamp was a Heat/energy source and the ice was a Heat/energy sink.

24. What two science phenomena were seen in demonstration 3 and what are their reactions?

Evaporation: the process when liquid water is turned into gaseous water (water vapor).
Reaction: $H_2O(l) + heat \rightarrow H_2O(g)$
Condensation: the process when gaseous water (water vapor) is turned into liquid water.
Reaction: $H_2O(g) \rightarrow H_2O(l) + heat$

25. These phenomena are known as phase changes, which always have energy change associated with them.

26. What could be like the lamp in your model? The sun

27. What could be like the ice in your model? Air masses or other objects that are cold.

28. When energy flows from the surroundings to the liquid water, it causes the water to turn to a gas, which is known as evaporation This causes the surroundings to cool down. This should be shown in the model with an orange arrow pointed towards liquid water.

29. When energy flows from the gaseous water to the surroundings, it causes the water vapor to turn to a liquid, which is known as condensation. This causes the surroundings to warm up. This should be shown in the model with an orange arrow pointed away from water vapor.

30. Are there any other water phase changes that we see in the water cycle and what are their reactions?

Melting: the process when solid water is turned into liquid water.
Reaction: $H_2O(s) + heat \rightarrow H_2O(l)$
Freezing: the process when liquid water is turned into solid water
Reaction: $H_2O(l) \rightarrow H_2O(s) + heat$

Revise Model

Part 4:

Phase Changes Review

31. Describe one process that happens in the water cycle that requires energy to transfer **into** water. Make sure to include the phase of water before and after the process. During evaporation, energy from the air/surface the liquid water is touching, enters the liquid water making it change to gaseous water.

Was energy created or destroyed during this process? (circle one) Yes (No)

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32. Describe one process that happens in the water cycle in which energy is transferred **out** of water. Make sure to include the phase of water before and after the process. During freezing energy from the liquid water is transferred to the air/surface. Causing it to change to solid water (ice).
Was energy created or destroyed during this process? (circle one) Yes (No)

33. How might desert plants get water if there is no rain? The leaves of the desert plants are cooler than the air. This causes the water vapor to lose energy when it hits the leaves. This converts the gaseous water into liquid water which then drops to the ground and waters the plant.

Role of Plants in the Water Cycle

34. Do you think plants play a role in the water cycle? (circle one) (Yes) No
If yes, what role do they play? Plants take in water through their roots.

35. Record observations from the start of demonstration 4 when the picture was taken. A plastic bag was placed over the leaves of a plant and the bag was sealed.

36. Describe what happened since the start of demonstration 4.
Liquid water has collected in the bag

37. How do plants play into the water cycle? Plants take in water through their roots. This water flows through the plants and ~95% of it is given off as water vapor through a process called transpiration.

38. Do you think energy is associated with this phenomenon? (circle one) (Yes) No
If so, what does this energy transfer do to the plant? In order for water to go from a liquid to a gas, energy needs to be put into the water. This energy comes from the plant which causes the leaves of the plant to cool down.

Role of Animals in the Water Cycle

39. Do animals play a role in the water cycle? (circle one) (Yes) No
If yes, what role do they play? Animals drink water and use water to bathe, etc.

40. Perform demonstration 5 and explain what happened. We breathed into a bag and saw water vapor on the inside of the bag.

41. Do animals release water into the environment? (circle one) (Yes) No
If so what is the phenomenon called? Respiration

Work on Model

Part 5:

Apply our Model of the Water Cycle

42. Using your model, explain how people can pump out groundwater from one well for many years without it going dry. You must use 5 scientific terms (terms on pink stickies) in your explanation. Underline these in your explanation.
The scientific terms I will use are: Precipitation, runoff, gravity, percolation, transpiration
Explanation: People can drill a hole and remove groundwater for their use. Even though we are extracting the groundwater it can be replenished during the next storm. This happens when it starts to precipitate in the form of rain. If the water does not runoff it can be absorbed into the soil where gravity can cause it to percolate into groundwater. One way people use water is by watering their plants. Some of this water passes through the plants in a process called transpiration which allows the water to reenter the atmosphere where it will be able to be precipitation again and could eventually end up as groundwater. Thus, repeating the process.

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Verifying our model

43. What is one thing that you learned about water in Santa Barbara? The water in Santa Barbara comes from ground water, reservoirs, state water, and desalination. Desalination is the most expensive.

Part 6:

Checking our Predictions

Look back at question 42 to answer questions 44-46.

44. Does the reading support any of your answer? (circle one) (Yes) No
    If yes, highlight the part of the reading that agrees with your answer and fill out the following sentence frames.
    On page 4 it says percolation is when gravity pulls water into the ground
    which agrees with what I wrote. In addition, on page 4 it says people have to dig wells to access the groundwater
    which agrees with what I wrote.

45. Does the reading disagree with any of your answer? (circle one) (Yes) No
    If yes, highlight the part of the reading that disagrees with your answer and fill out the following sentence frame.
    On page 4 it says people can remove too much ground water causing saltwater to enter the aquifer
    before the reading I thought the water would just be replenished through percolation.

46. Go back to the reading and highlight one thing that you did not include in your answer, that you could have, to make it stronger. Summarize what you highlighted. The water table is the depth that you need to drill down to reach the groundwater.

Revise Model

Final Water Cycle Model

47. Our group will discuss different water sources
    I will be presenter 1 and I will talk about the following terms: fresh water, creek, stream, river, lake, reservoir
    Facts I want to include in my presentation:
    - Only 3% of the water on earth is fresh water
    - Lake Cachuma is a reservoir in our area
    -

Walking in a Water Wonderland

Is water really that important? To answer this question let's look at the life of a typical 6th grader. They get up in the morning and the first thing they do is go to the bathroom, flush the toilet (1.6 gallons [gal]), and wash their hands (1 gal). They then sit down to a breakfast of eggs (53 gal) and toast (24 gal). It is now time to get dressed, so they go to the dryer and pick out clean clothes for the day (20 gal per load). They slip on their t-shirt (766 gal) and jeans (20,000 gal) and are ready to be driven to school (13 gal of water per gal of gas). In the morning they use 5 sheets of paper for their classwork (10 gal). Then it's time for lunch. They eat an apple (18 gal), a turkey sandwich (162 gal), and a bag of chips (49 gal). After lunch, the class goes out to play soccer (1000 gal per day to water the field) for PE. When the school bell rings, they go home and help make burgers (699 gal) for dinner. After dinner it is their night to wash the dishes (17 gal). With the dishes done, there is time to relax and watch TV for a couple of hours (5 gal in electricity use) before they take their shower (17 gal), brush their teeth (1 gal), and go to bed. By the time the day is over, most people do not realize that they have used more than 100 gallons of water directly as well as countless gallons indirectly (Graph 1, Figure 1). We rarely stop to think about the important role water plays in our lives. In fact, water is so important that if there were no water on Earth there would be no living things on the planet.

Graph 1: Household Water Use

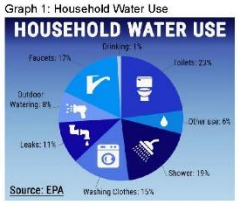
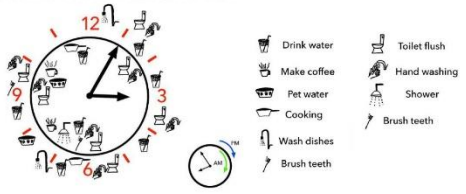
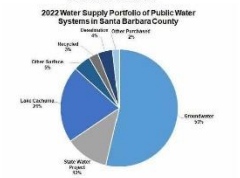


Figure 1: Where our Water is Used Over 24 Hours

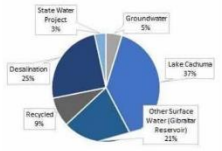


If we use so much water, where does it come from? In Santa Barbara County, the water that comes out of our faucets comes from four main sources: groundwater, reservoirs, desalination, and water provided by the State of California commonly called State water. The pie charts show the percentages of water that come from these sources for the County (Graph 2), as well as for Santa Barbara (Graph 3) and Goleta (Graph 4).

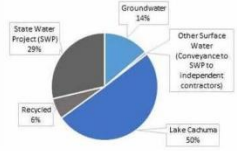
Graph 2: Water Sources County of Santa Barbara



Graph 3: Water Sources Santa Barbara



Graph 4: Water Sources Goleta



Let's take a closer look at each of these sources of water. The first is groundwater. As the name suggests, this is water located underground that can be accessed through deep holes drilled into the ground, commonly known as wells. Map 1 shows the location of groundwater in Santa Barbara County.

Map 1: Groundwater Locations

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Map 2: Santa Barbara Reservoirs and their Watershed

Map 3: State Water Canals and Pipelines

The second source of water is reservoirs. The two largest reservoirs in Santa Barbara County are Twichell Reservoir, which holds 243,928,000 cubic meters (m^3) and Lake Cachuma which holds 238,437,000 m^3. These reservoirs are located in the hills above Nipomo and Santa Barbara respectively, shown on Map 2. Each of these reservoirs holds about enough water to supply all of the people in the County with water for 1.5 years if they are not refilled.

The third source of water is desalination, a process by which saltwater is turned into potable (drinkable) water. This is possible since Santa Barbara is located next to the ocean. Making freshwater from saltwater is a very energy intensive process that produces water that is 75% more expensive than water that comes from groundwater or reservoirs.

The final major source of water is State water. In order to have water during drought conditions, a common occurrence in Santa Barbara, we need to transport water in from other parts of the state. Southern California accounts for approximately 80% of the water needs in California, however approximately 45% of California's water comes from the San Joaquin River Delta in Northern California. The state has canals and pipelines that bring this water to Southern California, including Santa Barbara County (Map 3).

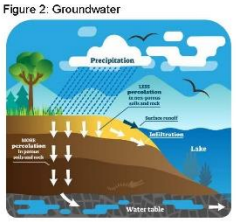
On Earth there are two types of water: salt water and fresh water. Salt water makes up 97% of the water on Earth. If you look closely in your community, you will find a lot of different water sources such as: **creeks**, **streams**, **rivers**, **lakes**, **ponds**, **reservoirs** and the **ocean**. Some of these water sources contain water year-round and others contain water only during certain seasons. But how does water get into these sources? One way that water enters these sources is through **precipitation**. Precipitation is when water is released from clouds in the form of **rain**, **sleet**, **snow**, or **hail**. The type of precipitation that falls is dependent on the temperature. If the temperature is below 0°C (32°F) the liquid water loses energy and turns into solid water (snow or hail). This process is known as **freezing** and the reaction for it is: $H_2O(l) \rightarrow H_2O(s)$ + heat. If the temperature is above 0°C, the precipitation is in the form of liquid water (rain). If the temperature is at approximately 0°C then you can get sleet which is a mixture of ice, rain, and

snow. Since 71% of the Earth's surface is covered in water, most of the precipitation falls directly into these water sources.

Many water sources such as creeks and rivers start in the **mountains**, at high elevation. As the precipitation falls them, **gravity** start to pull the water downhill. Gravity is the force of attraction between anything that has mass (i.e: an object) and the Earth, which pulls the object towards the center of the Earth. You can see gravity in action when you drop a pen and it is pulled to the ground. As water is pulled downhill, several smaller sources of water can combine to form a larger water source such as a river. Several rivers can flow into a lake or reservoir. The area in which all of the streams and rainfall flow into a common outlet is known as a **watershed.** Coastal watersheds often flow into the ocean since they are at the lowest elevation, which is referred to as **sea level.**

Even though most of the Earth's surface is water, not all precipitation falls directly into a water source. Some of the water falls onto land. When this happens, the water can be absorbed into the soil, Figure 2. If the soil is already waterlogged, however, it can be pulled by gravity into another water source at a lower elevation which is referred to as **runoff**. Even the process of absorbing water into the Earth is driven by gravity. **Percolation** is the movement of water down through the soil itself. The rate at which water passes through the soil is dependent on the type of soil. **Groundwater** is stored in cracks and spaces in soil, sand, and rock and is known as an **aquifer**. Groundwater makes up 29% of the freshwater on Earth. To access this water, people have to dig wells. Wells are deep holes in the ground that allow water to seep into them. Once the water is in the hole, the water can be pumped to the surface for use. These wells have to be drilled deep enough to reach the water table, or the level at which the ground is saturated with water. The groundwater also flows laterally in a process called **infiltration.** This connects the groundwater to other water sources such as lakes and the ocean. In coastal areas it is important that scientists monitor the groundwater levels to make sure that people are not removing too much water from the water table. If people remove too much groundwater, it will cause the water table to be below sea level. If this happens, it causes salt water to seep into groundwater sources making them unusable.

Figure 2: Groundwater

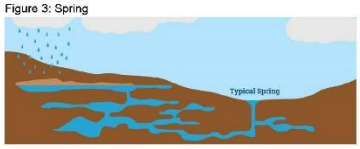


It makes sense that when it is raining, creeks and rivers flow. But why do they keep flowing even after the rain has stopped? The two main sources that keep rivers and creeks flowing are snowpack and springs. First, let's explore snowpack. When the snow falls on the ground it stays frozen as snow (solid water). For solid water to become liquid water, known as **melting**, energy in the form of heat is needed. The reaction that happens is $H_2O(s)$ + heat → $H_2O(l)$. Until the

temperature is above 0°C (32°F), the snow will not melt. When the temperature starts to warm in the spring, the snow starts to melt, which allows water to be absorbed into the ground or slowly run off into nearby water sources. It takes about 8 weeks (2 months) for the snowpack to melt in the Sierra Mountains, the largest snowpack in California. During this time, runoff will slowly feed nearby water sources. Approximately 30% of the water that we use in California comes from melting snowpacks.

This explains why rivers and creeks run during the rainy season as well as a few months into the dry season. But there are some rivers that run year-round. What feeds these rivers? These rivers get some of their water from springs. Springs allow groundwater to resurface (Figure 3). How does this happen? As gravity pulls the water deeper into the ground, the water has more force acting on it (is at a higher pressure). Since the land is not flat, if the elevation drops, the pressure on the groundwater can cause it to bubble up from the ground. These groundwater seepages are called springs, and they can slowly feed rivers and creeks all year round.

Figure 3: Spring



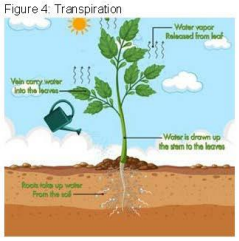
Now that we have explored how water gets into our water sources and flows on the ground, we need to explore the water in the atmosphere. Is the atmosphere able to create an unlimited amount of water? The answer is no. Water, like any other form of matter, takes up space and has mass, and therefore cannot be created or destroyed. Instead, the water has to be transferred from location to location. During these transfers it is also possible for the water to take different forms (**solid**, **liquid**, and **gas**). When water reaches the land as precipitation, how does water move from the land to the atmosphere? 90% of the water returns to the atmosphere through a process called **evaporation.**

Evaporation allows liquid water to be converted to gaseous water. For this to happen, energy must enter the water through the following reaction: $H_2O(l)$ + heat → $H_2O(g)$. Typically, the water gets this energy from the **Sun**. The hotter the temperature, the greater the amount of water that will evaporate. In areas like Antarctica where there is no liquid water, is it still possible for gaseous water to enter the atmosphere? Yes, through a process called **sublimation** in which solid water turns into a gas. This process also requires energy to enter the solid water. The reaction for this process is $H_2O(s)$ + heat → $H_2O(g)$. The amount of water that enters the atmosphere via sublimation is much less than 1%. You might have experienced sublimation before. Have you ever looked at an ice tray in the freezer and noticed that the ice is not full to the top, but you remembered that you filled the tray full of water? This is because just like snow

and ice in the environment, ice in your freezer can sublimate, which results in the ice in the tray shrinking.

If 90% of the water in the atmosphere comes from evaporation, where does the other 10% come from? It turns out that plants play a critical role in the water cycle. **Plants** are able to extract water from the ground through their roots. About 2% of that water is used in **photosynthesis**, the process in which plants get energy from the sun and convert water and carbon dioxide into glucose and oxygen (O_2). Glucose is used by the plant as food, while O_2 is given off as a waste product. What happens to the other approximately 98% of the water? This water helps transport minerals and nutrients to the plant and is ultimately given off through the plant's leaves through a process called **transpiration** (Figure 4). An acre of corn gives off about 13,300 L (3,500 gal) of water each day. During transpiration the following reaction occurs ($H_2O(l) \rightarrow H_2O(g)$). Does this reaction look similar to any other reactions that we have seen? Do you think energy is involved in this process? This process is the same as evaporation, and just like evaporation, energy is needed for this process to happen. The plant itself provides this energy in the form of heat. When energy and water leave the plant, it causes the plant to cool down, this can result in the plant leaves being approximately 2°C lower than the ambient temperature.

Figure 4: Transpiration



Transpiration can also help provide water for the plant. Didn't we just say that transpiration causes water to leave the plant? Yes, that is true, but in the process, it cools the plant down to below ambient temperature. So, what does this have to do with helping the plant get water? Have you ever gone outside and noticed that the bench and other objects are wet even if it has not been raining? If so, you have experienced **condensation**, the process in which gaseous water turns into a liquid water by the following reaction: $H_2O(g) \rightarrow H_2O(l)$ + heat. For this process to happen, energy has to leave the water. If a water particle in the air collides with an object at a lower temperature, energy can be removed from the water, allowing the gaseous water to become a liquid. This is often called **dew**. Dew can collect on benches, plant leaves, or other objects. If enough dew collects on the plant leaves, it can drip into the soil, watering the plant even if it is not raining. A process similar to condensation is called **deposition.** Deposition can happen if the temperatures are below 0°C, which causes gaseous water to be deposited on a surface as solid water. Similar to condensation, energy must leave the water ($H_2O(g) \rightarrow H_2O(s)$ + heat). Therefore, it requires gaseous water in the atmosphere to hit a surface that is a cooler temperature than the ambient air.

Not only does condensation happen on objects on the ground, but it also happens in the atmosphere. The atmosphere is made up of **air masses**. Air masses can be hundreds to

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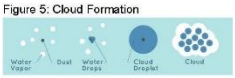
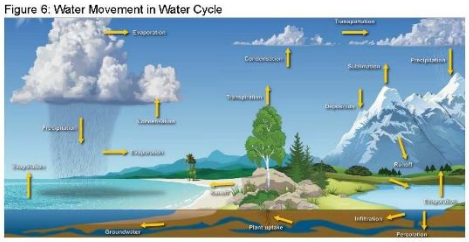
thousands of square miles in length. Deep air masses can be up to 10 miles high, while shallow air masses are less than a mile high. Each air mass is a body of air with generally uniform temperature and **humidity** (the amount of water in the air). When water in a warmer air mass hits a colder air mass, it can cause the gaseous water to lose energy and turn into liquid water. This process is facilitated by dust particles in the air. Dust particles act as a starting site for the water to condense on. As more and more water particles condense, they form water droplets, which collect together and form the **clouds** we see (Figure 5). Clouds can contain both liquid and solid water.

Figure 5: Cloud Formation



We have seen that plants play a critical role in the water cycle, but do **animals** play a role as well? If you breathe into a plastic bag or onto a mirror you can see tiny water droplets appear. These water particles are generated through **respiration**, the process by which the oxygen we take in along with glucose within our bodies is converted into **energy**, carbon dioxide, and water. This water is expelled into the atmosphere. While we do emit water, we also take in a lot of water through direct consumption (drinking water) and indirect consumption (eating foods that contain water). Therefore, animals do not play an appreciable role in the water cycle through respiration. However, unlike other animals, humans can influence the water cycle by extracting groundwater, seeding clouds (putting substances in the atmosphere to make it rain), as well as changing where water is located.

Figure 6: Water Movement in Water Cycle



We have now learned about the water cycle and seen that it is driven by gravity and energy transfers. During this process water is found in all three states: solid, liquid, and gas. The water cycle is the environment's way of recycling the water on the planet (Figure 6). Of all the water on the planet, just 3% is freshwater. Only 1% of this fresh water is in accessible sources. The other 99% is in the form of groundwater (29%) and ice caps/glaciers (70%). Therefore, it is critical that we understand the water cycle so that we can protect our fresh water sources.

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