Water Cycle Inquiry

How do the three phases of water move through the water cycle?

Grade Level(s)
5th to 8th grade

Subject Areas
Life Science, Earth Science

Key Topics
Water cycle, solid, liquid, gas, precipitation, evaporation, condensation, sublimation, transpiration

Duration
Preparation Time: 60 min
Activity Time: 2 x 50 min

Setting
Classroom (Individual or groups)

Skills
Making observations, identifying patterns, communicating

Standards
NGSS & MT Science Std.:
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.
ESS2.C: The Roles of Water in Earth's Surface Processes
CROSSCUTTING CONCEPT(S): Patterns, Energy and Matter
SCIENTIFIC & ENGINEERING PRACTICE(S): Obtaining, Evaluating, and Communicating Information

Common Core:
W.5-8.4: Produce clear, coherent writing
W.5-8.4: Write informative texts
L.5-8.6: Acquire and use vocabulary

Overview
Water is necessary for all living organisms on the planet. Water's unique properties allow it to move seamlessly on Earth. In doing so, it shapes the Earth's surface, creates unique permanent and seasonal habitats, and helps to control the climate globally. This lesson will help students to understand that water moves through every environment, but how that water moves can greatly vary depending upon the area of Earth in which it is moving through.

Objectives
Students will be able to:
- identify how the 3 phases of water move through the water cycle.
- explain how evaporation changes water from liquid to gas and how condensation changes water from gas back to liquid.
- provide evidence of sublimation.
- describe how water expands when it freezes.
- predict the impact leaves, stems, and roots make on transpiration

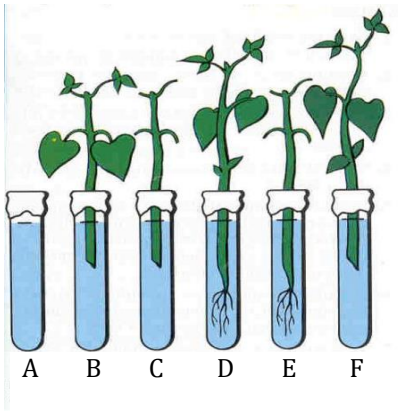
Materials
Warm Up / Activity / Wrap Up
- Computer, projector, student worksheets, quiz, and signs
- Chromebook, laptop, or tablet for each student
- Inquiry Activity Materials:
  - #1: Three 500 mL water bottles, 12"ruler
  - #2: Electric scale, weigh boats (2/group), ice cubes (2/group), timer, paper towels
  - #3: Mug, mirror, electric kettle or thermos of hot water
  - #4: Electronic scale, beakers(1 /group), 1" x 4" paper towel strips (1/group), food coloring, flat tray
  - #5: test tube rack, 6 25mm test tubes, 5 live basil plants, parafilm or Glad™ Press'n Seal saran wrap, pipette, extra fine sharpie, 12" ruler, Vaseline

Advanced Preparation
- Copy the student worksheets #1-5 (double-sided).
- Copy the Activity Signs (Teacher Resources #1-6)
- Reserve the chromebooks, laptops, or tablets for student use.
- Create a Quizizz vocabulary quiz or copy Water Cycle Vocabulary Quiz A (download from the FLBS website below).
  https://flbs.umt.edu/newflbs/k12teachingmaterial

Advanced Preparation continued:

- Group the students into groups of 3-4. We recommend creating groups based upon similar ability level rather than grouping the students into groups of mixed ability levels. This allows the groups to work at their own pace as they complete the activities.
- Prior to class, gather the materials and set up the 5 activities:
  - Arrange the class tables to create 5 work areas so that the students can easily rotate in a clockwise or counterclockwise direction. Place one activity sign at each work area.
  - Activity #1: Fill 3 of the same brand of 500mL water bottles with 400mL of water, use a sharpie to mark the water level on the sides of the bottles, place two bottles UPRIGHT in the freezer overnight, and keep the third bottle at room temperature. Place one frozen water bottle, one warm water bottle, and a ruler on the table when the students begin the station. *TIP: The 2nd frozen bottle can be swapped out for the 1st bottle after it thaws a bit.*
  - Activity #2: Place an electronic scale, 2 plastic weigh boats per group (labeled with group #s), 2 ice cubes per group, and paper towels at the station. *TIP: Keeping the ice cubes in a small cooler or thermos helps to keep them from melting before they are used.*
  - Activity #3: Place an electric tea kettle with tap water, a coffee mug, and a mirror (to cover the top of the mug) at the station. Before the students begin, heat the water.
  - Activity #4: Make one 1" x 4" paper towel strip (absorbent brand) per group. Fill beakers or cups with water and add a different food coloring to each cup. One beaker will be needed per group. Place the paper towel strips, beakers, electronic scale, and a cookie sheet or flat tray at the station. Note- If needed, students may share the scale between activities #2 and #4.
  - Activity #5: Place 6 25mm test tubes in a test tube rack. Gently remove the soil from the roots of the 5 plants, prep the 5 plants as indicated below, and place them into the 5 designated test tubes, fill the test tubes to ~1/2" below the top with water, mark the starting water line on the test tubes (at the meniscus), and label the tubes with the corresponding letter. Seal the top of the tubes with parafilm or Glad™ Press N Seal plastic wrap so that no water can escape (be careful to not damage the stems as you wrap the base of the plants).

A: Control - Water present (NO PLANT)
B: Water, leaves, & stems present (NO ROOTS)
C: Water & stems present (NO LEAVES/ROOTS)
D. Water, leaves, stems, & roots present
E: Water, stems, & roots present (NO LEAVES)
F: Water, leaves, & stems present (NO ROOTS) + Vaseline on surfaces



NOTE: We recommend for the students to create their Water Cycle Vocabulary Foldables before starting the Water Cycle Inquiry Activities. See the Water Cycle Vocabulary Foldable lesson plan for how to prep. the materials for the foldables.

Background

The cycling of water of water on Earth is greatly controlled by the sun and gravitational forces. Water moves freely between the hydrosphere, atmosphere, and biosphere. As the sun shines on the Earth, the water **molecules** change from a **liquid** to a **gas** and **evaporate**, **sublimate, or transpirate** from the Earth's surfaces and plants. The gas molecules rise up into the atmosphere, cool, and eventually **condense** back into liquid when they stick to particles in the air. The clouds we see on a daily basis are the result of evaporation followed by condensation. Although common in our environment, these processes are often difficult to articulate. The students will engage in 5 inquiry activities that will help them to learn the vocabulary while they observe the water cycle processes in action.

Water Cycle Inquiry

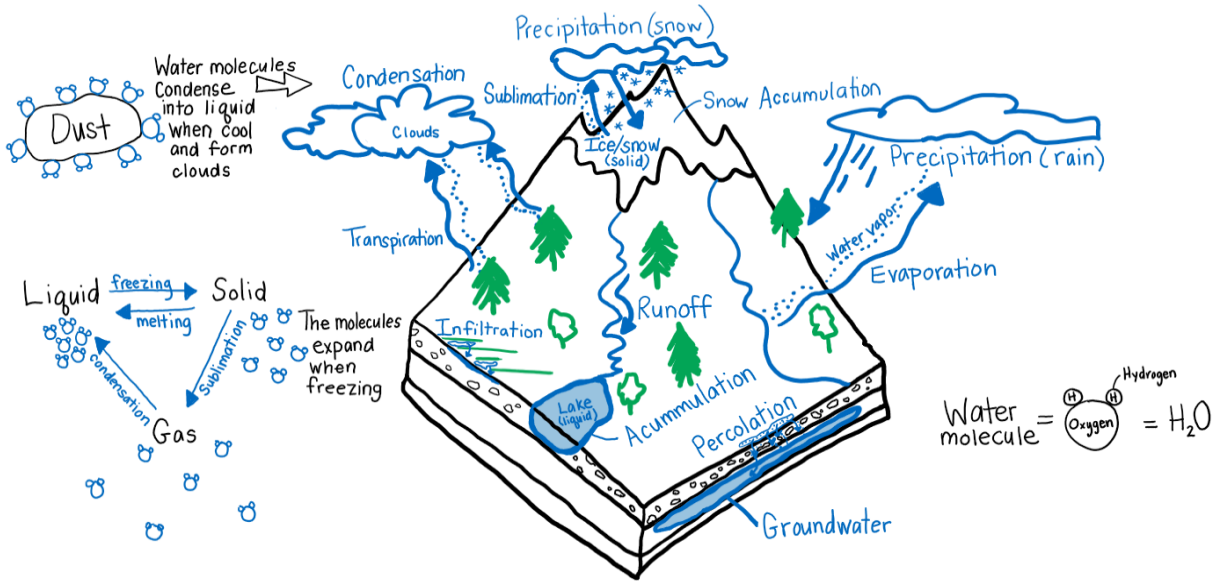
Lesson Vocabulary

Accumulation – Process of a substance gathering in an area (ex. a lake).
Condensation – Process of a gas changing into a liquid (ex. clouds).
Evaporation – Process of a liquid changing into a gaseous phase (ex. steam).
Expansion – When something spreads, extends, or enlarges (ex. water molecules expanding as they freeze)
Gas – A state of matter that expands freely into any available space.
Groundwater– Water held underground in the soil or in pores or crevices in rocks.
Infiltration – Process of water moving from the ground surface into the soil.
Liquid – A state of matter that flows freely but is of constant volume.
Molecule – A group of atoms bonded together to create a basic unit of a chemical (Ex. H_2O or one water molecule is formed from the combination of two hydrogen and one oxygen atoms).
Percolation – Process of water slowly moving through a filter (ex. water moving through the soil).
Precipitation – Products of water vapor condensation in the atmosphere that fall to the ground (ex. rain, snow, sleet, grauple, or hail).
Runoff – Process of water draining away from the surface of the land (ex. water that flows off the land into streams, rivers, lakes, or oceans).
Solid – A state of matter that stays fixed in a firm and stable shape.
Sublimation – Process of a solid changing directly into a gas without passing through the liquid phase (ex. glacial ice turning into water vapor).
Transpiration – Process of water moving through a plant and evaporating out of the leaves, stem, and flowers.
Water vapor – Water in the gaseous phase.

Procedure

◆ Warm Up (30 minutes)

- Students either take the Water Cycle Vocabulary Quiz A or take the quiz online on Quizizz.
- Pass out the student worksheets. Students build their Water Cycle Vocabulary Foldable (see separate lesson plan) and fill in the vocabulary words using the list provided on the worksheet. Stop after each student has filled in all 16 words and at least 1 definition. They can keep working on this later in the day or at home.
- Draw a water cycle on the whiteboard or Jamboard (see example on the next page) and explain the role of each vocabulary word in the water cycle.



- **Water Cycle Inquiry (10 minutes per activity = 50 minutes)**
  - Place the student into 5 groups (see note in Advanced Prep.). The students pick group names and are assigned a group number. They write both the name and number on their worksheet.
  - Explain to the students that they will be completing 5 activities to learn more about the processes used in the water cycle. Explain that although they will be working in groups, each student will be expected to complete their own worksheet. Explain what they will be doing for each activity, that they must carefully follow the directions, and that they need to work as a group to answer each question before they move on to the next activity.
  - **Activity #1 – Liquid and Frozen Water**: Students write down three observations of the before and after water bottles in the table and then answer the provided questions. They may use the ruler to make specific measurements.
    Teacher Notes: The students need to be able to think about and explain why the water expands and takes up more space when it freezes. This is a good time to discuss how water molecules expand in space when frozen in comparison to liquid water molecules that take up less space. As the ice melts, the students should also notice water condensation occurring on the outside. This is a great opportunity to have the students think through why water is on the outside and where it is coming from (water vapor from the air cools when it hits the cool bottle and turns to liquid). This is a great time to mention that clouds occur when water vapor cools in the air and hit a dust particle in the sky.
  - **Activity #2A – The Shrinking Ice Cube**: Students place the weigh boat on the scale and press tare. They grab an ice cube, place it into the weigh boat, and weigh the ice cube. They record the weight and place the ice cube in a second weigh boat on the table. At one minute intervals they pick up the ice cube, blot it with a paper towel, reweigh the ice cube, and record the new weight.
    Teacher Notes: The speed that the ice melts will depend upon the room temperature. If you turn up the heat in the room the ice will melt faster. This is a great activity to discuss how the water changes when it goes from a solid to a liquid and how sublimation can occur simultaneously
  - **Activity #2B – The Disappearing Ice Cube:** Students place one ice cube on a tared weigh boat (labeled with their group number) and record the initial weight. They reweigh it the next day.
    Teacher Notes: The ice will most likely be gone the next day. The students should be able to conclude that the water evaporated from the weigh boat overnight and went up into the air.
  - **Activity #3 – A Steamy Encounter:** The students predict what they think will happen when the mirror is placed over the mug with hot water, they place the mirror over the cup, record their observations, and write an explanation for what they observed.
    Teacher Notes: The students should observe liquid water condensed on the mirror surface. When the liquid water molecules get excited from the heat, they jump out of solution, and turn into water vapor. The water vapor rises, hits the cool mirror surface, cools, and turns back into liquid. So the students should be able to conclude that both evaporation and condensation have occurred. This is a great demonstration of how the lakes in the area loose heat in the fall and look steamy in comparison to the surrounding cool air.
  - **Activity #4 – The Thirsty Paper Towels:** The students observe the 1" x 4" strip of paper towel, place it on the scale, weight it, record the initial weight, dip the paper towel into one of the beakers, reweigh it wet, record the wet weight, and then place it on the tray to dry. The students then reweigh the paper towel strip the next day.

Teacher Notes: The students should observe that the paper towel gains weight from the water and then goes right back down to its original weigh the next day after it is dried. All of the water evaporates into the air overnight.

- **Activity #5 – How Much Water Will the Plants Lose?:** Students rank the 6 test tubes according to how much water they think they will lose over 24 hours.
  Teacher Notes: The students often predict the plant with all of the structures (that has leaves, stems, and roots) will lose the most water. In fact more often than not, the plant that has leaves and stems but does not have roots will lose the most. A good analogy is the example of drinking from a coffee straw versus an extra-large bubble tea straw. Bottom line…the plants need leaves to transpire and their roots slow down the transpiration so that they do not loose water too fast. Note: Plants loose more water to transpiration on windy, dry days than on calm, moist days.

Test Tube	***Expected Result***	***Explanation***
A (control)	*6*	*No plants to loose water from.*
B (no roots)	*1*	*Typically loses the most since it is like a large straw sucking water up to the leaves.*
C (no leaves or roots)	*4*	*In comparison to tube E, the water exits slightly faster due to the lack of roots but still not as much as tube B due to not having leaves.*
D (all present)	*3*	*The plants naturally have small narrow roots that control the flow of water. This prevents the plants from losing too much water. There is also a protective layer on the roots that prevents unwanted chemicals from entering the plant. So the plants with roots will lose water slower as a means of self-preservation.*
E (no leaves)	*5*	*Loses the least dues to a lack of leaves and roots that slow it down. The water exits/transpires through the stomata in the leaves. So no leaves = less transpiration.*
F (no roots + Vaseline)	*2*	*The Vaseline plugs up the stomata (holes in the leaves) so less water can exit in comparison to tube B.*

◆ Wrap Up (20 minutes)

- After the groups have all completed the activities, discuss the results of each activity and ask the students to use the vocabulary words to explain what happened in each activity.
- Alternatively, each group can explain the results one of the five activities to the class using the words.

Teacher Resources

Assessment Options

Have students:

- **complete the Water Cycle Inquiry** as described.
- **create a Flipgrid video** to demonstrate their understanding.

Modifications

- This lesson can be completed individually instead of in groups so that each student can work at their own pace.
- The worksheets can be enlarged for students in need of larger text.

Extensions

Students can:

- **create a portrait of understanding or collage** to demonstrate the role of each vocabulary term in the water cycle.

Online Resources

USGS - The Fundamentals of the Water Cycle:
https://www.usgs.gov/special-topic/water-science-school/science/fundamentals-water-cycle?qt-science_center_objects=0#qt-science_center_objects

Acknowledgements

Many thanks to Shelley Emslie at Swan River School for helping to co-develop this lesson and unit

Photo credit: Pat Van Eimeren / FS (public domain)

Water is critical for all life on Earth. The water cycle moves this important resource from place to place, which allows the planet to distribute heat and provide an abundance of aquatic and marine habitats for animals to inhabit. There are many factors that impact how fast it flows through an environment and moves on to another location. Including how fast it flows in and out or our bodies. The seasonal ebb and flow of water around us, helps to create the natural beauty we enjoy here in Montana.

Name _____
Group Name/#:_____

Water Cycle Inquiry

Student Worksheet (1 of 7)

As you record your group observations, use the vocabulary words below to explain what happened in each activity and to answer the provided questions.

WATER CYCLE VOCABULARY LIST:

Vocabulary Word	Definition
Accumulation	Process of a substance gathering into an area (ex. a lake)
Condensation	Process of a gas changing into a liquid (ex. clouds)
Evaporation	Process of a liquid changing into a gas (ex. steam).
Expansion	When something spreads, extends, or enlarges.
Gas	A state of matter that expands freely into any available space.
Groundwater	Water held underground in the soil or in pores and crevices in the rock.
Infiltration	Process of water moving from the ground surface into the soil.
Liquid	A state of matter that flows freely but is of constant volume.
Molecule	A group of atoms bonded together to create a basic unit of a chemical (ex. water or H_2O)
Percolation	Process of water slowly moving through a filter (ex. water moving through the soil).
Precipitation	Products of water vapor condensation in the atmosphere that fall to the ground (ex. rain, snow, sleet, graupel, and hail).
Runoff	The draining away of water from the surface of the land.
Solid	A state of matter that stays fixed in a firm, stable shape.
Sublimation	Process of a solid changing directly into a gas without passing through the liquid phase (ex. ice turning into a gas).
Transpiration	Process of water moving through a plant and evaporating out of the leaves, stems, and flowers.
Water Vapor	Water in the gaseous phase.

Hint hint...the more you use the words above the better you will be prepared for the spelling and vocabulary quiz at the end of the unit!

Activity 1: Liquid vs. Frozen Water

Write down three observations of before and after water bottles:

Before Frozen	After Frozen
1. 2. 3.	1. 2. 3.

Why were the two bottles different?

How did the water change when it froze? Be SPECIFIC (use the vocab) and explain what happened to the water molecules.

Activity 2A: The Shrinking Ice Cube

Place the weigh boat on the scale and press tare. That will zero your scale with the weigh boat on it! Get an ice cube and weigh it immediately. Record the initial weight of your ice cube. Then weigh the ice cube at one-minute intervals for three minutes and record your weights below.

Place the ice cube in the SPARE weigh boat in between weighing!!!

Time (min)	Weight (g)
0	
1	
2	
3	

How did the ice change over time? BE SPECIFIC (use the vocab) and explain what happened to the water.

Activity 2B: The Disappearing Ice Cube

1. Tare the scale to zero it. Dry out the spare weigh boat.
2. Place the weigh boat on the scale and record the weight below.
3. Get new ice cube and place it into the weigh boat on the scale. Weigh the weigh boat and ice together and record the weight below.
4. Subtract the two numbers to get the ice weight. Record the weight below.
5. Let the ice sit overnight. Weigh them together again in the morning to see if there are any changes.

Time (h)	Weight of weigh boat (g)	Weight of ice with the weigh boat (g)	Weight of the ice (g)
0			
24			

Did the weight of the water change overnight?

BE SPECIFIC (use the vocab) and explain why or why not the weight changed.

Activity 3: A Steamy Encounter

If you place the mirror over the glass of boiling water, what do you think will happen? What is your hypothesis? (If…. then… because…)

Actual Observations:

What happened to the water molecules in the glass? BE SPECIFIC (use your vocab) and explain.

Activity 4: The Thirsty Paper Towels

Task	Results
1. Record initial observations of the DRY paper towel. Example: The paper towel is dry, thin, light, and rough to touch.	
2. Tare the scale, place your paper towel on the scale, and record the initial weight of the DRY paper towel (g).	
3. Dip the end of the strip into the beaker of colored water until the entire strip is wet.	
4. Record observations of the paper towel as you wet it.	
5. Tare the scale, place the wet paper towel on the scale, and record the weight of the WET paper towel (g).	
6. Calculate the difference in the weight between the dry and wet paper towel (g).	
7. Lay your paper towel on the tray and dry off the scale for the next group	
8. THE NEXT MORNING: Record observations of the paper towel.	
9. THE NEXT MORNING: Tare the scale, place the paper towel on the scale, and record the weight of the paper towel (g).	

What happened to the paper towel when you wet it? BE SPECIFIC (use the vocab) and explain.

What happened to the water in the paper towel overnight? BE SPECIFIC (use the vocab) and explain.

Activity 5: How Much Water Will the Plants Lose?

1. Make a prediction and rank the following test tubes on which one will lose the most water over the next 24 hours (On a scale of #1 will lose the MOST water and #6 will lose the LEAST water).
2. After 24 hours: Measure the amount of water LOST from the test tubes. Measure in millimeters from the starting line marked on the test tube to the meniscus (the bottom of the dip of water).

Test Tube	Treatment	Prediction	Actual Results
A	Water present (NO PLANT)		
B	Water, leaves, & stems present (NO ROOTS)		
C	Water & stems present (NO LEAVES OR ROOTS)		
D	Water, leaves, stems & roots present		
E	Water, stems, and roots present (NO LEAVES)		
F	Water, leaves, & stems present (NO ROOTS) with vaseline		

Which plant lost the most water after 24 hours?

Why did that plant lose the most water? BE SPECIFIC (use the vocab) and explain why!

Where did the water go that was initially in the test tube?

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Activity 1:

Liquid vs. Frozen Water

Activity 2A: The Shrinking Ice Cube

Activity 2B: The Disappearing Ice Cube

Activity 3:

A Steamy Encounter

Activity 4:

The Thirsty Paper Towels

Activity 5:

How Much Water Will the Plants Lose?