Exploring the Water Cycle Teacher's Guide

Lesson Overview: Students will observe/investigate the movement of water through the different stages of the water cycle and determine what drives this cycle. They will discover how changes in heat energy occur throughout the cycle. This lesson will take at least two 45-minute class periods to complete. The mini-project could be given as a homework assignment.

National Standards:
ESS2.C: The Roles of Water in Earth's Surface Processes - How do the properties and movements of water shape Earth's surface and affect its systems?
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.
[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [*Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.*]

Background Information:

Water is found almost everywhere on Earth, from high in the atmosphere (as water vapor) to low in the atmosphere (precipitation, droplets in clouds) to mountain snowcaps and glaciers (solid) to running liquid water on the land, ocean, and underground. Energy from the sun and the force of gravity drive the continual cycling of water among these reservoirs. Sunlight causes evaporation and propels oceanic and atmospheric circulation, which transports water around the globe. Gravity causes precipitation to fall from clouds and water to flow downward on the land through watersheds.[1]

More Background Information:

- **NASA Science/Earth: Water Cycle:** http://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle/
- **NASA GPM: The Water Cycle**: http://pmm.nasa.gov/education/water-cycle
- **Earth Observatory Water Cycle Overview**: http://pmm.nasa.gov/education/articles/earth-observatory-water-cycle-overview

[1] Authors: Achieve, Inc.; Next Generation Science Standards, Core Idea ESS2.C ; Publisher: Achieve Inc.; Copyright: 2013.

Materials:

- Pre and Post Assessments – 1 each per student
- Student Capture Sheet – 1 per student
- Materials for Teacher Demonstrations *(See Teacher Demonstration Instructions Sheet)*

Engage:

1. Students will think-pair-share an answer to the following question: "What is precipitation?". (slide 2) The teacher can record their answers on the board or chart paper.
2. Show the video, "The Freshwater Connection" (1:25) video at: http://pmm.nasa.gov/video-gallery/what-is-global-precipitation-measurement. (slide 3) *(This is a good introduction to why it is important to study the water cycle.)*
3. After the video, have students Think-Pair-Share the question, "Based upon what we just viewed, why is it important to study and understand the water cycle?" (slide 4) Solicit responses.

Explore:

1. Hand out the Water Cycle Capture Sheet. Students will use this throughout the rest of the lesson.
2. Show the water cycle video (slide 5). Students should be labeling their blank diagrams as they watch. This version of the water cycle is more complex than the one on their capture sheets. Students only need to copy the ones from the word bank. http://www.youtube.com/watch?v=iohKd5FWZOE. This video has no narration so you will need to talk the kids though it, pausing as necessary.
3. Ask, "Which of the stages in the water cycle required energy from the Sun?" (Evaporation and Transpiration.) Click on the diagram (slide 6) and the correct labels will be circles. Go to next slide.
4. Ask, "Which of the stages requires water to give off heat? (Condensation) (slide 7). Click on the diagram and the correct labels will be circles. Go to next slide.
5. Ask, "Which of the stages are driven by the force of gravity?" (slide 8). (Precipitation, Runoff, Infiltration, Groundwater Flow) Click on the diagram and the correct labels will be circles. Go to next slide.

Explain:

1. Complete the teacher demonstrations (slide 9). Students will complete the demonstration questions at the end of each demonstration. The teacher should have these demonstrations

prepared the day before this lesson. See the Teacher Demonstration Instructions sheet for full instructions.

2. Show the video, "Water, Water, Everywhere." (6:31) It ties together the concepts in the lesson.

   http://pmm.nasa.gov/education/videos/water-water-everywhere

   Note: You can go to full screen mode by right-clicking on the viewing window and using the 'Zoom' feature. The video can also be downloaded in advance by the teacher.

Evaluate:

Students will complete a mini-project (slide 11) in which they describe one possible path that a water molecule can take through the water cycle. They have the following choices in order to demonstrate their understanding:

1. They may make a *mini-poster* with a diagram of the water cycle. (8.5" X 11" maximum)
   - The diagram should not look just like the one we used in class. It should have the water molecule moving from one step to another.
   - Each step in the cycle needs to have text that describes what is happening to the molecule. This text can be 'spoken' by the drop, or written as a caption near the drop.

Or-

They may make a *comic strip* with a molecule of water as the main character.

- The comic must include text that explains what is happening in each frame.
- The text can be dialog 'spoken' by the drop, or written as a caption at the bottom of the frame.

Or-

Electronic Options for students who prefer to use a computer:

- A Glogster poster http://www.glogster.com or http://edu.glogster.com (for education)
- Computer generated comic strip

2. Grade their projects with the accompanying rubric (slide 12) or set your own standards by which to grade the projects.

3. Administer the post-assessment as a summative assessment.

Extend/Elaborate:

1. Have the students think-pair-share answers to the question, "How do we measure precipitation?" Solicit and record responses. Be sure to add satellites to the list if the students left it off.
2. Ask, "Which of these tools is the most efficient?"
3. Show the video, http://pmm.nasa.gov/education/videos/for-good-measure. Ask the students to watch for the way the NASA GPM mission will make gathering precipitation measurement data more efficient – even over the oceans.

Teacher Notes:

Even though the procedures are long and preparation of materials needs to take place in advance, the demonstrations will only take 15 – 20 minutes of class time. The demonstrations give the students a visual, concrete model of a relatively abstract concept. The understanding of the water cycle is important throughout their learning years and these demos help to reinforce their understanding.

If you have more than one day to work on this topic, then you may want to use one or more of these demonstrations as hands-on activities.

You can find many additional educational resources and materials at this site:
http://pmm.nasa.gov/education/water-cycle

There is a list of many additional educational resources related to the water cycle at this link:
http://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/water%20cycle%20toolkit/Water%20Cycle%20NASA%20resources%20for%20presenters.pdf

Teacher Demonstrations – Instructions

You will complete the following demonstrations for your students as part of a one-day Water Cycle Lesson. Labels for each stage in the water cycle are included to match the diagram in the student capture sheet. This is optional, but may help some students match the term to the concept being demonstrated.

Evaporation:

Note: Be sure to emphasize to the students that the SUN is the heat source that drives the water cycle. You could even put a cut-out of the sun in front of the Bunsen burner so they keep this in mind.

Materials:

- Safety equipment - goggles, gloves for heat protection, apron
- Beaker with approximately 200 mL water
- Bunsen burner or hotplate
- Beaker tongs
- If using a Bunsen burner
  - striker/lighter
  - ring stand, with beaker platform and screen
- Water Cycle Labels (optional)

Procedures:

- Ask the students, "What will happen when heat is added to this beaker of water?" Wait for responses.
- Turn on heat lamp to represent the incoming solar radiation, and light the Bunsen burner.
- Tell them that the beaker is representing large bodies of water such as oceans. The Bunsen burner represents the heating of the water as it absorbs the Sun's radiation.
- Ask the students, "What happens to the water as it receives heat energy from the Sun?" Emphasize the fact that the water temperature will increase the longer the water is exposed to the Sun's energy. (The Bunsen burner is used just to save time for the demonstration.)
- Ask, "What phase change is occurring in the water?" *(It is going from liquid to gas.)*
- Explain that the molecules of water are getting more excited and moving faster. This added energy allows them move apart and become a gas - just like the water on Earth's surface does every day.

Transpiration:

Teacher Note: This demo needs to be set up the day before. This should only take a couple minutes of class time.

Materials:

- Potted plant
- Clear Plastic bag
- string or rubber band

Day before the lesson: (2 or more days will work even better as long as the plant has been watered.)

1. Place the bag over part, or all of a well watered, potted plant.
2. Tie off the bottom of the bag so is tightly closed, but does not damage the plant.

Procedures:

1. Carry the plant around the room to show that there is water in the baggy. (If you feel that there is not enough water in the baggy, you can spray a little in before class begins and retie the bag.)
2. Ask the students how the water got in there. Explain that the plants take in water through their roots. The water is moved throughout the plant and then evaporates through its pores and stomata. Also, this process happens continually, wherever there are plants.

Condensation:

Teacher Note: If you have enough mirrors, you could hand them out to each group and have the kids breath on them in place of you doing so.

Materials:

1 cold, drink can (kept cold in fridge or small cooler.)
Mirror (optional)

Procedures:

1. Wipe off the outside of the can so that it is dry.
2. Hold the can about a foot or so, over the 'ocean' beaker. Hold it there for about ten to fifteen seconds or until you see condensation forming on the can.
3. Either pass the can around the room, or walk around with it so that the students can see the condensation forming on the can.
4. As you move about, ask the students, "Where did the water on the outside of the can come from?" Solicit responses, but be sure they understand that the water vapor that condensed was in the air.
5. Optional: You can skip the following steps, do them yourself, or have the students complete them with their own set of mirrors.
    a. Show the students that the mirror is clean.
    b. Breathe on it and show them the cloudy mirror. Ask, "What is making it foggy?" (The water vapor from your breath that is condensing on it. The mirror is cool enough to condense the water for at least a short time.)

Use condensation to make a cloud:

Teacher Note: The procedures for this demonstration are written for students to follow. The teacher can easily adapt them to do it herself/himself. If sets of materials are prepared in advance, this could be done as a group activity. To save time, have a container (materials tub) for each group ready to hand out before class begins. If this will not fit your schedule, this can also be done as a teacher demo.

Be sure to use all safety equipment for this activity.

Materials: (per group)

- Goggles and lab apron for each participant
- 2 liter, clear soda bottle - with cap, and about 40 mL H_2O
- 1 match
- 1 match striker
- warm tap water (fill the 2 liter bottles with about 2 inches)

Procedures:

1. With the lids on the bottles, shake them for three to 5 seconds so that there will be plenty of water vapor in the bottle.
2. Squeeze the bottle very hard and then release the pressure quickly. Explain that when a compressed gas (the air inside the squeezed bottle) expands rapidly (releasing the squeeze quickly), it cools. An everyday example of this is the way a metal hairspray or deodorant can feels cooler after it is used.
3. Ask what they see form inside the bottle. *(No clouds should form, but there may be a little condensation on the sides of the bottle.)* Ask why this happened. *(Some of the water vapor cooled and condensed back into a liquid on the sides of the bottle, but NOT in the air.)*
4. Tell the students to take off the bottle cap and, working as a team, they will add smoke to the bottle.
   a. One partner holds the bottle on the lab table.
   b. Another partner holds the cap.
   c. A third partner lights the match, counts to 3, and drops it into the bottle.
   d. The first partner then quickly replaces the cap, tightly.
5. Repeat step two above. The quickly cooling air should now form a cloud in the bottle.(It may take two or three squeezes for some students to get the cloud to form.) Explain that this happens because the water vapor has condensation nuclei (the smoke particles) on which to condense. The tiny smoke particles are like the soda can and mirror in the previous demo.
6. Have students open the bottles and GENTLY squeeze out the cloud and smoke. Then they should replace the caps and return everything to the tubs.
7. Students should complete the condensation part of the *Capture Sheet* as the teacher collects the materials tub.

Infiltration:

Teacher Note: This is a simple version of this demo. You can make it more complex with a number of different soil and rock types. This demo is intended to show the basics of infiltration.

Materials:

- 1 clear plastic bottle *(wide mouth preferred)* set up so that water will infiltrate through soil and gravel and into the bottom of the bottle.
  - *Cut around the bottle so a little more than ½ the bottle makes up the bottom part.*
  - *Tie or rubber band a piece of panty-hose, fiberglass screen, or cheesecloth over the open neck of the bottle in place of the cap. This will create a funnel with a filter.*
  - *Turn the funnel over and place a layer of gravel about 2cm thick in it.*
  - *Place 1 to 2cm of soil over the gravel.*
  - *Place the funnel onto the bottom piece of the bottle and tape it to the bottom part so that it won't slip or shift during the demo.*

Procedures:

1. Pour water into the set-up until it starts to flow through the gravel and into the bottom part of the bottle.
2. If there is excess water left 'above ground', ask the students what would happen to it if the soil on were on a slope. Lead them to understand that water that does not infiltrate creates runoff – like water running down a street after a storm, or water in a river.
3. Students should fill in the capture sheet while you prepare for the next demo.

Freshwater from Saltwater.

Teacher Note: Students have often asked how freshwater comes from the ocean. The day before you teach this lesson, make a saturated solution of saltwater. Then, vaporize (evaporate) the water by heating it over a hot plate or Bunsen burner. Have it set aside to show the students.

Freshwater from saltwater:

1. Students predict the answer to the question on the *Student Capture Sheet*.
2. Pass around the saltwater beaker that you evaporated in advance, so the students can see the salt crusted on the bottom.

Explain that the water absorbed enough energy to turn from liquid to a gas (evaporate) but the salt remained behind. In the ocean, the salt would mix with the water that did not evaporate.

THE WATER CYCLE

Evaporation

Condensation

Precipitation

Runoff

Infiltration

Groundwater Flow

Solar Radiation