Lesson 2

Water Cycle (The Hydrologic Cycle)

Overview:

Two investigations introduce students to the hydrological cycle (water cycle). An understanding of the basic water cycle is the base for knowing that the Columbia River and its watershed is part of an earth system that continually renews itself.

Investigation 2.1 students create a simple model of the water cycle and identify the primary locations where water condenses, evaporates and precipitates. Through class discussion they will identify the state of matter as water moves through the cycle.

Investigation 2.2 students will explore the water cycle in more depth as they travel through the in and around earth as a molecule of water. They will collect a record of their travels to be discussed as a class and recorded at the end of the activity.

Student Learning Targets

I can explain the Water Cycle in words, phrases, pictures, or diagrams.

I can explain the energy transfers between solid, liquid and gas forms of water in words, phrases, pictures, or diagrams.

I can sketch and label the Washington State Water cycle in words and pictures or diagrams.

Disciplinary Core Ideas

Science

4PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, **heat**, and electric currents.

Social Studies

Geography 3.1.2
Understands the physical, political, and cultural characteristics of places, regions, and people in the Pacific Northwest…

Scientific and Engineering Practices

Developing and using models

Crosscutting Concepts

Energy and matter: Flows, cycles, and conservation

Teacher Background Information

Academic Vocabulary

Energy transfer: The movement of energy from one location to another.

Condensation: The change of the physical state of matter from a gas to a liquid.

Evaporation: The change in state of a substance from liquid to gas.

Precipitation: Any product of the condensation of atmospheric water vapor deposited on Earth's surface, such as rain, snow, or hail.

Gas: A state of matter consisting of a collection of particles without a definite shape or volume that are in more or less random motion.

Solid: Retains its shape when not Confined.

Liquid: A fluid that takes the shape of the part of the container that it occupies, and that forms a distinct surface.

States of Matter – states of water "Water is made of molecules; each water molecule contains two hydrogen atoms and one atom of oxygen. Molecules constantly move. Heat energy contributes to the motion of molecules (kinetic energy). When water feels warm, molecules are moving very rapidly. Water molecules with little heat energy, such as those in an ice cube, move more slowly. The motion of molecules determines the state of water. In the gaseous state (water vapor), water molecules have a large amount of heat energy and move rapidly. This rapid movement causes molecules to bounce off each other, resulting in greater distances between the molecules. (Compare the amount of space needed by a person who is moving around rapidly to someone who is standing still.) The molecules in liquid water move more slowly. The molecules require less space and are closer to each other. In ice, the molecules contain the least amount of heat energy, so their movement is very slow. (Water molecules in ice form a lattice pattern.
Water changes from one state to another when heat energy is added or lost. Heat travels from areas of high temperature (rapidly moving molecules) to low temperature (slower-moving molecules).

Ice melts in your hand because the heat from your body transfers to the colder material. Sometimes, when molecules near the surface of liquid water move very rapidly, they break away or evaporate, becoming water vapor. Eventually water vapor will lose energy and return to liquid form. This can be seen when steam condenses on a cool bathroom mirror. Water will also change from a liquid to a solid as heat energy continues to be lost. However, even as ice, water molecules contain some heat energy. Therefore, although the movement is limited, the molecules are still in motion." *"Project Wet"*

Water Cycle

"What is the water cycle? The water cycle describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it continuing to work; the Earth would be a pretty stale place to live without it.

Where does all the Earth's water come from? Primordial Earth was an incandescent globe made of magma, but all magmas contain water. Water set free by magma began to cool down the Earth's atmosphere, until it could stay on the surface as a liquid. Volcanic activity kept and still keeps introducing water in the atmosphere, thus increasing the surface- and ground-water volume of the Earth."

Resource:
http://ga.water.usgs.gov/edu/watercyclesummary.html

"The **water cycle**, also known as the **hydrological cycle** or **H_2O cycle**, describes the continuous movement of water on, above and below the surface of the Earth. Although the balance of water on Earth remains fairly constant over time, individual water molecules can come and go, in and out of the atmosphere. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In so doing, the water goes through different phases: liquid, solid (ice), and gas (vapor).

The water cycle involves the transfer of heat, which leads to temperature changes. For instance, when water evaporates, it takes up energy from its surroundings and cools the environment. When it condenses, it releases energy and warms the environment. These heat transfers influence climate. (4-PS3-2) By transferring water from one reservoir to another, the water cycle purifies water, replenishes the land with freshwater, and transports minerals to different parts of the globe. It is also involved in reshaping the geological features of the Earth, through such processes as erosion and sedimentation. Finally, the water cycle figures significantly in the maintenance of life and ecosystems on Earth.

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Description

The Sun, which drives the water cycle, heats water in oceans and seas. Water evaporates as water vapor into the air. Ice and snow can sublimate directly into water vapor. Evapotranspiration is water transpired from plants and evaporated from the soil. Rising air currents take the vapor up into the atmosphere where cooler temperatures cause it to condense into clouds. Air currents move water vapor around the globe, cloud particles collide, grow, and fall out of the upper atmospheric layers as precipitation. Some precipitation falls as snow or hail, sleet, and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Most water falls back into the oceans or onto land as rain, where the water flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff and groundwater are stored as freshwater in lakes. Not all runoff flows into rivers, much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers, which store freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge. Some groundwater finds openings in the land surface and comes out as freshwater springs. Over time, the water returns to the ocean, where our water cycle started.

Processes

Preciptation Condensed water vapor that falls to the Earth's surface . Most precipitation occurs as rain, but also includes snow, hail, fog drip, graupel, and sleet.[1] Approximately 505,000 km^3 (121,000 cu mi) of water falls as precipitation each year, 398,000 km^3 (95,000 cu mi) of it over the oceans.[2]
Canopy interception The precipitation that is intercepted by plant foliage, eventually evaporates back to the atmosphere rather than falling to the ground.
Snowmelt The runoff produced by melting snow.
Runoff The variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may seep into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.
Infiltration The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.[3]
Subsurface flow The flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface (e.g. as a spring or by being pumped) or eventually seep into the oceans. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures. Groundwater tends to move slowly, and is replenished slowly, so it can remain in aquifers for thousands of years.
Evaporation The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere.[4] The source of energy for evaporation is primarily **solar radiation**. Evaporation often implicitly includes transpiration from plants, though together they are specifically referred to as evapotranspiration. Total annual evapotranspiration amounts to approximately 505,000 km^3 (121,000 cu mi) of water, 434,000 km^3 (104,000 cu mi) of which evaporates from the oceans.[2]
Sublimation The state change directly from solid water (snow or ice) to water vapor.[5]
Deposition This refers to changing of water vapor directly to ice.
Advection The movement of water — in solid, liquid, or vapor states — through the atmosphere. Without advection, water that evaporated over the oceans could not precipitate over land.[6]
Condensation The transformation of water vapor to liquid water droplets in the air, creating clouds and fog.[7]
Transpiration The release of water vapor from plants and soil into the air. Water vapor is a gas that cannot be seen.
Percolation Water flows horizontally through the soil and rocks under the influence of gravity

The *residence time* of a reservoir within the hydrologic cycle is the average time a water molecule will spend in that reservoir (*see adjacent table*). It is a measure of the average age of the water in that reservoir.

Groundwater can spend over 10,000 years beneath Earth's surface before leaving. Particularly old groundwater is called fossil water. Water stored in the soil remains there very briefly, because it is spread thinly across the Earth, and is readily lost by evaporation, transpiration, stream flow, or groundwater recharge. After evaporating, the residence time in the

Average reservoir residence times[8]

Reservoir	Average residence time
Antarctica	20,000 years
Oceans	3,200 years
Glaciers	20 to 100 years
Seasonal snow cover	2 to 6 months
Soil moisture	1 to 2 months
Groundwater: shallow	100 to 200 years
Groundwater: deep	10,000 years
Lakes (see lake retention time)	50 to 100 years
Rivers	2 to 6 months
Atmosphere	9 days

atmosphere is about 9 days before condensing and falling to the Earth as precipitation.

The major ice sheets - Antarctica and Greenland - store ice for very long periods. Ice from Antarctica has been reliably dated to 800,000 years before present, though the average residence time is shorter.[9]

Resource: http://en.wikipedia.org/wiki/Water_cycle

Investigation 2.1

Most precipitation occurs over land than water on the earth's surface but evaporation takes place most over the oceans. The model that students will be creating is representative of what takes place on earth's surface. Warm water poured into their models creates a body of water representative of "the lakes, oceans, or other bodies of water into which streams empty after they flow over and through the land.

To understand how land and water interact, students cover their models with plastic and observe that water evaporates into the air, cools and condenses, and eventually falls as precipitation to earth. Although students cannot see evaporation … they will observe the formation of water droplets on the underside of the plastic. …warm water into their land models will speed the process of evaporation.

To model the cooler air that occurs high above the earth, students place a frozen ice pack on the plastic that covers the model...Droplets of condensate should form on the underside of the plastic. When students remove the ice pack and tap on the plastic the droplets should join and fall from the plastic, simulating rain."
Adapted from STC/Land and Water

Materials

For each student
River of Power science notebooks

For each four students
1 clear plastic box
1 sandwich size containers
plastic wrap
soil bags
1 blue ice – frozen
1 large rubber band
warm water*

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Gas: A state of matter consisting of a collection of particles without a definite shape or volume that are in more or less random motion.

Solid: Retains its shape when not confined.

Liquid: A fluid that takes the shape of the part of the container that it occupies, and that forms a distinct surface.

Preparation:

1. Read the teacher background information.

2. Prepare a location for students to collect their materials for this investigation.

3. Remove ice packs from the freezer prior to beginning of lesson keep frozen until students are ready to use them.

4. Set up distribution center with materials for each group of four students.

8 clear plastic boxes (1 per group)
8 sandwich size containers with 1 cup of soil mixture (1 per group)
8 sheets of plastic wrap (1 per group)
8 blue ice – frozen (1 per group)
8 large rubber bands (1 per group)

5. If students have not previously worked in cooperative learning groups of four prepare to establish groups and assign tasks. (materials manager, recorder/summarizer, time keeper, facilitator)

Procedure

1. Introduce the concept of modeling by asking questions such as:

- What models have you seen or made?
- How does the size of a model compare with those of the actual object?
- What are some examples of models scientists might use?
- Why do you think scientists use models?
- What could be some limitations of a model?

**you may wish to have examples of models for student reference during discussion i.e. car, airplane, doll, etc.

2. Let students know that they will be working in groups to build their own models of a natural system called the ***water cycle***. They will be observing and drawing pictures in their science notebooks to identify the locations states of water and where the changes of states take place. ***This is a good time to review the states of water. If students do not remember you may want to access the River of Power website for photographs for discussion in addition to showing an ice cube and a glass of water or in advance place some ice cubes in a glass of water. If available you can boil water for steam ***use extreme caution with students near steam***.

3. Model the process of building a model water cycle for students, and review student instructions for building their own models of the water cycle.

MODEL CYCLE-parts Fig 2.1

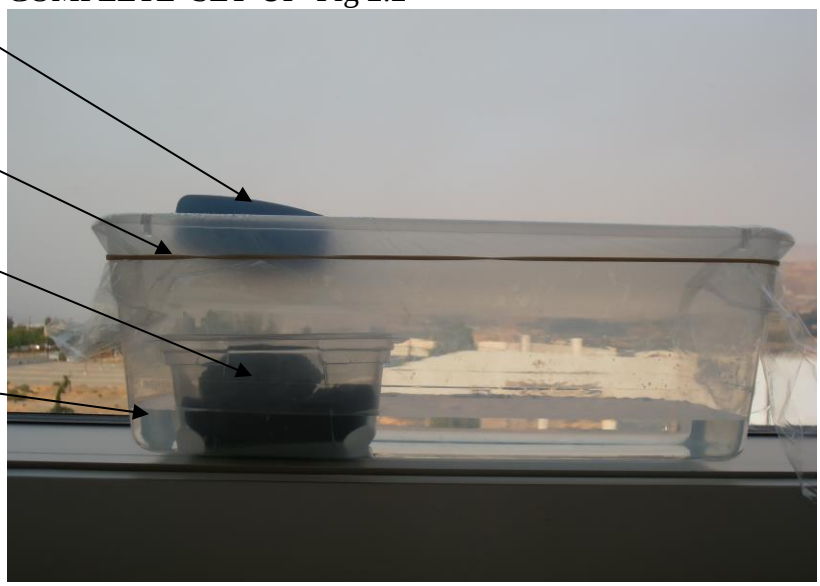
Blue Ice

Plastic wrap & rubber band

Dirt in container

Water

COMPLETE SET-UP Fig 2.2



4. While students gather in pre-determined groups the materials manager will go to distribution center to collect materials. (* you may choose to take plastic wrap to groups as it can be difficult to handle and transport, you may also want to pour water).

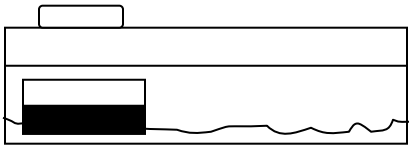
5. Circulate through classroom to assist with construction of models as needed and observe comments that are made during observations by students. Students should be drawing a profile picture of their models and writing down observations in science notebooks while observing any changes taking place to be ready for final activity.

Final Activities

1. Table group discussion to locate where the states of water appear and describe where condensation and precipitation took place based on their observations and inferences.

2. Draw a simple line drawing of their water cycle in profile form on an overhead or chart paper then ask reporters from cooperative group describe the locations of water states and where the processes of changing states occur. Discussion of where condensation and precipitation took place, under the ice block and over the soil. Where does most of the evaporation take place; over the water/under the ice.

Fig 2.3



3. Talk about the limitations of the model and have student make connections to where those locations could occur on, in and around earth (mountains, oceans…) and label them on your drawing.

4. Have students label states of water and energy transfers within the water cycle and label the areas where evaporation, condensation and precipitation take place in their science notebooks.

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Social Studies Connection - Same day or before next lesson.

Whole group discussion. Bring out schematic drawing of water cycle profile and explain that Washington State has a similar profile. Show the Washington State Water Cycle map overhead and go over the geographic features with students. Ask them to take out their science notebooks and compare to the prepared profile map. Tell them that they will now spend some time to decide where the most evaporation, condensation and precipitation takes place in Washington State. Give them a few minute to think and then have them work together with an elbow partner.

Come together as a group to label the overhead map, then students will label their individual maps and glue into their science notebooks. *Note: Google "Washington State Topographic Maps" will provide an overhead view for students to "see" the geographic features.*

Extensions

Glad Unit Links

Forest Grove School District
http://fgsd.schoolfusion.us/modules/groups/homepagefiles/cms/788348/File/ELL/GLAD%20Units/Weather%20and%20Water%20Cycle.complete.pdf?sessionid=1736ec173a5a307155a5cc18a3958ba2

Matanuska- Susitna Borough District
http://www.matsuk12.us/173310829134941600/lib/173310829134941600/Water__Grade_4.pdf

Is This the Water Cycle?

By Eva Thaddues

Is this the water cycle? Yes, ma'am.
Is this the water cycle? Yes, ma'am.
How do you know? It repeats itself.

Is this evaporation? Yes, ma'am.
Is this evaporation? Yes, ma'am.
How do you know? Liquid into gas.
How do you know? The water disappears.

Is this condensation? Yes, ma'am.
Is this condensation? Yes, ma'am.
How do you know? Gas into liquid.
How do you know? You can see it again.

Is this precipitation? Yes, ma'am.
Is this precipitation? Yes, ma'am.
How do you know? Liquid or a solid.
How do you know? Falling from the sky.

Is this the water cycle? Yes, ma'am.
Is this the water cycle? Yes, ma'am.
How do you know? It repeats itself.
How do you know? It keeps on moving.
What is it called? Water cycle!
Tell me again? Water cycle!

Sources:

Project Wet *"The Incredible Journey" p 161-165*
"Molecules in Motion" p 47-49
STC/ Land and Water *"The Water Cycle: Modeling Land and Water" P 11-18*

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Investigation 2.2

In this lesson students will experience the movement of a water molecule as it travels through the water cycle. They will build on the simple water cycle model they constructed during Investigation 2.1 by adding more depth to their understanding of the variety of places that water can travel through the its cycle.

Academic Vocabulary

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Materials:

9 station posters
9 bags of colored beads
9 game die
50 pipe cleaners (1 for each student with bead attached) Fig. 2.4
8 sandwich size containers
1 10 oz. plastic cup

Fig. 2.4

Preparation:

1. Building on the activity from Investigation 2.1 review Teacher Background information.
2. Affix 9 station pictures on walls around the classroom. Under each picture place a container with corresponding bead colors.
3. Hang clothesline at a convenient spot for hanging up bead chains for concluding discussion.

Procedure:

- Ask students to recall and identify the different places water went as it moved through and around Earth in their water cycle models in Investigation 2.1. Write their responses on the board. Ask if there are other ways that water can cycle or move through the hydrological cycle (system). Record these responses also on the board.

- Tell students that they are going to become water molecules moving through the water cycle.
- Discuss some of the different places water can go between the stations and conditions that cause water to move. Note that sometimes water will not go anywhere. The water cycle table provides and explanation of water movements from each station.
- Assign an even number of students to each station and have them look at their die to identify the different places water can go from their location.
- Tell students that as water molecules they will be demonstrating water's movement from one location to another. Each student receives a pipe cleaner with a bead attached to use for keeping a record of their movements through the water cycle.
- In this game, a roll of the die determines where water will go. Students line up behind the die at their station in single file. Taking turns students will **take a bead** and **slide it onto their pipe cleaner** and **then role the die**. They **then move to** the location indicated by the die by the label facing up. When students arrive at the next station **they get in the back of the line. If the die lands on "stay" they move to the back of the line at the same station.** When they reach the front of the line at any station they again take a bead to place on their pipe cleaner and role the die, read the description out loud, to determine the next move. Students are building a visual record of their travels. Fig. 2.5

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Fig. 2.5

- Tell students the game will begin and end with the sound of bell (or buzzer or whistle)
- Observe and assist as students move through the stations. When they have been able to add a small string of beads to their pipe cleaners you may end the game.

Final Activities

1. Have students bring their pipe cleaner bead chains to the front of the room and hang over clothesline. During a whole-class discussion look at the patterns made by beads showing the locations of molecules traveling through the water cycle. Compare the complexity of their travels through the water cycle to the introductory discussion and notes on written on the board. Talk about the states of water they were in as they traveled between stations. Notice that sometimes they seemed to stay in one location for a long time and discuss the reasons for it.

2. Students will then use their beads to write or draw in their science notebooks about the places they have been as water molecules (using graphs, diagrams and words). They should include a description of what conditions were necessary for water to move to each location and the state water was in as it moved.

3. Students will remove beads from pipe cleaners and return them to the appropriate containers.

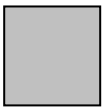
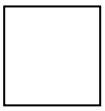
Extensions:

Have students compare the movement of water during different seasons and at different location around the globe. They could adapt the game by changing the faces of the die and adding alternative stations to reflect the different conditions or locations.

Sources

Adapted from:
Utah State University Water Quality Extension
https://extension.usu.edu/files/publications/publication/NR_WQ_2011-13.pdf
(Utah State University Water Quality Extension, 2011-2013)

Water Journey Color Key

Clouds	=	
Glacier	=	
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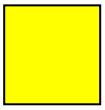
Lake	=	
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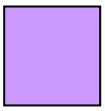
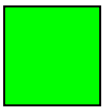
Animal	=	
Soil	=	
Plant	=	
Groundwater	=