THE SCIENCE OF
Water

What Is the Water Cycle?

from *The Science of Water Teacher's Guide* and for *Mystery of the Muddled Marsh*

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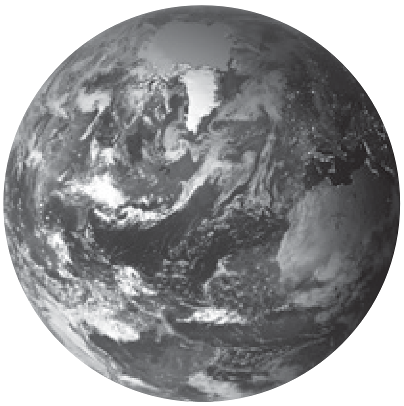
Properties of Water

Physical Science Basics

More than 70% of Earth's surface is covered by water, with about 96.5% of it in the global oceans. This amazing substance is essential for all life on our planet and helps maintain Earth's climate. Water has several unique properties that distinguish it from most other substances.

- **Water has both a high boiling point (100°C; 212°F) and a low freezing point (0°C; 32°F).** Consequently, it can be found naturally as a solid (ice or snow), a liquid (liquid water) and a gas (steam or water vapor), at any given time on our planet.
- **Liquid water changes temperature very slowly.** This characteristic helps animals to maintain their body temperatures. It also keeps large areas of water from warming or cooling rapidly, thereby helping to regulate Earth's climate.
- **Liquid water is an excellent solvent.** This property makes water valuable to living organisms. All of the thousands of chemical processes inside cells take place in water. Water also carries dissolved nutrients throughout the bodies of living organisms and transports wastes. Unfortunately, the same characteristics make liquid water easy to pollute, because so many different chemicals can be dissolved in it.
- **Molecules in liquid water are attracted to one another and, as a result, "stick" very closely together.** This properly explains water's ability to form rounded droplets and to rise within a thin, hollow tube. This characteristic is important for plants, which conduct water and nutrients through very narrow tubes extending from the roots to the branches and leaves.



In the water (hydrologic) cycle, individual water molecules travel as liquid water in the oceans, water vapor in the atmosphere, water and ice on the land, and underground water.

Source: NASA Earth Observatory.

Water droplets on *Taraxacum officinale*, the common dandelion.

Composite image of Earth by Reto Stöckli, NASA Earth Observatory. Photo of *Tarasacum officinale* by Böhringer Friedrich, Wikimedia Creative Commons 2.5.

- **Liquid water expands when it becomes a solid (ice).** Most substances take up less space when they are transformed from a liquid to a solid. Water, on the other hand, actually takes up more space as a solid because the molecules in ice crystals are farther apart than those in liquid water. Since it is less dense, ice floats on top of liquid water.

Ice, liquid water and clouds at Lake Yellowstone, Teton County, Wyoming.

- **Water is colorless and allows light to shine through it.** Plants can grow underwater because water is transparent to the wavelengths of light needed for photosynthesis.

Most of these properties are related to the structure of the water molecule, which consists of two hydrogen atoms and one oxygen atom. The oxygen atom and the hydrogen atoms share electrons, but the electrons are not shared equally. The electrons are pulled toward the oxygen side of the molecule, which ends up with a slight negative charge. Correspondingly, the hydrogen side of the molecule ends up with a slight positive charge. This separation of positive and negative charges (polarity) causes each water molecule to act like a tiny magnet, capable of clinging to other water molecules and to any other electrically charged particle or surface.

TEACHER RESOURCES

Downloadable activities in PDF format, annotated slide sets for classroom use, streaming video lesson demonstrations, and other resources are available free at www.k8science.org or www.bioedonline.org

Photo of Lake Yellowstone by J. Schmidt, National Park Service.

What Is the Water Cycle?

Physical Science

CONCEPTS

- Water can be found naturally as a solid, a liquid and a gas on Earth.
- Water circulates among these three states in the water cycle.

OVERVIEW

Students create a simple model of the water cycle.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making and recording observations
- Measuring
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30 minutes to set up; 30 minutes to observe and draw conclusions

MATERIALS

Each group will need:
- 20 ice cubes
- 2 cups of sand
- Shoebox (see SETUP for alternative)
- Aluminum foil (to line the bottom and sides of the shoebox)
- Plastic wrap (to cover the top of the shoebox)
- Large rubber band, about 7 in. x 1/8 in. (to secure the plastic wrap)
- Measuring cup, 8 oz
- Lamp with incandescent bulb if sunny window is not available
- Copy of "The Water Cycle" page

Each student will need:
- Sheet of drawing paper

Water is one of the few substances that can be found in all three states—solid, liquid and gas—at any given time somewhere on Earth. For example, snow and ice always are present at the poles, as well as on the tops of high mountains. Liquid water is abundant in many places on Earth, including lakes, rivers, oceans and underground. Water vapor, the gas phase of water, usually makes up a small component of the air around us (up to 5%), and can be observed as steam when liquid water is heated.

When talking about this important resource, we usually think of liquid water. However, if water were not continuously cycling among its three states, the world's stores of freshwater quickly would become depleted or too polluted to use. Fortunately, our supply of freshwater continually is collected, purified and redistributed as part of the water cycle. Also known as the hydrologic cycle, this continuous process replenishes our water sources through precipitation (rain, mist, snow and sleet, for example). Some water from precipitation soaks into the ground. The rest runs off into streams, lakes and the oceans. Heat from the sun causes water to evaporate from the land and from bodies of water. Water vapor collects in the atmosphere until there is too much for the air to hold in clouds, leading once again to rain or snow.

This activity allows students to explore properties of water that are important to the water cycle.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 10–13;
Science box, p. 3

Explorations
What Am I?, p. 5

SETUP

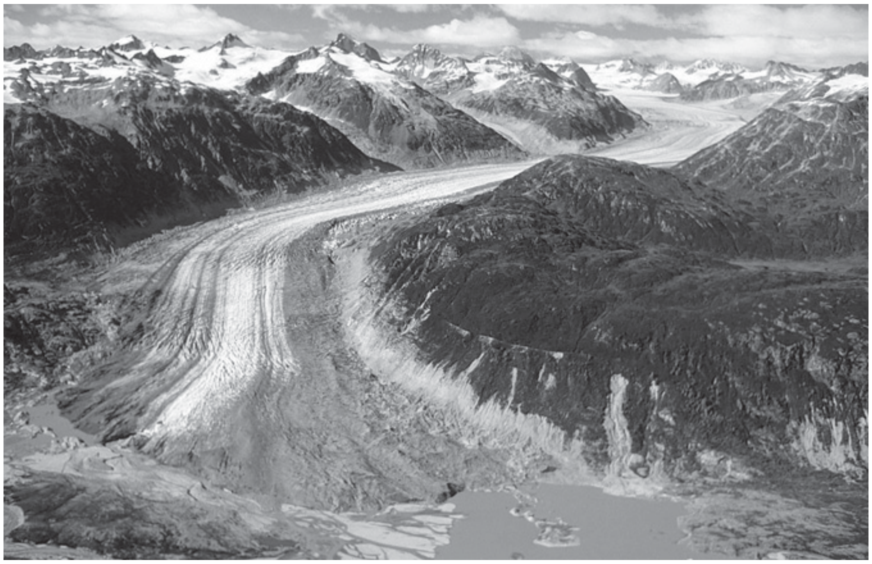
Place a container of sand in a central area, so that groups may measure out the quantities they need. As an alternative to shoeboxes, aluminum foil and plastic wrap, students may use plastic boxes with clear covers.

Have students work in groups of four.

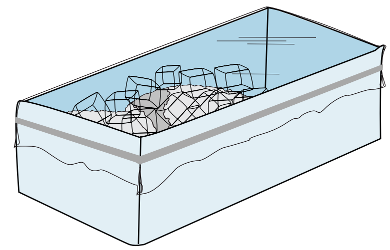
PROCEDURE

Session 1: Making the model

1. Have each group line the inside of its box by pressing a single sheet of aluminum foil along the bottom and up the sides of the box.
2. Direct groups to take turns measuring out two cups of sand and placing it in a pile at one end of their boxes.
3. Have each group smooth the sand to create a hill at one end of



Aerial photo of the retreating Tanaina Glacier and the recently re-formed Summit Lake in Alaska. The lake is dammed by sediment and an ice-cored moraine left by the retreat of the glacier.



Students create a model of the water cycle by placing ice cubes over a mound of sand within a closed container.

the box, gradually sloping it toward the other end. This will form the "land" in the model.

4. Have each group place 20 ice cubes on top of the "land" in the box. The ice cubes will represent "snow" and "ice" in the model.
5. Help the groups cover each box with a sheet of clear plastic wrap and secure it with a large rubber band. (If using plastic storage boxes, cover them securely.)
6. Discuss the models with the class. Ask, *Which part of the box and its contents could represent land? Which part could represent snow on the tops of mountains or ice in the winter? Do you think a lake could form? If so, where would it be?*
7. Ask students, *What do you think will happen if we put the boxes in the sun?* Have each student fold a sheet of drawing paper in half. Then direct students to use one-half of the sheet to draw a "side view" of what they think the box will look like at the end of the day.
8. Place the boxes in a sunny window or a under a lamp with an incandescent (not fluorescent) light bulb. If possible, have the students observe their boxes at intervals throughout the day. Otherwise, have them observe the boxes within the next day or so.

Session 2: Looking at results

1. Have the students observe their boxes without removing the covers. Ask them to note the changes that have occurred inside the boxes. *What happened to the ice cubes? What else is*

Continued

TRANSPIRATION

Water also cycles through living organisms. Transpiration is the loss of water from parts of plants. Water evaporates through tiny pores in leaves and stems. This process creates a pressure change that draws water and nutrients up from the roots into other parts of the plant.

While evaporation from the oceans is the primary vehicle for driving the surface-to-atmosphere portion of the water cycle, transpiration also is significant. For example, a cornfield 1 acre in size can transpire as much as 4,000 gallons of water every day.

Photo of Tanaina Glacier by William R. Reckert, U.S. Geological Survey.

Most snowflakes are hexagon-shaped. This six-sided arrangement actually reflects the arrangement of water molecules inside the crystals of snow. Each snowflake contains approximately 10^{16}, or 10,000,000,000,000,000 water molecules!

QUESTIONS FOR STUDENTS TO THINK ABOUT

- What would happen to the water on our planet if the recycling of water through the atmosphere suddenly stopped? What does this teach us about using water wisely?
- When water evaporates, any substances that had been dissolved in the water are left behind. What eventually happens to manufactured chemicals that have been mixed into water? How could this be avoided?

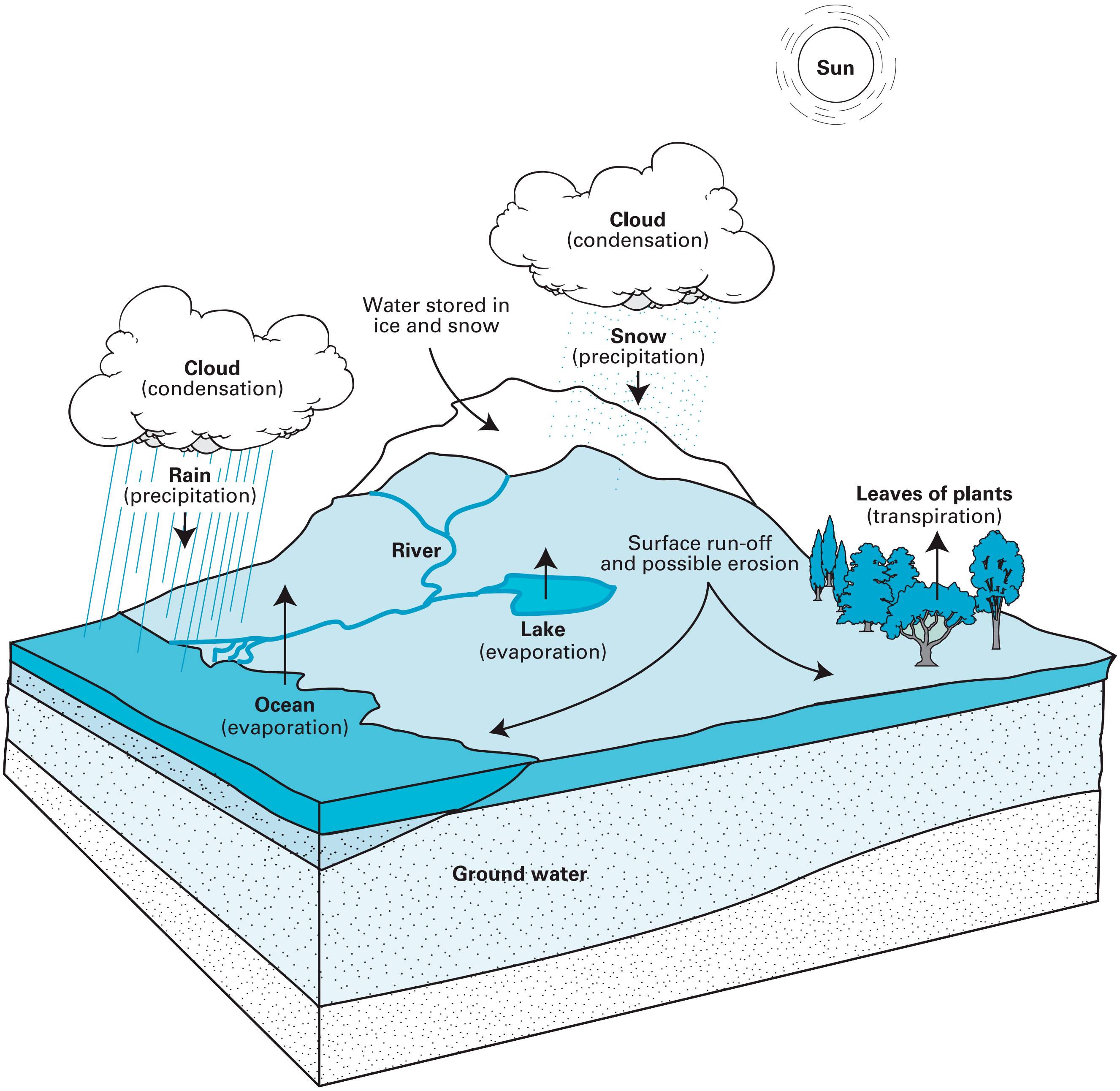
different about the inside of the box? In most cases, at least a few drops of water will have condensed on the inside of the covering. Ask, *Where did the drops of water come from?*

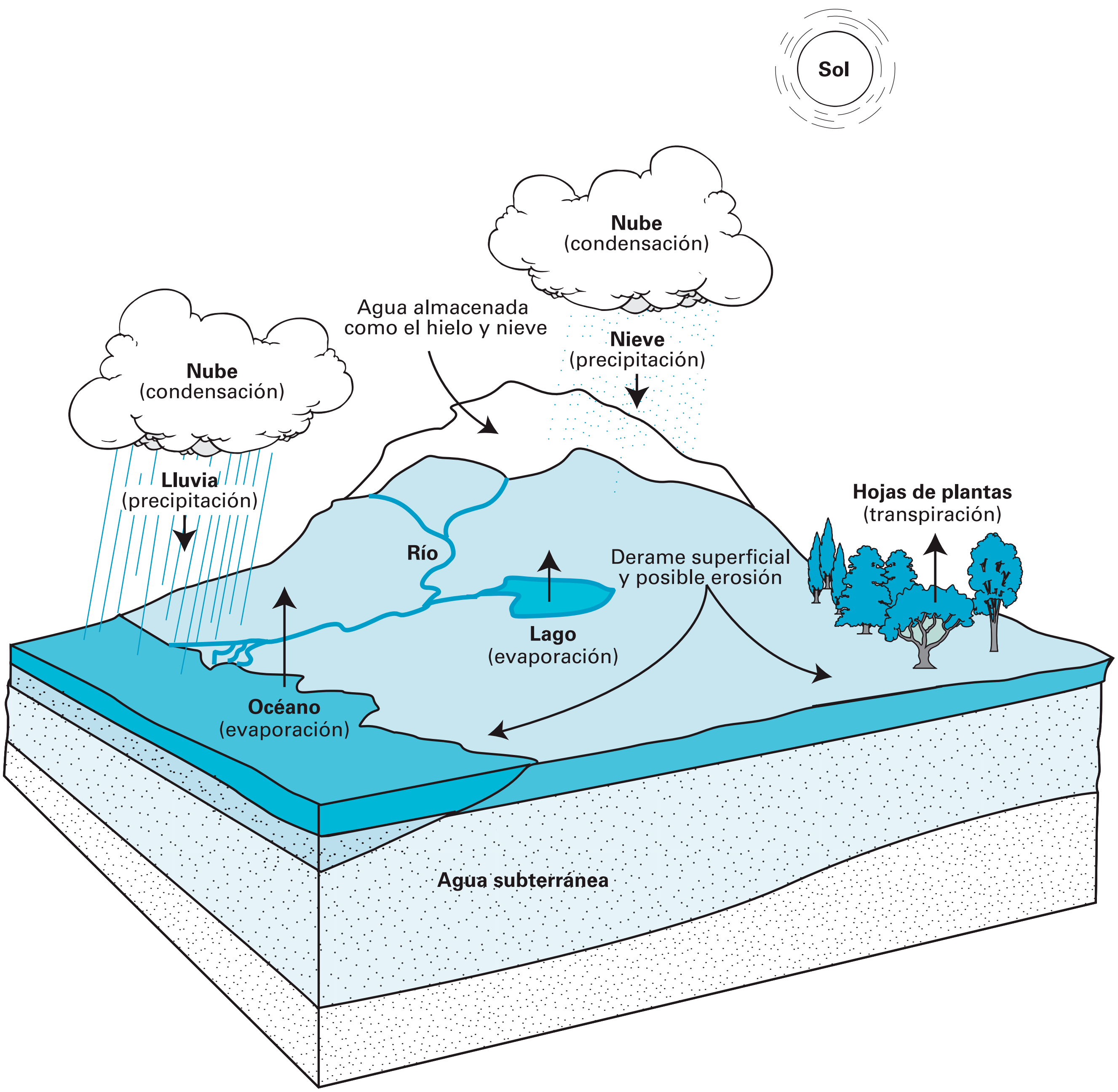
2. Help students understand that all three states of water have been present in their shoeboxes. Review the different states in which water can be found—ice or snow (solid), liquid water and water vapor. Breathe on a mirror or piece of glass to show students how water vapor condenses on a surface, OR boil a small container of water, so that students may observe the cloud of steam. Hold a glass or mirror above the steam.
3. Let the students remove the covers from their boxes. Ask them to observe the surface of the sand. Ask, *Has the surface of the sand changed? In what ways?*
4. Talk about where the water in the box has gone. *Where was all of the water in the box when we started? Where is the water now?* If students have not noticed that the surface of the sand is wet, point out that some of the water has run into the bottom of the box to make a "lake," and some has soaked into the sand. Help students understand that the same processes take place outside when it rains and snows.
5. Have students draw a side view of the box on the remaining half of their folded sheet of drawing paper. Discuss the outcomes they observed and compare their findings with their predictions.
6. Challenge students to think about what would happen if other substances (for example, chemicals, oils, etc.) also were present on or in the sand.
7. Give each student a copy of "The Water Cycle" page, or project an overhead transparency of the page. Have students identify the forms in which water is present in the diagram (for example, snow on mountaintops is a solid form of water, and water evaporating from the ocean represents water in a gas phase). Direct very young students to place a sticker everywhere on the page where they can find some form of water.

VARIATIONS

- Have students design experiments to learn what happens to chemicals in soil by placing drops of food coloring on the sand in the shoeboxes before adding the ice cubes. Ask students to note where the colors end up in the system.
- A limited version of this activity can be conducted using plastic resealable bags. Add small amounts of sand and ice to each bag, then tape the bags to a window.
- Provide an opportunity for students to observe water transport within plants. Place a stalk of celery in a container of water with a few drops of food coloring. The colored water will travel up through the water-conducting tissue in the stalk into the leaves.

The Water Cycle




Sol
Nube
(condensación)
Agua almacenada
como el hielo y nieve
Nieve
(precipitación)
Nube
(condensación)
Lluvia
(precipitación)
Hojas de plantas
(transpiración)
Río
Derame superficial
y posible erosión
Lago
(evaporación)
Océano
(evaporación)
Agua subterránea