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BIOLOGY TEACHER RESOURCES FROM BAYLOR COLLEGE OF MEDICINE

The Water Cycle and Global Warming

OVERVIEW

Life on Earth is dependent on water and variations in its availability. The Earth's hydrological (water) cycle controls the distribution of water, which is always in movement; and always changing states from liquid to vapor to ice and back again. The water cycle is integrated with the complex physical, chemical, and biological processes that sustain ecosystems and influence climate. Ongoing research focuses on human activities that influence the natural distribution system and quality of water within the Earth's systems and to what extent the resulting changes are predictable.

OBJECTIVE/PROFICIENCIES

Students trace the flow of water in the environment; investigate simulated effects of global temperature change on oceanic surface levels, evaluate consequences of changes within water cycle using data from current models, and observe and explain several different properties of water.

NATIONAL SCIENCE EDUCATION STANDARDS

- The Interdependence of Organisms:
    - The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.
    - Human activities modify ecosystems.
- Physical properties of compounds reflect the nature of the interactions among their molecules.

GRADE LEVEL

8 - 12

TIME

Two 55-minute class periods

MATERIALS

Teacher Materials (see Setup)

- Computer, projector and projection screen
- PowerPoint® slide 13, "Biogeochemical Cycles," and slide 14, "Water Cycle," from the BioEd Online slide set "Introduction to Ecosystems."
- Overhead projector (optional, see Setup, item 1)

- Transparencies of slides (optional)

Materials per Student

- Copy of "Why Should I Care?" and "3-2-1" student sheets

SETUP

1. Prepare to project the slides (see Teacher Materials, above) from a computer OR make transparencies of the slides and use an overhead projector.
2. Demonstration: Assemble the materials listed for the demonstration of "The Three States of Water Demonstration."
3. Assemble the materials for the "Water Level Investigation" activity.
4. Access the most recent yearly "State of the Climate Report" from the National Climatic Data Center. Make a PowerPoint® slide or a transparency of "Global Surface Mean Temp Anomalies."
5. If students will be reading the activities online, locate each of the following four *Nature News* articles and preload the articles prior to class.
    - "Sea-level rise is quickening pace." January 19, 2006, *Nature News* (BioEd Online)
    - "Ocean Currents Flip Out." January 4, 2006, *Nature News* (BioEd Online)
    - "Ocean Freshens Up." June 16, 2005, *Nature News* (BioEd Online)
    - "Amazon Hit by Worst Drought for 40 Years." October 11, 2005, *Nature News* (BioEd Online)
6. Have students work in pairs.

LESSON

Engage

1. Follow instructions for "The Three State of Water Demonstration." Begin the activity by conducting Part 1 as a class demonstration.
2. Distribute the activity sheet entitled, "Why Should I Care?" or demonstrate to students how to set up their own paper.
3. Show the class the "Water Cycle" slide. Ask students (working in pairs) to respond to the questions in column 1 (column 2 is for additional notes and changes later in the lesson). Each student should fill out an activity sheet.
4. Discuss the responses that different groups listed for each question. As the discussion progresses, refer to the diagram. Ask students to add information and questions to think about in Column 2.
5. Conduct Part 2 of "The Three States of Water Demonstration" as a class demonstration.

EXPLORE

Option 1

1. Have students conduct the "Water Level Investigation" in groups of two. Follow proper safety guidelines when using a hot plate. Make certain that students wear safety goggles when heating liquids.

    Students should notice that ice melting in the container does not raise the water

level since ice is less dense than liquid water.

As water cools, the molecules pack together and it becomes more and more dense until it reaches 4° C. Any attempt to pack them closer together cause the molecules to repel each other; at freezing point, the molecules form a lattice structure, such as ice and snow, which is significantly less dense than liquid water. Ask students, *What things in your lives would be different if ice were more dense than liquid water?*

2. Conversely, as water temperature increases, liquid water becomes less dense and expands. Student may or may not observe the water in the container expanding enough to overflow. Ask students, *Did you notice water vapor escaping from the container? Did you detect a change in the shape of the water surface?* Depending on the air temperature, evaporation rates change. Surface tension is also reduced as water is heated. This is a great time for students to research some of the properties of water.

Option 2

Ask students to design an investigation that will explore how temperature affects water level.

EXPLAIN

1. Present "State of the Climate Report" graph, "Global Surface Mean Temp Anomalies." [Anomaly refers to a deviation from a normal or average and often is used when describing climatic data.]
2. Based on the results from the "Water Level Investigation," ask students to propose and support ideas about the effect that increasing temperatures might have on ocean water levels. For example, as water temperature in the ocean increases, the volume expands and levels rise. As ice floating in the ocean melts, the level is not raised, however, as surface temperature increases, additional ice breaks off which causes an increase in ocean levels. Ask students to access data from the internet to see if their ideas are supported. (Examples: the IPCC Third Assessment Report and United Nations Environment Programme: Vital Graphic Series).
3. If you only have one computer in the classroom, consider projecting the screen and ask the class to direct the search.
4. Encourage students to suggest additional factors that influence ocean levels such as movement of the ocean floor, evaporation, subsidence, run off from snow melt, changes in currents, salinity levels and so on. It is important for them to realize that determining the cause of events is not simple.

ELABORATE/EXTEND

1. Divide students into groups of four. Have each student group member to read of the following articles.
    - "Sea-level rise is quickening pace"
    - "Ocean currents flip out"
    - "Ocean freshens up"
    - "Amazon hit by worst drought for 40 years"

2. Ask each student to summarize the article they read and share the information with the group. Distribute the "3-2-1 Activity" sheets and have each student to complete it based on all four articles.

EVALUATE

Ask each student to create an article or bio-political cartoon for the school newspaper concerning problems with any of the resources or processes within the water cycle.

EXTENSION

Use the internet to access data on sea level changes, climate changes, and coastal changes. Have students explore questions such as: Is the hydrological cycle (water) changing? Are sea levels changing? Is the climate becoming more variable? Why is Antarctica important to all of us?

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Name_____ Date _____

Why Should I Care?

Column 1	Column 2
In what ways do you think water is important to people?	
How do you think that people change or impact the water cycle?	
Do you think we have serious problems facing us with respect to how the water cycle functions?	

The Three States of Water Demonstration

CONCEPTS

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

OVERVIEW

Create a simple model of the water cycle.

SCIENCE, HEALTH & MATH SKILLS

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

MATERIALS

- plastic shoebox with a clear plastic lid (see SETUP)
- 2 cups sand
- measuring cup, 8 oz
- lamp with incandescent bulb if sunny window is not available
- 20 ice cubes (approx.)

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 tiny 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 of the 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.

SETUP

1. Optional: Instead of conducting this activity as a demonstration, divide the students in groups of 4 and direct each group to set up the investigation. Place a container of sand in a central area, so that groups may measure out the quantities they will need.

Development of this activity was supported, in part, by grant number R25ES06932 from the National Institutes of Health, National Institute of Environmental Health Sciences. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine, the sponsoring agency or the publisher.

2. An alternative to using clear plastic shoe boxes is to line a cardboard shoebox with aluminum foil. Cover the top with plastic wrap and secure with a large rubber band.

PROCEDURE

Part 1: Making the model

1. Obtain a plastic shoebox with a clear lid
2. Ask for a volunteer to measure out two cups of sand and place them in a pile at one end of the box.
3. Have another student volunteer smooth the sand to create a hill at one end of the box, gradually sloping it toward the other end. This will form the land in the model.
4. Place 20 ice cubes on top of the "land" in the box. The ice cubes will be "snow" and "ice" in the model.
5. Cover securely. (If using a cardboard box, cover the top with a sheet of clear plastic wrap and secure it with a large rubber band).
6. Discuss the model with the class. Ask students what they think is the purpose of the demonstration. Encourage student ideas and discussion.
7. Ask students to predict what will happen if the box is place in a sunny location. Encourage them to elaborate and explain the basis for their prediction.
8. Place the box in a sunny window or a under a lamp with an incandescent (not fluorescent) light bulb. If possible, have the students observe the box at intervals throughout the class period and over the next few days. If you are doing this with several different class periods, you may wish to vary the amount and intensity of the heat source.

Part 2: Looking at results

1. Have the students observe the box without removing the cover. Ask them to note the changes that have occurred inside the box. What happened to the ice cubes? What else is 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 the shoebox. 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. Remove the cover from the box. Ask students to observe the surface of the sand. Has the surface of the sand changed? Encourage students to elaborate.
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. Ask students to compare the prediction they made at the beginning of the demonstration with the observed results.
6. Facilitate a discussion with students as they compare the model with water cycle. Encourage them to think about anything that has an effect on the way water moves through the environment. How could the model be improved?

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6. Challenge students to think about what would happen if other substances (for example, chemicals, oils, etc.) also were present either on the surface or mixed into the sand.

VARIATIONS

- Have students design experiments to test what happens to chemicals in soil by placing drops of food coloring on the sand in the shoeboxes before adding the ice cubes. Ask them to note where the colors end up in the system.
- This activity also can be conducted using plastic re-sealable bags. Add small amounts of sand and ice to each bag, then tape the bags to a window.

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 this resource wisely?

When water evaporates, any dissolved substances are left behind. What do you think eventually happens to manufactured chemicals that have been mixed into water? How could this be avoided?

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WATER-LEVEL INVESTIGATION

Part 1

Question: Does the water level change as ice floating in a beaker begins to melt? **Make a prediction.**

Materials: water, ice, 250 ml beaker, cake pan

Investigate:
1. Put two ice cubes in a 250ml beaker. Add room temperature water to make the beaker as full as possible without overflowing. Make observations as the ice melts. How did the results compare with your prediction? Explain what happened.
2. After the ice has completely melted, carefully add another ice cube to the glass. What happens? Does the water level in the glass with ice change over time?
3. Is ice more or less dense than liquid water? Explain

Part 2

Question: Does a volume of water expand when heated? **Make a prediction.**

Materials: hot plate, 250 ml beaker, small metal cake pan, water.

Investigate:
1. Follow your teacher's safety instructions when using a hot plate. Wear your safety goggles.
2. Place the cake pan on the hot plate (cool, no heat). Set the beaker in the cake pan. Fill the beaker **as full as possible** with **very cold** water (without spilling).
3. Turn the heat to the lowest setting. As the water warms, observe the water in the container carefully. Closely monitor and record all observations. How did the results compare with your prediction? Explain.

Extension:
1. Compare air temperature data (morning, noon, and evening) for a coastal area with that of an area approximately 50 to 75 miles inland. Use a local weather site (such as a television station) or a national weather site to obtain temperature readings for several different dates. What did you find? Do you think that ocean temperatures affect climate? In what way?

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3-2-1 Activity

Name _____ Date _____

New things learned:

3

Things that surprised you:

2

Questions you have:

1

3-2-1 Activity

Name _____ Date _____

New things learned:

3

Things that surprised you:

2

Questions you have:

1