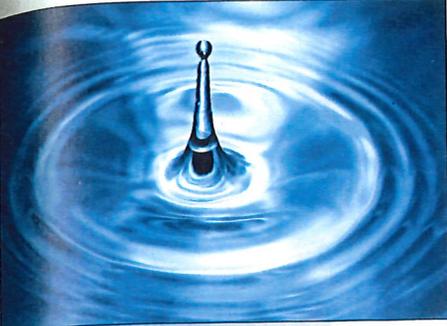


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Molecules in Motion

Simulate molecular movement in water's three states.

Grade Level
Pre-K through 2, Upper Elementary

Subject Areas
Physical Science

Duration
Preparation time: 40 minutes
Activity time: 50 minutes

Setting
Classroom or open area

Skills
Analyzing information (identifying patterns); Interpreting (summarizing); Presenting (drawing, writing)

Charting the Course
"The Incredible Journey" and "Molecules in Motion" serve as a good introduction to the properties of water and the water cycle. Investigations into the role of hydrogen bonding are provided in "Hangin' Together."

Vocabulary
kinetic energy, heat energy, evaporate, condense, solid, liquid, gaseous (gas), water molecule, hydrogen, oxygen, water vapor, lattice pattern, heat of vaporization, buffering, weather, climate

Summary
This activity brings water molecules up to size (student-size!) by physically involving students in simulating molecular movement in each of water's physical states (solid, liquid, gas).

Objectives

Students will:

- model the effects of heat energy on the state of water.

Materials

- Samples of water in each state (a glass of water, ice and boiling water or water evaporating on a sunny window ledge) (optional)
- 2 flashlights (one covered with a red filter or transparency and one with a blue filter or transparency)



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Making Connections

Students have had close encounters with all three states of water: they drink water, inhale and exhale water vapor and crunch ice cubes. Understanding the behavior of water molecules helps students acquire a fundamental knowledge of the physical properties of water.

Background

Water is made of molecules. Each water molecule contains two hydrogen atoms and one atom of oxygen. Molecules constantly move. Heat energy is energy that is transferred from one molecule to another, contributing to the motion of molecules (kinetic energy). When water feels warm, molecules are moving 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 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). This is



why ice melts in your hand: The heat from your body transfers to the colder material, warming it up and turning it to water. When molecules near the surface of liquid water absorb heat and move very rapidly, they break away or evaporate, becoming water vapor. Eventually water vapor loses energy to the atmosphere and returns to liquid form. This can be seen when steam condenses into droplets on a cool bathroom mirror. Water changes 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.

The transfer of heat energy from warmer to cooler molecules explains why the ambient outside temperature warms up when it rains: As water vapor condenses to a liquid state, heat energy is released into the cooler air. Conversely, after a rain, the ambient temperature decreases as water evaporates from surfaces: These molecules absorb heat energy from the warmer air, begin to move very rapidly, and become vapor again. The amount of energy required for molecules near the surface of liquid water to evaporate is called the heat of vaporization. Water has a very high heat of vaporization (it requires a lot of heat to evaporate). This property of water has a huge impact on our weather and climate. Because so much of Earth is covered with water and because water evaporates relatively slowly, we are protected from large fluctuations in atmospheric temperature.

Solid*Liquid**Gas*

Procedure

▼ Warm Up

- Have students write down or draw pictures of what happens to an ice cube on a window ledge as the weather turns warmer. Discuss their views and collect their papers.
- Discuss and compare the three states of water. (A sample of each can be available for reference.) Have students identify the conditions needed for each to exist.
- What happens when water evaporates? Where does the water go? Students may know or guess the answer. Help them to understand that water has been broken down to its tiniest form—a water molecule.
- Tell students that water is made up of millions of tiny molecules. A cookie appears to be one solid piece, but when crumbled it is made up of many tiny pieces. This analogy can be used to help young learners understand the particulate nature of matter.

▼ The Activity

1. **Tell the class they are going to become water molecules. They will begin as water in its solid form, ice.** As ice, students stand in place and move very little. (You may want to incorporate hand signals as an additional visual cue for students during phase changes: a fist for solid, open hand wave motion for liquid and wiggling fingers for vapor.)
2. **Inform students that for this activity, a flashlight with a red filter will be used to represent the addition of heat energy.** Shining the light on a student represents heat energy traveling from an outside source (for instance the sun) to that water molecule (student), resulting in increased temperature and molecular motion (kinetic energy).

3. **Beam the flashlight on a few students.** They should begin to move slowly in place, gently bumping into each other. Through a chain reaction, all students begin moving.
4. **Tell students they are now liquid.** As liquid molecules, students should stay close together.
5. **Add more heat; the liquid turns into a gas.** In its gaseous state, water molecules move freely. Students step away from each other and roam randomly around the room. Music may enhance the flow of “molecules” around the room.
6. **Explain that eventually, heat energy will be lost.** The loss of heat energy is represented by the flashlight with the blue filter. (Heat travels from the molecule to the colder object.)
7. **Shine the blue flashlight on a group of students.** Droplets of water form around the room as molecules lose energy and move together. After all the students are liquid, continue to shine the blue light (representing a continued loss of energy) on students until they become ice.

▼ Wrap Up

- Have students write in their own words or draw a picture or diagram to represent how water behaves in each state and what happens during the transition from one state to another.
- Provide students with a scenario, such as a glass of ice set on a sunny porch, and have them describe in molecular terms what will happen to the ice. Have students keep their descriptions of molecules in motion in a handy place (such as a Water Log), to be used as a reference when learning other water concepts.
- This activity should be repeated a number of times throughout the year. A story or different scenario may be used to illustrate the activity.

▼ Project WET Reading Corner

Aliki. 1991. *My Five Senses*. New York, NY: HarperFestival.*

This book helps younger students learn how their senses provide a gateway into the world.

Cassino, Mark and Jon Nelson. 2009. *The Story of Snow*. San Francisco, CA: Chronicle Books.

Explore the complex structure of snow and its relationship to water chemistry and the water cycle.

Farndon, John. 1999. *Hydrogen. The Elements*. Tarrytown, NY: Marshall Cavendish Corporation.

Take a look at hydrogen from A to Z: its atomic weight, abundance in nature, bonding characteristics and the part it plays in everyday life.

Gardner, Robert. 2006. *Melting, Freezing, and Boiling Science Projects with Matter*. Berkeley Heights, NJ: Enslow Publishers.

Using concise, easy-to-understand explanations, this book offers fun experiments that teach younger students about phase changes in matter.

Guillain, Charlotte. 2008. *Water*. Chicago, IL: Heinemann Library.

Through photographs, Guillain portrays water in its various states (liquid, gas and solid) in order to teach students about the water cycle.

Pipe, Jim. 2002. *Why Does Ice Melt?* Brookfield, CT: Copper Beech Books.

This book explores the processes of freezing and melting using simple terms and projects.

Rosinsky, Natalie M. 2002. *Water: Up, Down, and All Around*. Minneapolis, MN: Picture Window Books.

Rosinsky describes the water cycle, explaining evaporation and condensation, dew and frost and the three states of water, as well as discussing the importance of water.

Sarquis, Jerry, Lynn Hogue, Mickey Sarquis and Linda Woodward. 1997. *Investigating Solids, Liquids, and Gases with Toys: States of Matter and Changes of State*. New York, NY: McGraw-Hill.

This book contains 24 experiments designed to teach concepts to students in grades 5 to 8.

Walker, Sally M. 2005. *Heat*. Early Bird Energy Series. Minneapolis, MN: Lerner Publications Company.

This book introduces younger students to the concept of heat energy, exploring how it is measured and how it affects the movement of molecules and matter.

Wick, Walter. 1998. *A Drop of Water: A Book of Science and Wonder*. New York, NY: Scholastic, Inc.*

Wick captures the properties of water in photographs.

*National Governors Association Center for Best Practices and Council of Chief State School Officers. "Texts Illustrating the Complexity, Quality, and Range of Student Reading K-5" and "Texts Illustrating the Complexity, Quality, and Range of Student Reading 6-12." *Common Core State Standards Initiative*. www.corestandards.org (June 2009)

Assessment

Have students:

- demonstrate and compare the movement of water molecules in solid, liquid, and gaseous form (steps 3-7).
- create a written account or a picture of what happens to water as it changes from one state to another (*Wrap Up*).

Extensions

Have students create a musical interpretation of "Molecules in Motion." Students can select music that represents the various energy levels of molecules and the resulting states of water. Loud music with a rapid tempo may create the impression of water vapor. Intense, concentrated, slow music may symbolize the solid state of ice. Harmonies incorporating the sounds of flowing water or patterns of rainfall may accompany the liquid state.

Have students coordinate their musical selections with images to create a musical journey. They may draw pictures or collect photographs or slides that illustrate the various states of water. Ask them to create a computer slide show with their music as the soundtrack. Student drawings or pictures from magazines may also be organized on a flip chart; students may turn the pages in time with the music.

Teacher Resources

Books

Blake, Robert, Jr. et al. 2010. *Inside-Out: Environmental Science in the Classroom and the Field, Grades 3-8*. Arlington, VA: National Science Teachers Association.

The chapter titled "Water" is available as a free download from the NSTA web site.

NSTA Learning Center. 2005. *Properties of Objects and Materials*. Arlington, VA: National Science Teacher Association.

This SciGuide includes lesson plans, simulations, and web-based resources for teachers. It is available at http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/5/SG-01. Accessed May 29, 2011.

Journals

Ansberry, Karen and Emily Morgan. 2008. "Teaching through Trade Books: The Wonder of Water." *Science and Children*, 46 (4), 16-18.

Brown, Tom, Greg Rushton and Marie Bencomo. 2008. "Mighty Molecule Models." *Science and Children*, 45 (5), 33-37.

Cavallo, Ann M. L. and Pamela A. Dunphey. 2002. "Sticking Together." *Science Teacher*, 69 (8), 24-28.

Jackson, Julie. 2009. "H₂O and You." *Science Activities: Classroom Projects and Curriculum Ideas*, 46 (1), 3-6.

Kessler, James. 2003. "Science 101: What Causes Water's Surface Tension?" *Science and Children*, 40 (8), 21.

McCarty, Robbie V. 2000. "Water: A Sticky Subject?" *Science and Children*, 37 (6), 44-47.

Purvis, David. 2006. "Fun with Phase Changes." *Science and Children*, 43 (5), 23-25.

Robertson, William C. 2008. "Science 101: What Causes the Different States of Matter?" *Science and Children*, 46 (4), 56-59.

Websites

NSTA Learning Center. 2011. *Explaining Matter with Elements, Atoms, and Molecules*. Arlington, VA: National Science Teachers Association.

This SciPack provides an online learning experience to enhance teacher understanding of matter; it also discusses educational implications for student learning. It is available at http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/6/SCP-EAM.0.1. Accessed May 29, 2011.