WATER WORKS:
Hangin' Together

Students mimic the water molecule's special ability to bond to other water molecules and investigate four properties of water that are critical to life on Earth.

Adapted from "Project Wet"

Activity Time: I: 10 minutes
II: 50 minutes, III: 30 minutes

Grades: 4-6

Water Words:
Electromagnetic forces, hydrogen bond, polar, solution, adhesion, cohesion and surface tension

Materials:

- Balloon
- Colored plastic cup filled with water
- Comb
- Running or poured water
- 1-yard string or yarn per student
- Magnets
- Paper clips
- Forks
- Plastic cups
- Sugar
- Oil
- Copy of Activity Cards for each group.
- Copy of Hydro-Charade cards for each group.
- Yard stick
- Water
- Markers

Background
Understanding the molecular forces of water requires a basic understanding of atomic and electromagnetic theories. These theories explain why the water molecule's shape causes it to be attracted to other water molecules.
The water molecule consists of two elements, hydrogen and oxygen. One molecule of water contains two hydrogen and one oxygen atom. The formula for water is H_20. Water molecules are polar; that means they act like magnets. One end has a negative charge and the other has a positive charge.
The positive end of one molecule is attracted to the negative end of another molecule. When the molecules stay in contact with each other, a bond called a **hydrogen bond** forms between the two molecules. The structure and nature of the water molecules give it various interesting properties that are critical to life on Earth.

Water Properties:
Review each property of water with the class.

- ***Water exhibits cohesion and adhesion properties.*** These were observed and learned about in H_2O Olympics.
- ***Water dissolves a variety of substances.*** More things dissolve in water than in any other substance. Other polar compounds like sugar dissolve in water because the water molecule forms a hydrogen bond with the sugar molecule. Nonpolar substances like oil do not dissolve in water because hydrogen bonds cannot form between the two different molecules. This is very important in our bodies. Sugar can dissolve in our blood and be carried throughout our bodies. Cells within our bodies are made of fatty

substances and do not dissolve in water. Good thing, or we would be mush!

- ***Water cools as it evaporates.*** Water constantly evaporates from the surface of our skin. Without evaporation the body would overheat. Water in the body is heated by the metabolism that digests nutrients. Sweat glands excrete the heated water to the skin's surface. Because the water molecules contain heat energy they move quickly. Because the molecules have so much energy, they form gas molecules and are able to break away or evaporate. As the power-packed gas molecule takes the heat energy with it, it leaves slower moving molecules behind, which makes the body feel cooler. Evaporation also helps to cool water in oceans, lakes, or a cup of coffee.
- ***Water expands when it freezes***. Ice floats on the surface of ponds. One might expect the slower moving molecules to be closer together than liquid and therefore, denser. As water molecules reach a temperature below 39° Fahrenheit the hydrogen bonds form a lattice -like pattern that spreads the molecules apart and decreases the density. Water that seeps into the fissures of rocks and freezes exerts an incredible force of 30,000 pounds per square inch on the surrounding rock. The alternating freezing and melting water that seeps into cement or rocks causes them to crack and erode.

Warm Up-
Teacher Demo

Show students a dark-covered bottle or jar with water in it. Do not tell them what is inside. Tell them it contains something unique, something that can support six-legged creatures, make a pile of sugar disappear, crack a boulder and cool an elephant. Tell them another amazing thing is that this liquid is all around them. Have students guess what it may be and their reasons. You can assess their prior knowledge of water by their responses. They probably won't know that these properties of water occur due to its molecular structure. Tell them you will be giving them hints to explain how water can do all these things.

DEMO 1:
Demonstrate static electricity by rubbing a balloon and having it stick to your clothes or attract a student's hair to stand up. Explain that electrical charges on the balloon attract opposite charges in the fabric or hair.

DEMO 2:
Transfer electrical charges to a comb by running it through a student's hair or on wool. Ask them if they think water has electrical charges. Demonstrate that it does by one of two methods. If you have a faucet in your room, turn on a steady slow stream of water and move the charged comb slowly towards the stream. The water will bend towards it. Or, have a student slowly pour a slow stream of water from a container into a bucket and move the comb slowly towards the stream.

Ask the students what water has that would give it an electrical charge? Tell them they are going to become the smallest parts of water and will investigate how and why water behaves as it does.

Getting Wet - Activity I

1. Have all students stand at their desk or in an open area, or have a few students stand in front of the class to demonstrate.
2. Explain that they are a water molecule. Have them tie a string around their waists with a tail hanging behind each student.
3. Have them stand and hold their arms straight out in front of their bodies parallel to the ground and then have them bend their arms slightly at the elbows to form a "V".
4. Explain that water molecules are like magnets and have a positive charge or pole and a negative charge or pole. Identify their hands as the positive poles of the hydrogen atoms and the yarn at their back as the negative pole of the oxygen atom.
5. Explain that water molecules attract each other like magnets. Show them two magnets and how they are attracted to each other. Demonstrate how magnets repel each other if two like poles are put close.
6. Have students demonstrate how water molecules act like magnets: one student holds onto another student's string. The hand or positive hydrogen holds or bonds to the string-the negative pole or oxygen atom of another student.
7. Have students summarize how hydrogen bonding occurs in water molecules.

Activity II

1. Have 4 stations set up for the Activity Cards: 1. Call Me Bond, Hydrogen Bond, 2. How Can You Tell a Polar Molecule from a Polar Bear?, 3. It's No Sweat…Or Is It? and 4. Freezing Water is a Swell Idea. Have all materials listed on cards ready at each station along with a direction card.
2. Divide class into groups. Groups can rotate through the stations or with less time, have groups explore one station. Have students discuss their investigations and the role hydrogen bonding plays in each.

Activity III

1. Form new groups or keep the groups from the previous activity.
2. Give each group one Hydro-Charade Card. They will act out one of the behaviors of water related to hydrogen bonding. This will be like a game of charades. No talking, and the audience can try and guess what property is being presented.
3. Allow time for groups to practice their skits.
4. Groups present to class. Have the audience write down what property they think is being presented and why or have them raise their hand to offer their ideas.

Wrap Up

Have students apply the demonstrations to other real-life examples. Have them explain the examples of water's unique feats given in the introduction. How does water make sugar disappear? (dissolves it), How does it keep elephants cool? (evaporation), How can insects walk on water? (surface tension), How can it crack giant boulders? (freezing water expands).

Assessment

Have students:

- Demonstrate in a charade a property of water they encounter in their day.
- Write a paper or draw a picture of how their life would be different without hydrogen bonding.
- Design an experiment to determine if a cup of water can dissolve more sugar than salt.

Student Activity Cards

CALL ME BOND, HYDROGEN BOND

Information: The surface of water acts like a skin that keeps some things out. The skin is actually a layer of water molecules help tightly together by hydrogen bonds. This is why water forms drops, and why some insects can skate on water's surface.

Challenge: Can you make water demonstrate the properties described in the paragraph above? Describe or draw a picture of how you did it. If you need help, ask the teacher for suggestions.

Items needed: Cup of water, paper clip, and fork

HOW CAN YOU TELL A POLAR MOLECULE FROM A POLAR BEAR?

Information: More things dissolve in water than in any other substance. Some materials are magnetically charged (polar) and dissolve easily in water. Water molecules dissolve these materials by forming hydrogen bonds with each molecule in the material. Other substances are nonpolar. These do not dissolve or mix in water because hydrogen bonds are not formed.

Challenge: Which of these two materials is polar, oil or sugar? How can you tell? Check with the teacher to see if your response is correct.

Items needed: Two cups of water, oil and sugar

IT'S NO SWEAT… OR IS IT?

Information: It is a very hot day. You and some friends decide to race around the block to the playing field. Suddenly, one of your friends stops and complains about feeling overheated. You happen to be carrying a bottle of sun tan oil and a bottle of water. One friend says oil will help cool down the overheated friend; the other claims the water will work better.

Challenge: Which of your friends is right? Try spreading a thin layer of each on your hand. Which one feels cooler? Suggest reasons for the outcome. Check with the teacher to see if your response is correct.

Items needed: Oil and water

FREEZING WATER IS A SWELL IDEA

Information: You plan to go on a hike tomorrow. You plan to bring some water. You have water in both glass and plastic bottles. A friend suggests freezing the filled bottles overnight, so the water will still be cool when you need a drink.

Challenge: Which container of water should you put in the freezer? Draw a picture of and provide an explanation for what you think each might look like when you check the freezer the next morning. Don't try this one at home! Check with the teacher to see if your response is correct.

Items needed: None! This is a mental lab.

Hydro-Charade Cards

HYDRO-CHARADE CARD

HOW THE SURFACE OF WATER SUPPORTS A PAPER CLIP

All members of your group except one represent water molecules at the surface of a cup of water. Tie strings around your waists, leaving a tail hang in back. Your backs represent the negative pole or end of the molecule. Indicate the positive end by holding your arms outstretched in front of you like a "V". Now hold tightly onto each other's strings; this symbolizes hydrogen bonding among water molecules.

To show a paper clip or a pin being supported by water's surface, one group member gently lays a broom handle or meter stick across several of the bonds (strings). You can also illustrate your failed attempts at floating the paper clip by placing the broom handle at an angle between the bonds.

Items needed: String and broom or meter stick.

HYDRO-CHARADE CARD

HOW WATER DISSOLVES SUGAR

Get several sheets of scrap paper and write a large "+" at one end and a "-" at the other end of each piece. The "+" represents the positive pole of a sugar molecule, and the "-" represents the negative end. Put the papers in a pile. (This represents a cube of sugar that has just been placed into a cup of water).

All members of your group except one represent water molecules swirling around the sugar cube. Each water molecule holds a string in each hand and has another string tied around his or her waist, leaving a tail hanging in back. Your backs represent the negative pole or end of the molecule. Indicate the positive end by holding your arms outstretched in front of you like a "V".

One group member, representing a spoon, "stirs up" the sugar and the water. This student tapes the positive end of the sugar molecules (pieces of paper) to the negative charge (the tail) of the water molecules. This student may also tape the negative end of the sugar molecule to the strings held in the water molecules' hands. The strings represent hydrogen bonds. The sugar molecules are kept in solution because they have formed hydrogen bonds with (are taped to) water molecules.

Items needed: String, scraps of paper, tape and marking pen

HYDRO-CHARADE CARD

HOW EVAPORATING WATER MOLECULES REMOVE ENERGY

All members of your group except one represent water molecules in a liquid state. Tie strings around your waists, leaving a tail hang in back. Your backs represent the negative pole or end of the molecule. Indicate the positive end by holding your arms outstretched in front of you like a "V".

In liquid form the water molecules remain close together, weaving in and about each other. Because water molecules are in motion in the liquid state, hydrogen bonds are constantly formed, broken, and reformed as molecules pass by each other. Represent this by weaving around each other, grasping onto and releasing the strings of other molecules as they pass by. The strings represent hydrogen bonds.

To show molecules being heated up, have one group member, representing a heat source, tag a few water molecules. Tagged molecules become energized. They move about more rapidly, making it more difficult for other molecules to hold on to them (to form bonds). Eventually, they break away, becoming gas molecules (evaporating). The molecules that are left behind have less heat energy, making the water feel cooler.

Items needed: String and a sign labeled "Heat source"

HYDRO-CHARADE CARD

HOW WATER EXPANDS WHEN IT FREEZES

All members of your group except one represent water molecules in a liquid state. Tie strings around your waists, leaving a tail hang in back. Your backs represent the negative pole or end of the molecule. Indicate the positive end by holding your arms outstretched in front of you like a "V".

Mark a boundary with chalk on the floor around all group members to represent sides of a container. As a liquid, the molecules must stay within the boundary, standing close to each other. Another group member (a cool student), representing a heat sink (something that "absorbs" heat energy, such as the cool air in a freezer), tags molecules (taps them on the shoulder). When you are tagged, begin to move more slowly – your heat energy has been transferred to the heat sink.

When water molecules move more slowly, hydrogen bonds form more easily. To represent this, have group members who are slowed down grasp each other's strings. Have them move apart from each other until the string is straight. Eventually, there will not be room within the boundary, and some group members will need to step outside the chalk marks.

Items needed: String, a sign labeled "Heat sink", and chalk