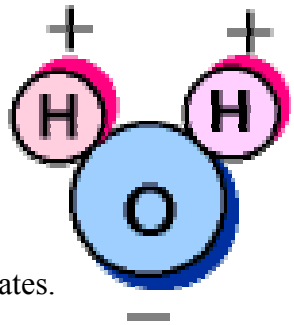
WHAT'S WATER MADE OF?



Objectives:

Students will:

- discover that water is composed of many molecules attracted to one another.
- analyze how water's physical structure changes as it freezes and evaporates.
- demonstrate how water dissolves other substances, such as salt.
- discuss magnetism and two different types of bonds.

Materials:

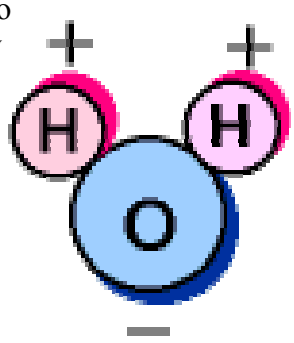
- Enough atom nametags for the class. Label the tags Hydrogen-H-(+) and Oxygen-O-(-); being certain to have a ratio of 2 hydrogens for each oxygen—the charge should be on the nametags to illustrate magnetism and polarity.
- At least 5 Sodium-Na-(+), and 4 Chloride-Cl-(-) name tags—the charge should also be on the nametags to illustrate magnetism and polarity.
- Velcro[tm] armbands of two different colors to give to each atom of the salt molecule
- Salt
- Magnifying lens

Background:

A solvent is a liquid capable of dissolving another substance. Not all liquids can dissolve other substances: for example formaldehyde and other types of alcohol are used to preserve. Water is capable of dissolving a variety of different substances, which is why it is called the universal solvent. It is water's chemical composition and physical attributes that allow this to happen. Water's polarity is one of its characteristics that makes it such a good solvent. A polar molecule is one that has positive and negative regions. This allows the molecule, in this case water, to become attracted to many other different types of molecules. Water can become so heavily attracted to a different molecule, like salt NaCl, that it can disrupt the attractive forces that hold the salt together—thus dissolving the salt.

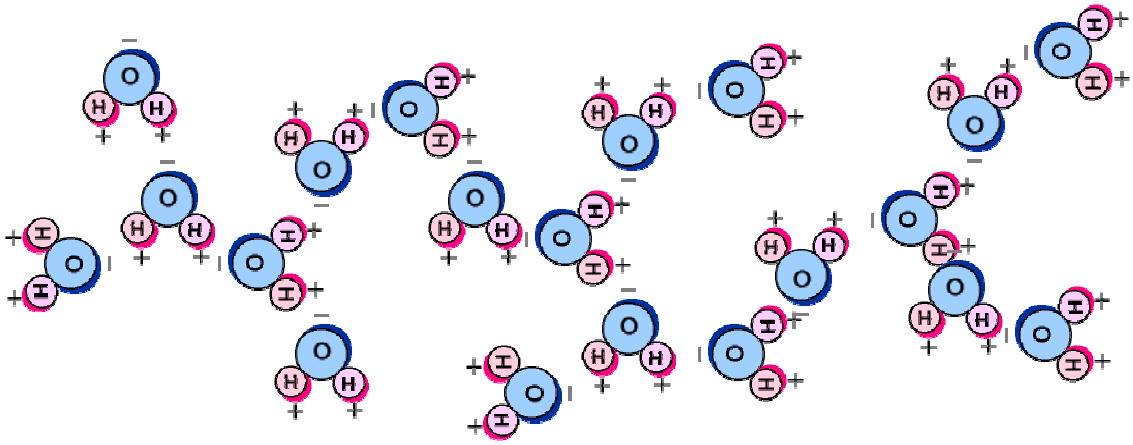
Procedure:

1. Ask the students "What is the composition of water?" Depending on the age group, possible responses are drops, molecules, and atoms. Ask what the composition of a drop of water is. What is the composition of a molecule? Discuss water molecules and the atoms that form them. Write the chemical formula (H_2O) on the board and discuss the meaning of the subscripted "2."
2. Discuss that the atoms of water are covalently bonded (if you have covered subatomic particles in class prior to this activity you can use this to support prior discussions). What is going to be discussed is the polarity of water and how this is essential in water's ability to dissolve. It is



important for the students to understand that covalent bonds are very difficult to break.

3. Draw two hydrogen atoms on the board and show their positive charge. Draw one oxygen atom on the board showing its negative charge. The board illustration should look like the water molecule diagram. Review the concepts of magnetism, attraction, and repulsion.
4. After you draw the first water molecule on the board with the correct charges, have the students one at a time draw several other water molecules on the board. Encourage the students to pay attention to the polarity (+/- charges on the opposite ends of the molecule) when drawing their molecules on the board. The molecules are attracted to each other magnetically – this is called hydrogen bonding. Hydrogen bonds are magnetic attractions; no sub-atomic particles are shared as in a covalent bond. The board illustrations should look something like the illustration below.



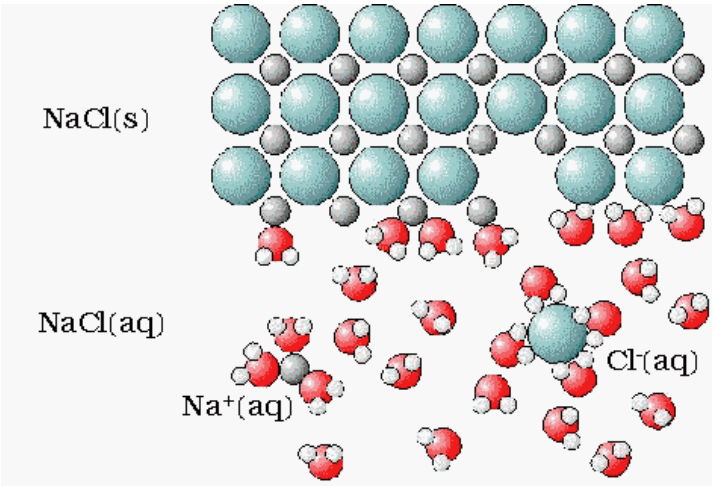
5. Tell the class that they are going to represent atoms. They will form covalent bonds to each other to form molecules of water. Give each student a nametag—make sure that there are twice as many hydrogen atoms as oxygen.
6. Have the hydrogen students form a covalent bond with the oxygen student by grabbing the oxygen's elbows. One hydrogen atom will connect with one arm of an oxygen atom and one hydrogen atom on the other. Tell the students that once they are bonded, these covalent bonds will not break in this activity. Pay special attention to the "V" shape that the molecules must create—this is why water is polar.
7. When all of the molecules are complete, have the students orient themselves into liquid water—note step #3 about polarity. The students can move and sway, representing the fluidity of the water.
8. Announce that it is now 32°F, and the water freezes. Have the oxygen atom slowly move away from the hydrogen atoms now holding on to their hands instead of elbow still maintaining the V form. (The size of the molecule expands and becomes less dense than the surrounding liquid water, which is why ice floats. The molecules of ice can no longer sway and move. Have the students stand still.) Notice how differently the ice structure is

compared to the liquid structure that the students drew on the board. Discuss why ice floats.

9. It is getting warmer, and the ice is beginning to melt. Have the students become liquid water again (keep with the polar bonds discussed in step #6). Tell the oxygen atoms to let go of the hydrogen atoms' hands but remain attached by the elbows.

10. Now, it is getting hotter. 100°, 200°, 212°. The molecules are moving rapidly. Ask the students what will happen when the water reaches 212°F. When water boils, the kinetic energy between the molecules increases with the temperature. This energy is enough to separate the polar attractions, which allows individual molecules to become vapor. Each group of three (H_2O) should be separate from the other groups.
11. Discuss evaporation and condensation. Introduce the concept of the water cycle. You can set up a puddle scenario with all of the student molecules that are in the room. What happens to the water on a sunny day? What happens at night when it gets colder?
12. Write NaCl (sodium chloride) on the board and explain that sodium chloride is salt. Draw a NaCl crystal on the board—note the illustrations below. Have the students look at a salt crystal with a magnifying glass. Ask if the students can see the difference in structure between the salt crystal and the water liquid (NaCl bonds differently from water—if you have discussed ionic bonding in class prior to this activity this is a good place to further discussion). What do the students think will happen when salt is added to the water? The polar attraction between the water molecule and the salt molecule will bring the two together. The chloride (negative) will become surrounded by the water's positive pole, and the sodium (positive) will become surrounded by the water's negative pole.
13. To illustrate this, pick three molecule groups and have them return the hydrogen and oxygen signs to you. Give five of them sodium (Na) sign and a soft Velcro armband and four of them chloride (Cl) sign and the rough armbands. (If you are using trunk materials, the red armbands are sodium and the beige are chloride.) Have them bond in a square-like shape according to the diagram with the Velcro to show ionic bonding (salt bonds ionically, which is why salt crystals are cubical. Again, it is not necessary to discuss ionic bonding, but have the Na and Cl atoms bond into a square and have the students note the difference in structure between water and salt).

$Na^+Cl^-Na^+$
$Cl^-Na^+ Cl^-$
$Na^+Cl^-Na^+$



14. Have the “water” students condense and become liquid again. Next, add a salt molecule.
15. Have the hydrogen atoms of the water molecules break their polar attraction from the negative force of the oxygen and adhere to the negative force of the chloride. (The negative force of the chloride is stronger than the negative force of the oxygen, which is why the polar attractive forces between the water molecules break.) This will also happen between oxygen and sodium, therefore breaking the structure of the salt crystal apart.
16. Have the students return their signs and other materials to you. Discuss water as a universal solvent. Why do the students think that water is able to dissolve so many things? Discuss polarity, magnetism, and repulsion. Is it easier to dissolve salt in warm water or cold water? Why? In warm water the molecules are moving quickly and the bonds are more stressed. This increases their chances of being able to bond with other substances.

Nametags

Hydrogen +
Oxygen -
Chloride -
Sodium +