Virginia Cooperative Extension Service

VIRGINIA TECH AND VIRGINIA STATE • VIRGINIA'S LAND GRANT UNIVERSITIES

4-H MARINE PROJECT
UNIT ONE

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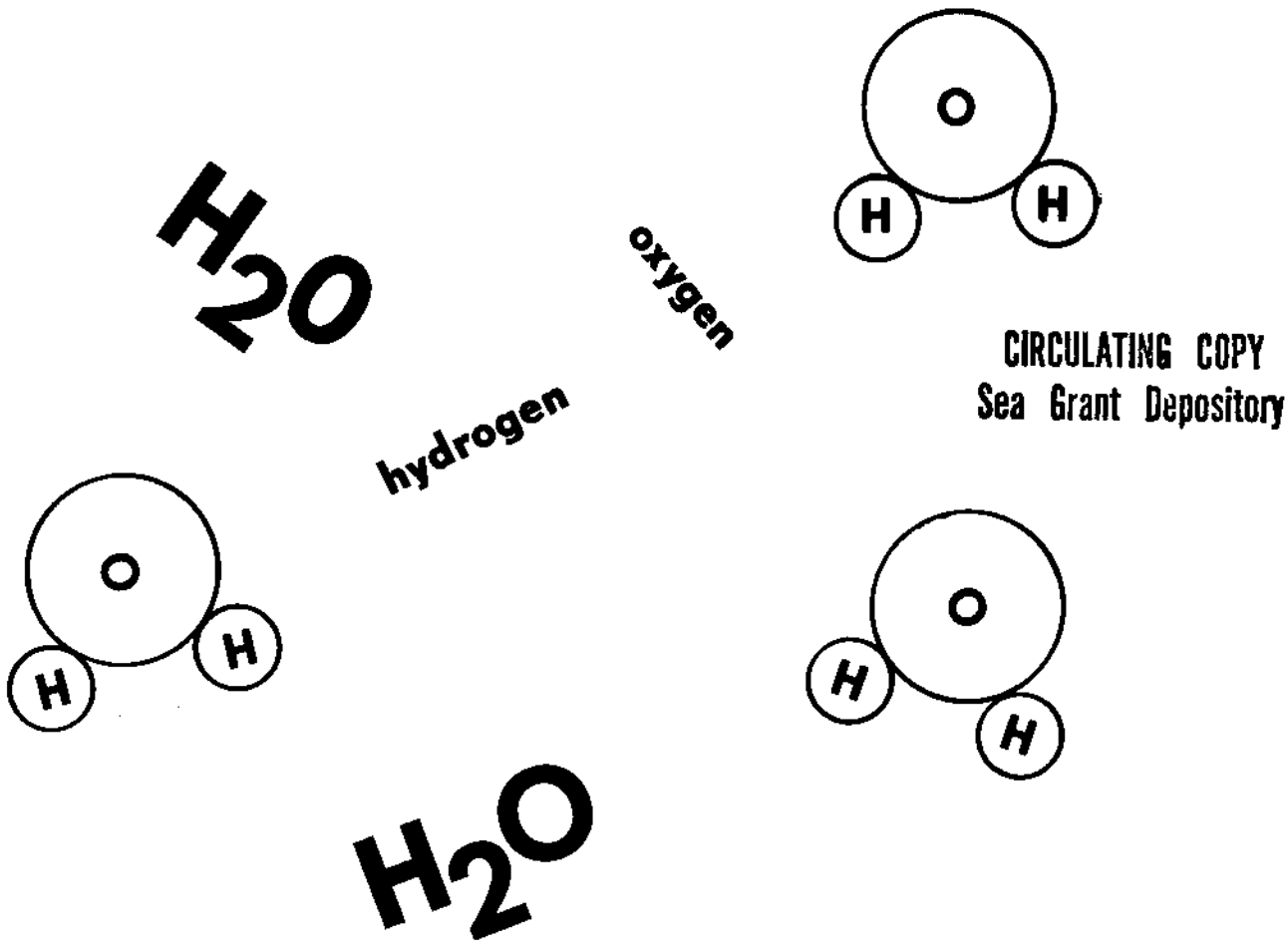
WHAT IS WATER?



Virginia Sea Grant College Program

H H H H

4-H MARINE EDUCATION

UNIT ONE

WHAT IS WATER?

(MEMBER GUIDE)

BY

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4-H Marine Education

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Water is found everywhere: in the air, on and under the ground, in living things and even combined with different minerals in rocks. Covering nearly three-fourths of the earth's surface, water supports all life on earth. It has caused the rise and fall of great civilizations and has been the major force shaping the face of the earth. Water determines the climate, assists in the formation of soil, and is used to generate hydroelectric power. Water is an indispensable part of nearly all manufacturing and chemical processes.

You use water everyday for drinking, cooking, washing, and recreation. Have you ever stopped to think about what water is and why it is such a unique substance?

Although many substances may look like water, nothing else on earth has properties like those of water. Some of these properties include:

* STRONG ATTRACTION BETWEEN WATER PARTICLES,
* ALMOST UNIVERSAL DISSOLVING ABILITY,
* LARGE HEAT HOLDING CAPACITY,
* GREAT EXPANSION WHEN FROZEN.

The following activities in this unit will investigate these properties of water and let you discover some interesting facts about water.

Before starting the activities, become familiar with the terms and definitions listed below.

ATOM	- smallest particle of an element
ELEMENT	- matter composed of one atom type
MOLECULE	- particle with two or more atoms
COMPOUND	- molecule with two or more elements
SURFACE TENSION	- surface film on water
UNIVERSAL SOLVENT	- water, dissolves many substances
HYDROGEN BOND	- bond that holds water molecules together

Visit your school or local library and read about water in a physical science book or an encyclopedia. Look up the terms listed above and read more about them.

Fill a glass or cup with water and take a close look at it.

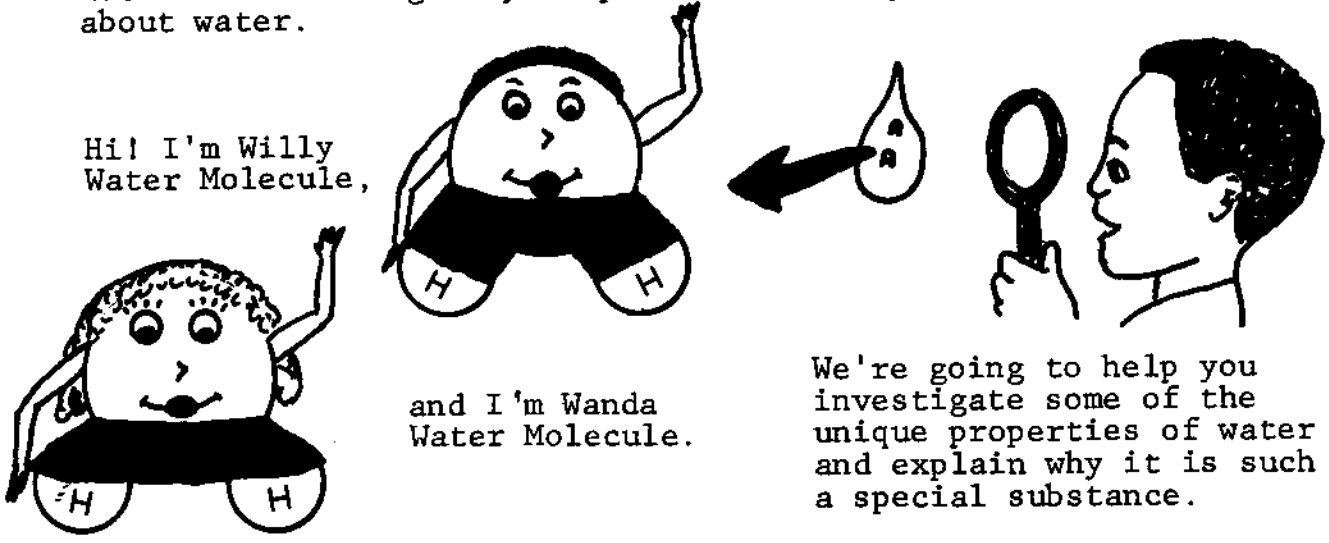
DESCRIBE THE SMELL. _____

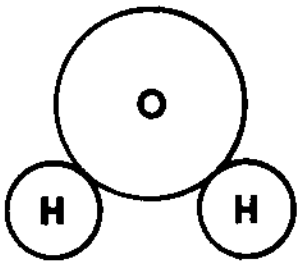
DESCRIBE THE TASTE. _____

DESCRIBE THE COLOR. _____

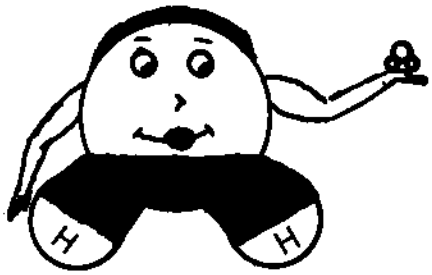
You probably noticed that water has no odor or taste and is colorless (unless something has been added to it). Most other liquids have a distinct odor, taste,and color. Liquids such as alcohol, white vinegar, gasoline,and kerosene may look like water, but they have very different properties.

Dip your finger into the water and notice that a drop of water clings to your finger. This single drop contains millions of water particles called MOLECULES. If these MOLECULES could speak, they would tell an interesting story about themselves. Let's take an imaginary trip into this drop of water to learn about water.





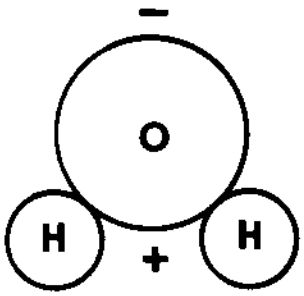
A lot of people call us H_2O because we have one ATOM of the ELEMENT OXYGEN and two ATOMS of the ELEMENT HYDROGEN. We have more than one ATOM and that means we are MOLECULES. Because our ATOMS are different, water is also called a COMPOUND.

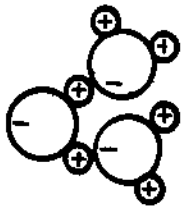


Water is a simple compound, but because of the molecule's structure,it has many unique properties. Water molecules are also very small. In fact, there are about 900 sextillion in one ounce of water. That's 900,000,000,000,000,000,000,000.

ACTIVITY Make a model of a water molecule. Using two different size round objects (jar lids, cups) and construction paper, trace and cut out one large and two smaller circles. The large circle will represent the oxygen atom; label it with an O. The smaller circles will represent the hydrogen atoms: label them with an H. Attach them together, as shown below, using glue or tape.

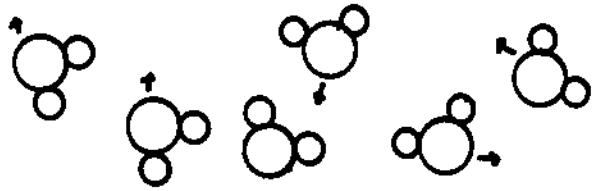
Notice the shape. The two hydrogen atoms are attached to one side of the oxygen atom.That gives water molecules a real charge. No kidding! The oxygen end of the molecule has a negative (-) charge while the hydrogen end has a positive (+) charge. This produces a very strong attraction between water molecules. They act like small magnets. The positive end of a molecule is attracted to the negative end of another molecule. This bond that holds them together is called the HYDROGEN BOND.



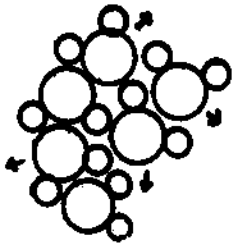


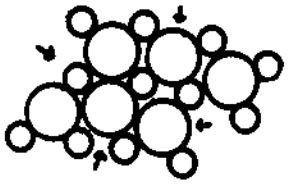
ACTIVITY Place two molecule models on a flat surface and arrange them so that the positive end of one molecule touches only the negative end of another. This represents hydrogen bonding that occurs between molecules. Make a sketch of the molecule models below. Label an oxygen atom, a hydrogen atom, and a hydrogen bond.

ACTIVITY Place six water molecule models on a flat surface, spread them apart, and move them around. This represents water in its GASEOUS form called WATER VAPOR. Few hydrogen bonds form between molecules because they have so much energy (heat energy). The molecules are free to move around.



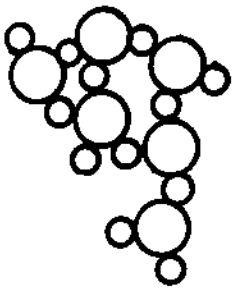
Now place the molecule models side by side, as close together as possible. This represents water in its LIQUID form. Although many hydrogen bonds form between molecules in the liquid state, they still possess enough energy to stay in constant motion. This explains the fluid property of water.

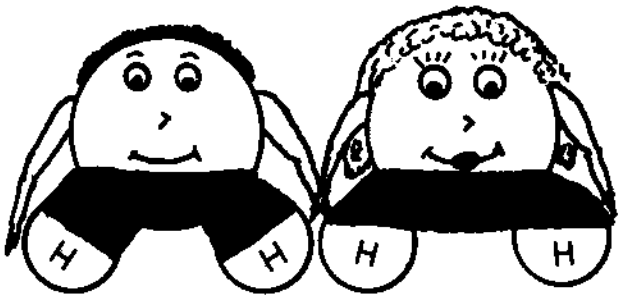




As water cools, the molecules lose energy and begin to cluster tighter together. This process continues until the water reaches 39°F (4°C). Water is densest at this temperatur Below this temperature , molecules begin forming hydrogen bonds with surrounding molecules and the water begins to expand.

Arrange the molecules so that each hydrogen (H) atom touches only an oxygen (O) atom. This represents water in its SOLID form called ICE. Each molecule forms hydrogen bonds with others around it. Notice that the molecules take up more space as a solid than as a liquid. In the solid state, water molecules do not move much at all and form rigid, hollow crystals (snow flakes are ice crystals).





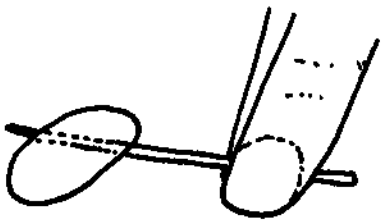
The strong attraction between water molecules, caused by hydrogen bonding, produces what scientists call SURFACE TENSION FILM. Water molecules form a layer or film on the water's surface. This film creates a boundary between the air and water.

ACTIVITY

1. Place a drop of water on wax paper and push the drop around with a toothpick. Describe the action.

2. Pull the toothpick through the water drop. Describe the action.

   Does the water drop appear to stretch? Why?



3. Dip the toothpick into liquid detergent and touch it to the water drop. Describe the reaction.

   What does the detergent do to the surface tension film?

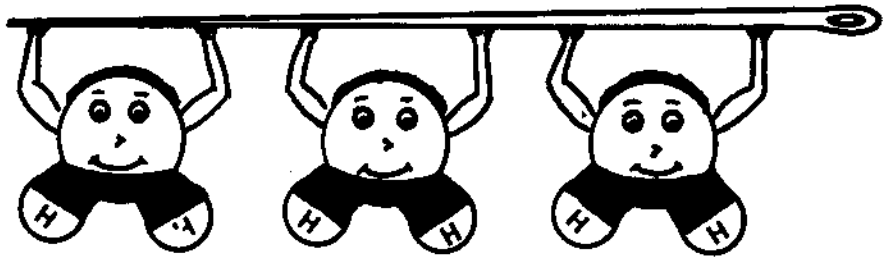
ACTIVITY Slowly fill a small glass with water. Carefully add drops of water until the water level is above the top of the rim. Why does the water pile up above the rim of the glass?

ACTIVITY

1. Place a sewing needle on a small piece of tissue paper. Fill a shallow tray or bowl with water. Place the tissue and needle on the water's surface. With a pencil carefully push the tissue under the water, being sure not to touch the needle. Describe the results.

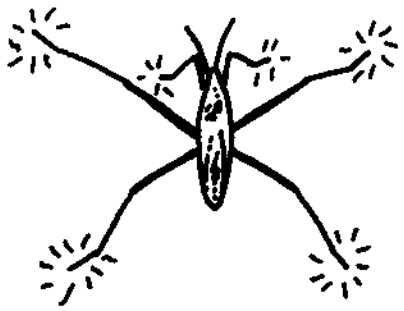
   The needle does not float but actually lies on top of the water. What causes this?

2. Dip a toothpick into liquid detergent and dip it into the water near the needle. Describe and explain the reaction.



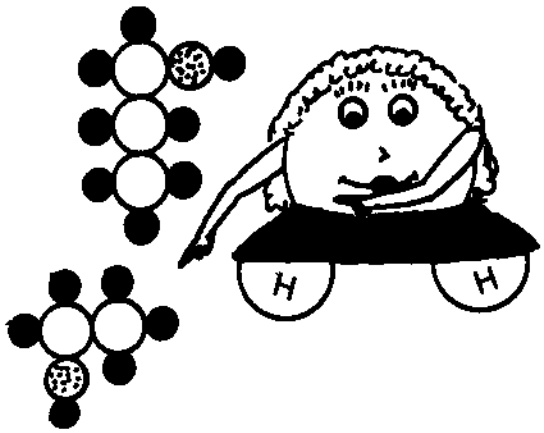
The surface tension film is surprisingly strong. Try using different objects (paper clip, some sand, metal shavings) to see if the surface film will support them.

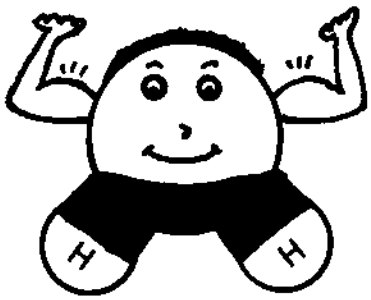
If you were small and light enough, you could actually walk on water, just like the small insects you see in ponds and streams.



One type of aquatic insect, called the water strider, walks on the surface tension film of water.

Not only do we have a strong attraction for each other, we are also attracted to molecules of many different compounds and the atoms of many elements. This makes water a good dissolving agent.





That is why water is called the UNIVERSAL SOLVENT. A solvent is a liquid that dissolves substances. The dissolving power of water is determined by two basic factors: 1) the nature of the substance being dissolved and 2) the temperature of the water.

The number of different substances dissolved in seawater is a good example of the dissolving power of water. There are approximately seventy elements and thousands of compounds found in seawater.

USE AN ENCYCLOPEDIA OR A BOOK ON OCEANOGRAPHY AND MAKE A LIST OF THE TEN MOST ABUNDANT OCEAN ELEMENTS.

_____

_____

_____

WITH THE HELP OF YOUR CLASSMATES, LIST REASONS WHY THE DISSOLVING PROPERTY OF WATER IS IMPORTANT TO US.

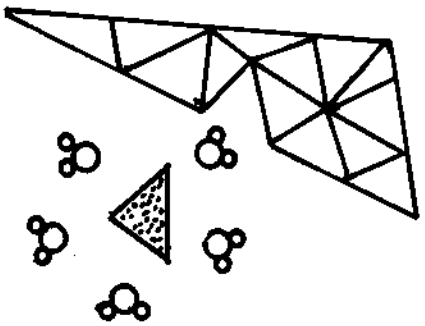
_____

_____

ACTIVITY Dissolve a teaspoon of each of the following substances in a cup of warm water. Record how each dissolves in the chart below.

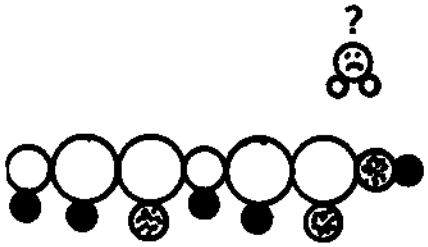
SUBSTANCE	HOW IT DISSOLVES (GOOD, FAIR, POOR)
SUGAR	
SALT	
BAKING SODA	
JELLO MIX	
VEGETABLE OIL	

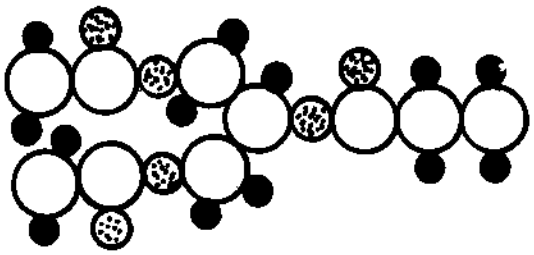
GOOD - dissolves quickly, FAIR - dissolves slowly,
POOR - no noticeable dissolving



How does water dissolve something? Water molecules act like cowboys cutting cattle from a herd. They separate and surround the molecules of the substance as it is dissolved (Water, Life Science Library, 1966).

If the molecules are large and strongly bonded together, as with jello, the substance will not dissolve easily.

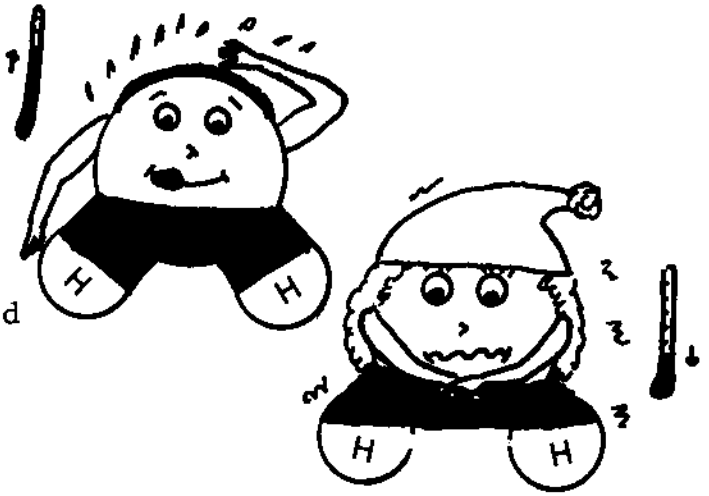




PART OF AN OIL MOLECULE

If the molecules are complex, as oil molecules are, the water molecules are actually repelled and no dissolving occurs.

Although water can not dissolve everything, many substances will dissolve more easily in hot water than in cold water. The process of dissolving requires energy. Hot water has more energy than cold water. Investigate this fact with the following experiment.

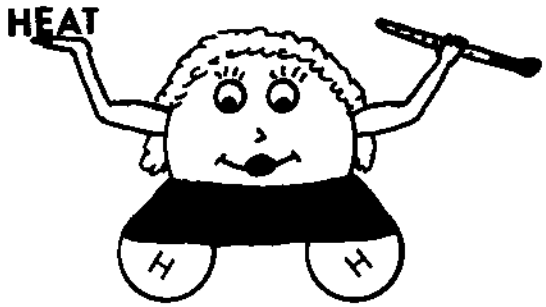


ACTIVITY To one cup of hot water add a level teaspoon of sugar. Stir until all of the sugar is dissolved. Continue adding sugar, one teaspoon at a time, until no more dissolves. Record the number of teaspoons of sugar dissolved.

Repeat the activity above but use ice water in place of hot water. Record the number of teaspoons of sugar dissolved.

Describe the differences in the dissolving power between hot and cold water. Why is there a difference?

There is another interesting fact about us that involves heat. We can store a great deal of heat energy, that is we have a large HEAT CAPACITY. When we get hot we slowly release the heat we have stored. As a result large bodies of water can affect the climate of coastal areas. You probably already know that winter temperatures along the coast are generally warmer than those farther inland. Try the next experiments to find out what affects the cooling rate of water.



ACTIVITY Fill two different sized but similar shaped containers, made of the same material, with hot tap water. Eight and sixteen ounce styrofoam cups do nicely. Place a thermometer in each container. Record the temperature every minute for ten minutes. Gently stir the water before recording each temperature.

TIME (minutes)	0	1	2	3	4	5	6	7	8	9	10
TEMPERATURE (°F, °C)											
LARGE CONTAINER											
SMALL CONTAINER											

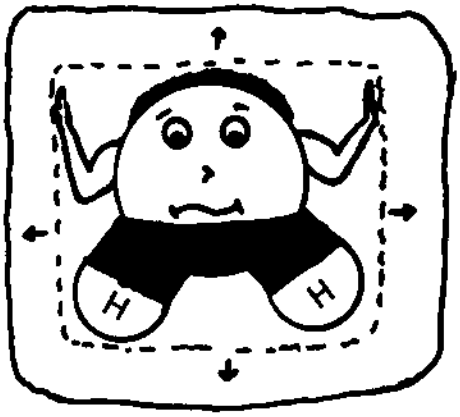
How does the amount of water affect the cooling rate?

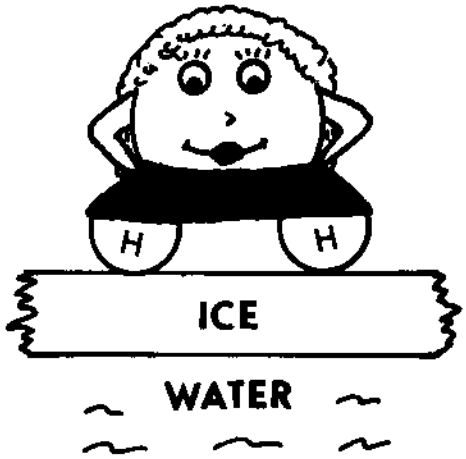
ACTIVITY Repeat the experiment, but use two different shaped containers of the same size and material. A plastic or styrofoam bowl and cup do nicely. Place the same amount of water in each container and number them container 1 and 2. Record the temperature every minute for ten minutes to determine how the cooling rate is affected by the amount of water surface exposed to the air.

TIME (minutes)	0	1	2	3	4	5	6	7	8	9	10
TEMPERATURE (°F, °C)											
CONTAINER 1											
CONTAINER 2											

How does the amount of water surface exposed to the air affect the rate of cooling?

If water loses enough heat , it will eventually freeze. Water's unique property of expanding when frozen separates it from all other liquids. Other liquids contract when frozen, taking up less space and becoming denser than the liquid state. Ice takes up more space and is less dense than liquid water.





Since it is less dense than liquid water, ice floats. This means that bodies of water freeze from the top down. This is fortunate for the earth. The layers of ice that form on lakes rivers,and cold oceans act as an insulator, preventing the water below from freezing.

If bodies of water were to freeze from the bottom up, the earth's climate would change drastically. Much of the earth's water would be locked up in ice and much of the earth would become barren wasteland.

ACTIVITY Fill a small, disposable plastic or paper container with water (DO NOT USE GLASS). A used pint milk carton is fine. Seal the container and place it in a freezer overnight. Examine it the next day and describe the results.

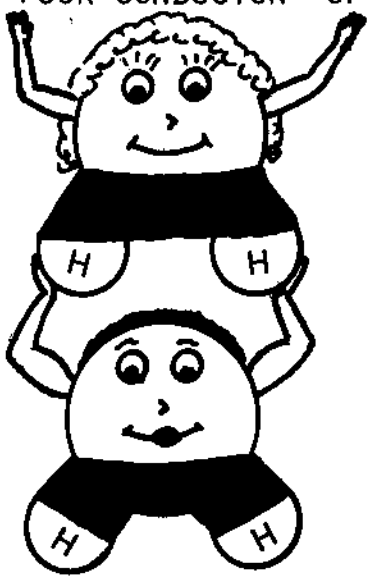
Explain why water expands when frozen.

WITH THE HELP OF YOUR CLASSMATES, MAKE A LIST OF THE BENEFICIAL AND DAMAGING EFFECTS OF ICE EXPANSION.

BENEFICIAL	DAMAGING

There are several other important properties of water:

* RELATIVE HIGH MELTING AND BOILING POINTS,
* A LARGE AMOUNT OF ENERGY IS REQUIRED TO SEPARATE THE ATOMS OF A WATER MOLECULE; HOWEVER, A SMALL AMOUNT OF ENERGY RECOMBINES THEM,
* UNIQUE ABILITY TO CLIMB INSIDE SMALL TUBES,
* POOR CONDUCTOR OF ELECTRICITY (PURE WATER).



As you can see, water is a very special substance. Life on earth can not exist without it and many of the earth's processes depend on it. There are many more interesting facts about water. If you want to learn more about water, visit your local or school library and read the following books: Science Experiments with Water by Sam Rosenfeld and The New Water Book by Melvin Berger.

WATER FACTS

Answer the following questions based on what you have learned from this project.

1. Water consists of one atom of _____ and two atoms of _____.

2. The smallest particle of water is called a _____.

3. Why are water molecules strongly attracted to each other?

_____

_____

4. What is the bond called that holds water molecules together?

_____

5. In which state (liquid, gas, solid) are water molecules closest together? _____

6. What produces the surface tension film on water?

_____

_____

7. Why is water called the universal solvent?

_____

_____

8. List two factors that affect the dissolving power of water.

A. _____

B. _____

9. Why does the water temperature at the beach stay relatively constant each day instead of rising during the day and falling at night?

_____

_____

_____

MORE WATER FACTS

* THERE ARE ABOUT 324 MILLION CUBIC MILES OF WATER ON THE EARTH'S SURFACE. THAT'S ABOUT 3,000,000,000,000,000,000,000 GALLONS.

* THERE ARE ABOUT 3,100 CUBIC MILES OF WATER IN THE ATMOSPHERE.

* IT TAKES 14 OUNCES OF PURE OXYGEN AND 114 OUNCES OF PURE HYDROGEN TO MAKE ONE GALLON OF WATER.

* THE ENERGY LIBERATED BY REACTING ENOUGH HYDROGEN AND OXYGEN TO MAKE ONE GALLON OF WATER WOULD KEEP A 60 WATT LIGHT BULB BURNING FOR 270 HOURS.

* THE AMOUNT OF HEAT ENERGY REQUIRED TO EVAPORATE ONE GALLON OF BOILING WATER IS ENOUGH TO MELT NEARLY SEVEN TIMES AS MUCH ICE.

* WATER IS DENSEST AT 39°F (4°C). AT ANY OTHER TEMPERATURE IT IS LESS DENSE AND THEREFORE LIGHTER.

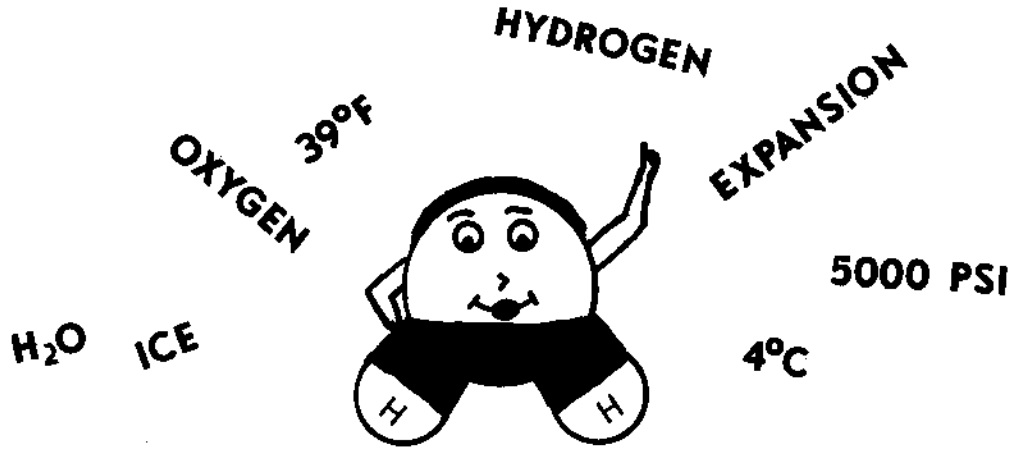
* A CAST IRON POT HEATS TEN TIMES FASTER THAN WATER.

* AN ICED DRINK IS COLD BECAUSE, AS THE ICE MELTS, IT DRAWS HEAT FROM THE SURROUNDING LIQUID. THE ICE DOES NOT "GIVE OFF" COLD.

* IF WATER BEHAVED LIKE SIMILAR COMPOUNDS IT WOULD BOIL AT -132°F (-56°C) AND FREEZE AT -148°F (-64°C).

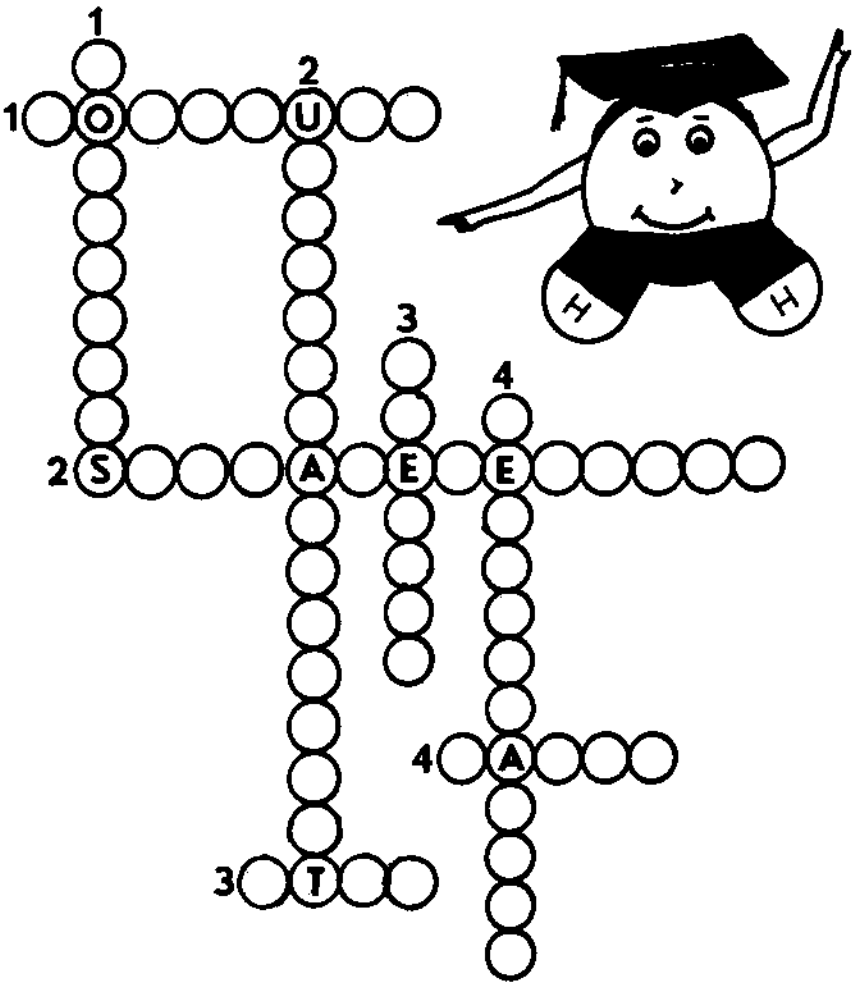
* FREEZING WATER EXERTS ENOUGH FORCE TO CRACK CONCRETE AND ROCKS, CRUSH ICE BOUND SHIPS, AND CAUSE A CAST IRON BALL FILLED WITH WATER TO EXPLODE LIKE A BOMB WHEN QUICKLY FROZEN.

* WHEN PLACED IN SMALL TUBES, THE SURFACE TENSION OF WATER CAN WITHSTAND 5000 POUNDS OF PRESSURE PER SQUARE INCH.



WORD PUZZLES

Test your knowledge about water with the following puzzles.



ACROSS

1. has more than one element
2. film on the water's surface
3. smallest particle of an element
4. water in gaseous form

DOWN

1. have more than one atom
2. what water is called
3. has only one kind of atom
4. heat storing ability

Find and circle the water related words listed below.

colorless
odorless
tasteless
oxygen
hydrogen
gas

P	K	G	S	O	L	I	D	R	K	F
C	T	F	L	U	G	I	P	S	C	N
C	S	T	R	M	U	G	H	J	F	E
X	O	Z	M	Q	D	C	T	F	O	G
C	F	L	I	P	S	C	T	D	A	O
M	C	L	O	O	C	T	O	S	X	R
T	H	T	C	R	X	R	P	Y	C	D
C	E	P	D	C	L	K	G	J	L	Y
T	A	S	T	E	L	E	S	S	O	H
F	T	F	S	D	N	R	S	C	P	M
D	I	S	S	O	L	V	E	S	K	T

liquid
solid
dissolve
heat
cool

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