

## Properties of Water Activities

Have you ever watched a water strider run across a pond without sinking? Did you ever fill a glass of water above the rim without it spilling? Ever wonder why water forms neat little dew drops that stick to grass in the early morning? All of these phenomena have to do with **surface tension**, which results when water molecules on the surface of water are packed tightly to-

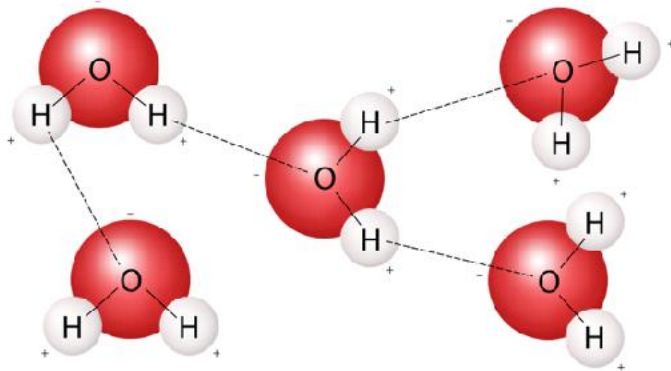


Water strider on the surface of a pond.

gether.

A water molecule, made up of two atoms of Hydrogen and one atom of Oxygen, is polar, with the hydrogen atoms having a slightly positive charge, and the oxygen atoms having a slightly negative charge. This causes a positively charged hydrogen atom on one water molecule to attract to the negatively charged oxygen atom on another water molecule. The molecules are held

together by a weak force called a *hydrogen bond*.



We call the attraction of like materials, such as water molecules, to each other **cohesion**, and cohesion causes surface tension. Water also attracts to many other substances (like dewdrops on leaves). The attraction of unlike materials is called **adhesion**, and is the reason why water sticks to many other objects, and can move upward against the force of gravity through plant cells.

Hydrogen bonding between water molecules causes cohesion.



The upward movement of water from the roots to the stems and leaves is the result of *capillary action*. As water *transpires* or evaporates from leaves, more water is pulled upward to fill the space due to the attraction of water molecules to each other (*cohesion*) and to the *adhesion* of the water to the plant tissue.

More than 70% of our planet is covered with water, and about 60% of an adult's human body is water. The unique properties of water make it essential for life on our planet. Below are some activities you can try at home to better understand *cohesion*, *adhesion* and *surface tension* in water.

Transpiration drives the movement of water from the roots to the stems and leaves of plants by capillary action.

### Traveling Water

What do you think will happen if you pour water from one cup into another cup along a string? Will the water spill out of the first cup or will it flow along the string to the second cup?

I think the water will \_\_\_\_\_ when it is poured from one cup to the other cup along a string.

Materials:

- Two plastic cups
- 1 foot cotton string
- Masking tape
- Water

Tape one end of the string to the inside bottom of one cup and the other end of the string to the inside bottom of the other cup. Fill one cup with water. Put the loose string in the cup of water to wet it, then pour the water into the other cup and add the string so that it is thoroughly wet. Now, holding the other cup so the string is taught, slowly pour the water from one cup into the other cup along the string (it helps to press the string against the edges of the cups with your forefingers. Do this experiment outdoors or over a sink or tray to avoid spills.

So what's happening? The water molecules stick to the string because of adhesion, and stick to each other because of cohesion. Therefore, most of the water will move along the string without spilling.

Challenge: How close to horizontal to the ground can you hold the string before the water spills? The water seems to defy the downward pull of gravity!



### Pepper and Soap Experiment

We can use soap and pepper to explain the importance of hand washing to prevent the spread of germs. In this experiment, pepper floating on water represents germs. We will see what happens to the germs when soap is added to the water.

I think the pepper will \_\_\_\_\_ when soap is added to the water with pepper.

Materials:

Plate or pan

Water

Black pepper

Liquid soap

Add water to the plate or pan and sprinkle black pepper all over the surface of the water. The pepper doesn't mix with the water, but rather floats on the water's surface. This happens because the water's surface tension prevents the pepper from sinking.



Now, put your finger into the pepper-water. Some of the wet pepper should have adhered, or stuck, to your finger. This represents the germs that are transferred to your hands when you touch

contaminated surfaces. Rinse and dry your finger, and place a small amount of soap on the tip of your finger. Now, touch the surface of the pepper-water.

What happened? The pepper should have quickly moved away from your soapy finger to the edges of the plate or pan. Why? Soap breaks the surface tension of the water, causing it to spread out and away from the soap, carrying the pepper with it. Some of the pepper may also start to sink due to reduced surface tension. Soap's ability to break surface tension is one of the reasons it helps to clean dirty dishes and also wash away germs. When the surface tension is broken, the water molecules don't stick together as well, and are able to mix with grease and germs better, which can then be rinsed down the drain!



Challenge: Try this experiment replacing soap with other substances (such as oil, hand sanitizer, etc.). Were any of these substances able to break the surface tension of the water in the same way that the soap did?

### Floating Paper Clip

A paper clip is denser than water, so it should sink to the bottom of a glass of water, right? Do you think you can make a paper clip float on the water's surface?

Materials:

- Cup of water
- Paperclips
- Liquid dish detergent
- Toothpick

Take a paper clip and drop it into the cup of water. It sinks to the bottom because the paper clip is denser than water. Now try to carefully place a paper clip onto the surface of the water. Make sure the flat side is parallel to the water's surface. (This may take some practice and patience at first, but don't give up!) The paper clip floats on the water due to surface tension!



The paper clip is able to float due to the water's surface tension.

What do you think will happen to the floating paperclip if liquid dish detergent is added to the water?

I think the paperclip will \_\_\_\_\_ if detergent is added to the water.

Now, place the tip of the toothpick into the dish detergent. With the paperclip still floating, touch the water's surface with the toothpick. What happens to the paper clip? It immediately sinks!

This is because the detergent acts as a *surfactant*, a substance that reduces the surface tension of the substance it is dissolved in, breaking the water's surface tension.

Challenge: What else can you get to float on water due to surface tension?

### How Many Pennies?

How many pennies do you think you can add to a glass that is filled to the rim with water before water spills out of the glass?

I think I will be able to add \_\_\_\_\_ pennies to the glass of water.

Materials:

- Glass of water
- About 50 pennies
- Dish detergent

**Part 1.** Fill a glass to the rim with water, but be careful not to overfill it. Add pennies one at a time by gently placing them in the water vertically at the edge of the glass, counting the pennies as you add them until the water overflows. How many pennies were you able to add to the glass? Were you surprised?

I was able to add \_\_\_\_\_ pennies to the glass of water.

What's happening? The attraction of the water molecules due to cohesion creates strong surface tension, and the water is able to form a convex *meniscus*, or curved surface, above the rim of the glass before spilling over.

**Part 2.** Now, add a drop of liquid dish detergent to an empty glass and fill it to the rim with water. Do you think the glass with the soapy water will hold the same number of pennies before spilling over?

I think I will be able to add \_\_\_\_\_ pennies to the glass of soapy water.

Repeat the procedure from part 1, carefully placing pennies into the glass and counting the pennies as you add them. How many pennies were you able to add to the glass before the soapy water spilled?

I was able to add \_\_\_\_\_ pennies to the soapy water.

What do you think happened? The detergent breaks the water's surface tension so the water spills out of the glass as soon as it reaches the top.

Challenge: What other variables might reduce the water's surface tension? Try this experiment with different liquids or change the temperature of the water.

### Drops on a Penny

How many drops of water do you think will fit on a penny?

I think \_\_\_\_\_ drops of water will fit on a

penny.

Materials:

- Cup of water
- Penny
- Dropper or pipette

Wash and dry a penny and place it on a flat surface. Draw water into your dropper or pipette, add drops of water, one at a time. Count how many drops of water you add, one at a time, until the water runs over the edge of the penny.



flat surface. and slowly Count how time, until the

I was able to add \_\_\_\_\_ drops of water

to the penny.

Were you surprised by how many drops

fit?

Challenge: Try this experiment again with different coins like nickels, dimes and quarters, or with different liquids like salt water, soda, oil, etc. How do the different-sized coins or different liquids affect the number of drops?

### Index Card Speed Boat

Can you use a drop of soap to propel a boat across the water?

Materials:

Index card

Scissors

Liquid dish soap

Tray, sink or you filled with water



Cut an index card so that it is shaped like the image above. Place it in the container of water so that it is floating on the surface. What do you think will happen if you add a drop of the liquid dish soap to the notch at the back of the boat?

I think the boat will \_\_\_\_\_ if a drop of soap is placed in the notch at the back of the boat.

Place a drop of the dish soap in the notch at the back of the boat. What happened? The boat sailed across the surface of the water! Soap is a *surfactant*, a substance that reduces the surface tension of the liquid it is dissolved in. As the soap breaks down the surface tension of the

water behind the boat, water molecules move from areas of low surface tension to high surface tension, so the molecules at the front of the boat pull the boat forward.

Challenge:

Can you make a boat using other materials such as cardboard, styrofoam, etc? Challenge a family member to make their own boat and have a race! Try this experiment with solid soap. Do you will get the same results? Why or why not?

### Drops of Water on Different Surfaces

When you spill a liquid what are you likely to use to clean it up? You probably thought of a paper towel, a rag or a sponge. These materials are *absorbent* - they're able to soak up and retain liquid easily. What are some other materials that are absorbent, and what are some materials that are not?

Materials:

Dropper or pipette

Cup of water

Small piece of each of a variety of materials, such as:

Paper

Wax paper

Aluminum foil

Paper towel

Plastic wrap

Which material(s) do you think will be the most and least absorbent?

I think the \_\_\_\_\_ will be the most absorbent and the \_\_\_\_\_ will be the least absorbent.

Place a drop of water on each of the materials and observe what happens. Does the water spread out, or ball up? Which material was the most absorbent? Which material was the least absorbent?

Paper towels absorb liquid through *capillary action*. As the liquid adheres to the paper towel and spreads out, it pulls along more of the molecules of the liquid with it. The small pores, or spaces in the paper towel act as capillaries, creating more surface area for the liquid to adhere to. A material that attracts water is said to be *hydrophilic*.

Materials that do not attract water are *hydrophobic*. If you tried to clean up a spill with wax paper, you would probably just spread the mess around. A drop of water placed on wax paper will ball up, because the water molecules are repelled by the wax, while being attracted to each other.

Challenge: Can you break apart the drop of water on any of the materials into smaller drops? Can you combine them back into one drop? Can you turn the material upside down so that the water drop doesn't fall? Do an experiment to determine which brand of paper towels is the most absorbent. Can you explain what is happening using the terms *cohesion*, *adhesion*, *hydrophilic* and *hydrophobic*?

## Water Movement in Plants

We all know that plants need water to survive. Water keeps plants healthy and prevents their leaves from wilting. Water also carries dissolved nutrients throughout the plant. You probably know that plants usually get their water from the soil, and that it enters the plant through its roots, but did you ever wonder how this happens? Water enters the plant through tiny pores, or openings, in the root's outer layer, and moves through the plant's vascular tissues by *capillary action*. When water *transpires*, or evaporates from a plant's leaves, it pulls along more water molecules due to the cohesion of the water molecules to each other and the adhesion of the water to the plant's vascular tissues. This works similarly to when you suck a liquid up through a straw. We can observe the movement of water through a plant by placing them in colored water.

### Materials:

Celery stalk (preferably with their leaves attached)  
Drinking glass  
Water  
Blue or red food coloring  
Knife

Add 1/2 cup of water to a glass, and add about 2 drops of food coloring. Cut the bottom of the celery and place the cut end into the water. Leave the celery in the water with food coloring and observe several times a day for 3 days. You can take pictures or draw images in a journal to record the changes in the celery. The color should have moved up the celery stem to the leaves

and dyed the leaves to match the water color!



### Challenge:

Try this experiment using several different colors. Which color produced the most visible result? Try adjusting the concentration of food coloring in the water. How does the concentration of food coloring affect the results? Try this experiment using flowers or other types of leaves (such as fresh white carnations or bok choy). Do different plants produce different results? Try splitting a celery stalk in half lengthwise, keeping the top part intact. Put one half of the celery in one glass with colored water, and the other half in another glass with water

colored a different color. What is the resulting color of the leaves?

## Ice Cream in a Bag

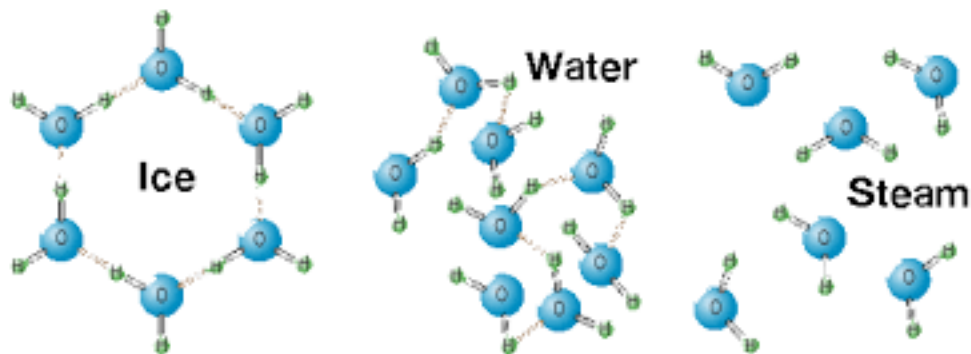
We know that water can exist in 3 phases: solid, liquid and vapor. Remember that a molecule of water is made up of one oxygen atom and two hydrogen atoms, causing it to be polar, with a positive charge on the hydrogen side and a negative charge on the oxygen side. The positively



charged end of one molecule of water attracts to the negatively charged end of another water molecule, and the molecules are held together by a force called a hydrogen bond.

In the liquid phase, the hydrogen bonds that are holding the water molecules together are constantly forming, breaking and reforming. The molecules are jumbled, disorganized, and packed closely together, causing liquid water to be fluid.

When you heat water in a pot, you can see that as it warms up, it begins to move rapidly. Water generally boils at 212 degrees Fahrenheit (100 degrees Celsius). In this state, the molecules are moving very rapidly and are no longer held together by hydrogen bonds, so they escape into



Water molecules in the three phases: solid, liquid and vapor.

the air. This is the invisible vapor phase.

When water cools, the molecules lose energy and slow down. At 32 degrees Fahrenheit (0 degrees Celsius), water freezes and the molecules arrange themselves into an organized crystal structure with spaces between them. This is why ice is less dense than water and floats!

You may have noticed that salt is sometimes added to icy streets and sidewalks in the winter-time to help it melt and make it less slick. This is because salt lowers the freezing temperature of water, causing ice to melt. Salt is also used to lower the freezing point of water when making ice cream! Try the recipe below to see why salt is added to ice in the ice-cream making process!

**Materials:**

- 1 cup half and half or whipping cream
- 2 tablespoons sugar
- 1/2 teaspoon vanilla extract

Ice

1/4 cup coarse salt

Quart-sized Ziploc bag

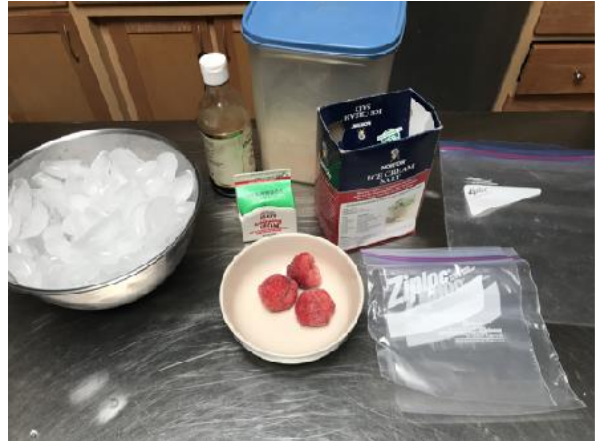
Gallon-sized Ziploc bag

Warm gloves

Optional: add-ins or toppings such as chopped fruit, chocolate chips or candy pieces

Directions:

To the quart-sized bag, add the half and half, sugar and vanilla extract. You can also add your add-ins at this time. Sealing the bag, removing as much of the air as you can. Make sure the seal is tight.



Fill the gallon-sized bag halfway with ice. Add half of the salt, then add the small bag and cover it with more ice and the remaining salt. Seal the large bag.

Shake, toss and roll the bag for 5 minutes. It will get very cold, so put on your warm gloves. After 5 minutes check to see if your ingredients have reached ice-cream consistency. If not, continue to shake, toss and roll, re-checking the small bag for hardness every 2 minutes.

When your ice cream is ready, rinse the small bag well to remove salt. Open the bag and scoop out your ice cream, or cut the corner of the bag and squeeze it out for soft-serve ice cream. Add

toppings if you choose to, and enjoy!

Explanation:

When salt was added to the ice in the larger bag, it lowered the freezing temperature to below 32 degrees Fahrenheit, and the ice began to melt. The heat energy used to melt the ice comes from the milk mixture, causing it to freeze, and voila, you made ice cream!

