SUGGESTED ACTIVITIES

(*States of Matter*)

From *Invitations to Science Inquiry 2nd Edition* by Tik L. Liem:

Activity	Page Number	Concept
• Can the container hold more?	91	Molecular spacing
• The shrinking balloon	92	Molecular spacing
• The shrinking mixture of liquids	93	Molecular spacing
• The clinging water streams	108	Cohesion
• The smaller, the stronger	109	Capillary action
• Pour water along a string	110	Adhesion
• Where does the cork float?	111	Surface tension
• How many pennies can go in?	112	Surface tension
• The detergent propelled boat	115	Surface tension

From *NSF/IERI Science IDEAS Project* (See following pages):

Activity	Page Number	Concept
• Kids as molecules	See following pages	Molecular spacing
• Poured gas	" " "	States of Matter
• Sticky water	" " "	Adhesion
• The shrinking mixture of liquids w/ measurement		Molecular spacing
• A"Mazing" Water	" " "	Cohesion
• Cheesecloth Demo	" " "	Cohesion/Adhesion
• Magic Pepper Sinker	" " "	Cohesion
• Merging Streams	" " "	Cohesion
• Pour Water sideways	" " "	Cohesion/Adhesion
• Where does the cork float	" " "	Surface tension
• Magical drops	" " "	Surface tension
• Propel the boat	" " "	Cohesion

From *Harcourt Science* Teacher's Ed. Unit E: (For ALL grade levels)

Activity	Page Number	Concept
• Solids are smaller	E17 (3rd grade text)	Molecular spacing

<u>CAN THE CONTAINER HOLD MORE?</u>

A. Question: *How much can a container really hold?*

B. Materials Needed:

1. A transparent container (glass or plastic).
2. Marbles, sand water and a graduated beaker.

C: Procedure:

1. Fill the transparent container up to the brim with marbles.
2. Show the students that you still have sand and water; ask them: "Can I add any other material to this container?"
3. Add sand to the container (shake to settle the sand in between the marbles); ask the same question again.
4. Now add water to the mixture of water and sand.
5. Measure off the amount of sand and water added to the marbles (do this by measuring how much is left over in a graduated beaker).
6. Do not neglect to tell students that the marbles, sand, and water particles are only illustrating how molecules of matter are behaving and that they are not molecules themselves! It is only a model!

D: Anticipated Results:

Students should be able to observe the sand and water take up space in between the marbles.

E: Thought Questions for Class Discussion:

1. Why could the container that was already filled with marbles still hold more sand and water?
2. Could we have started with water, then sand and marbles?
3. What would you infer that the sizes of molecules of different materials or substances would be?
4. What other material could be used to do this experiment?

F: Explanation:

The marbles, sand and water particles are used only as an analogy of how molecules of different sizes would behave. The smaller sized molecules can slip in between the larger ones. Thus it is possible to slip the sand or the water in between the marbles, but not the other way around. It is especially important to point out to students, that the marbles or sand grains are not molecules, but that molecules are so small that we cannot see them, not even with a microscope.

THE SHRINKING BALLOON

A. Question: *Can air slip through rubber?*

B. Materials Needed:

1. A balloon for each of the students.
2. Flexible measuring tapes or strings.
3. Meter sticks.

C: Procedure:

1. Divide the class into three groups A,B and C; distribute the balloons.
2. Have group A blow the balloon up and let about half of the amount of air out, have group B blow the balloon up and then let about ¼ of the air out, and have group C leave the balloon blown up fully, and tie a knot.
3. Have each student measure the diameter and length of his or her balloon with the measuring tape or place a length of string around the balloon and measure the string with a meter stick.
4. Let each student record theses measurements and mark their balloons with their names, and put them way for the next day. They can be stored in cupboards or stuck to the walls.
5. The next day, have students measure the diameter and length of their balloons and compare these with those of the day before.

D: Anticipated Results:

Students should expect to observe a shrinkage in the balloon after one day of performing the experiment.

E: Thought Questions for Class Discussion:

1. What made the balloon shrink in size?
2. Which of the three groups has the fastest shrinking balloon?
3. Were there any leaks in the balloons?
4. What would the balloon do if kept for another day?
5. Where do we find applications of this principle in daily life?

F: Explanation:

The air molecules in the balloon are much smaller in size than the rubber molecules of the balloon itself. Although many layers of rubber molecules are contained in the balloon membrane, the tiny air molecules can slowly slip through these bigger ones that hold them inside the balloon. As the pressure inside is larger than outside, the air molecules move faster inside and push through the rubber. Over time, so many air molecules diffuse through the rubber that the pressure inside decreases, thus decreasing the size of the balloon. The rate of losing air molecules is greater for the larger balloon, because of the higher pressure.

THE SHRINKING MIXTURE OF LIQUIDS

A. Question: *Can liquids shrink and take up less volume?*

B. Materials Needed:

1. A test tube and small beaker.
2. Alcohol - ethyl, methyl, or isopropyl-alcohol (methyl hydrate or rubbing alcohol may be used).

C: Procedure:

1. Fill the test tube half way with water.
2. Hold this test tube slanted and pour the alcohol slowly from a beaker until brim full.
3. Hold the test tube and place your thumb on the mouth of the tube, making sure that no air bubble is trapped.
4. Show the students that the tube is completely full.
5. Invert the tube several times (keep thumb on the opening of the test tube at all times; do not release any pressure).
6. Show to students that not the liquid level is lowered.

D: Anticipated Results:

Students should observe a decrease in volume of the mixture after shaking and inverting the test tube.

E: Thought Questions for Class Discussion:

1. Did the alcohol or water evaporate?
2. Was there any liquid spilled by inverting the tube?
3. Did the liquid shrink or contract?
4. Was there space between the water and alcohol molecules?

F: Explanation:

By closing the opening of the test tube tightly with the thumb, and not taking it off while inverting, no evaporation or spilling of the liquid could occur. By inverting the test tube, mixing of water and alcohol takes place, and because there are spaces between the molecules, the alcohol molecules slip in between the water molecules. Thus, making the total volume of the mixture to become less. Although the spaces between the molecules cannot be seen by naked eye, this demonstration shows that there must be room between the molecules. If ethyl alcohol is not available, methyl-hydrate (methyl alcohol) or rubbing alcohol (isopropyl alcohol) can be easily obtained from a drug store, and may replace it.

THE CLINGING WATER STREAMS

A. Question: *Do water molecules have forces between them?*

B. Materials Needed:

1. An empty milk carton or tin can.

C: Procedure:

1. Make three small holes on one of the sided near the bottom of the milk carton- about 1/2cm away from each other.
2. Fill the carton full with water and observe the water streams coming out of the holes.
3. Bring the streams together with the fingers to make one big stream.
4. Separate the streams by pushing one finger through the middle of the large stream (it usually takes several tries to separate them).

D: Anticipated Results:

Students should observe the three separate streams come together due to the cohesive forces between water.

E: Thought Questions for Class Discussion:

1. Why does the water stay in one stream once the are brought together?
2. How far can the holes be placed apart for the water still to be able to cling together?
3. Is it easier to separate (or bring together) the streams with a full of almost empty carton?

F: Explanation:

The closer the holes are placed in the carton, the easier to get a whole stream out of the carton, but the harder to separate it into three separate streams. The farther the holes are, the harder to bring the separate streams together. It is the **cohesive forces** between the water molecules that keep the streams together. The fuller the carton, the larger the pressure, and the easier the separate streams are obtained. With less water in the carton, we will get lower water pressure and thus an easier cohesive whole stream.

We find this phenomenon in daily life in the shower head with the many holes in it. When the valve is turned wide open, separate streams are distinguished, but when the valve is only partially opened, the many small streams will cling together and from one whole stream.

THE SMALLER THE STRONGER

A. Question: *Can water move upwards?*

B. Materials Needed:

1. Three or four capillary tubes of different diameters.
2. A small beaker.
3. Food coloring.

C: Procedure:

1. Fill the beaker with water and place a few drops of food coloring in it.
2. Hold the three or four capillary tubes close to each other and dip them in the water; observe the water level in each of the capillary tubes.
3. When a flat cell is available, the capillaries can be projected on the screen by slanting the overhead projector slightly.

D: Anticipated Results:

Students should be able to observe the movement of water up the capillary tubes.

E: Thought Questions for Class Discussion:

1. Will the water level in the capillaries change when the tubes are either moved higher or lower in the beaker?
2. What makes the water go up in the tubes in the first place?
3. Why does the water move up higher in the narrower capillary?
4. Where do we find an application of this capillary action in daily life?
5. What is the force between unlike or like molecules of matter called?

F: Explanation:

When a capillary tube is dipped in water, the adhesive forces between the water and the glass of the tube are so large that the water is pulled upwards. The smaller the capillary, the more glass surface per unit number of water molecules exists, and thus the larger the adhesive force. Furthermore, the distance between the water molecules and the glass molecules is so much shorter in the narrower tube, that the adhesive attraction between theses unlike molecules is greatly increased.

This is how the fibers in plants and trees bring up the water from deep in the ground to high up in the leaves. Capillary action combined with osmotic pressure caused by semi-permeable walls of the fibers and the plant juices, push up the water to the tree top. Another example of adhesion is the application of paint on any surface. The paint clings to the surface because of the adhesive forces between the paint and the surface molecules.

<u>POUR WATER ALONG A STRING</u>

A. Question: *Can water move along a string?*

B. Materials Needed:

1. Two beakers or plastic cups.
2. A water-absorbent string (thin rope).

C: Procedure:

1. Fill one of the beakers about ¾ full with water.
2. Stand a book about 20cm away from the empty beaker.
3. Show students the string and ask: “How can I transfer the water from beaker A to B without moving beaker A over or around the book?
4. Wet the string thoroughly in the water.
5. Hold one end of the string in beaker A and the other end over beaker B and pour the water slowly along the string.

D: Anticipated Results:

The students should observe water moving along a string and collect this water in a beaker.

E: Thought Questions for Class Discussion:

1. Why was it necessary for the string to be wet?
2. What forces were holding the water to the string?
3. What other material can be used in place of the string?
4. Is it possible to pour other liquids along a string?

F: Explanation:

The string needs to be wet so that the water molecules would adhere to the molecules of the string. The water molecules are attracted to the string molecules by **adhesion.** Once the string is wet, the water can cling to the already present water molecules, because of the **cohesive forces** between like molecules off water. The transfer of water will not succeed with a dry string or any material which is not water absorbent.

Other materials that would have the same properties as the water-absorbent string would do the same job, like: cotton, cloth, paper, wood, etc. Materials that are not water-absorbent, like nylon or wood cannot be used for this purpose.

Liquids that have strong cohesive forces between their molecules, like oil, vinegar, syrup, etc. can be poured along a string as well, provided that we make sure that the string or whatever material is used to transfer the liquid can absorb it.

<u>WHERE DOES THE CORK FLOAT?</u>

A. Question: *Can a cork move in water?*

B. Materials Needed:

1. A regular drinking glass.
2. A small cork.

C: Procedure:

1. Fill the glass half way with water and float the cork on the water surface: observe!
2. Where does the cork float? (It should be attracted toward the side of the glass; move it somewhat if it stays in the middle.)
3. Now add more water to the glass and fill it brimful. Observe where the cork now floats.
4. Try to push the cork towards the edge: it will not stay there!

D: Anticipated Results:

Students should observe the cork move to the area of the glass with the highest level of water.

E: Thought Questions for Class Discussion:

1. Why is the cork moving towards and sticking to the side of the glass (with the glass half-filled)?
2. Where is the water level highest in the half-filled glass?
3. Why is the cork floating in the center of the full glass?
4. Where is the water level highest in the full glass?
5. Why can we fill the glass more than full without overflowing the water?

F: Explanation:

When the glass is half-filled with water, the circumference of the meniscus is the highest level. This is caused by the adhesive forces between the water and the glass molecules. As a result of this high level at the side of the glass, the cork moves to that place.

When the glass is brimful filled with water, the surface tension and the cohesive forces between the water molecules form a film on the surface of the water, making it possible to fill the glass more than full. The highest level of the meniscus is now in the center of the glass, which is where the cork will float. As floating objects tend to float at the highest spots of the meniscus, the center would be the spot where the cork would float when the glass is full.

HOW MANY PENNIES CAN GO IN?

A. Question: *Can soap break forces such as tension?*

B. Materials Needed:

1. Two regular drinking glasses.
2. Liquid detergent.
3. About 50 pennies (or other small coins).

C: Procedure:

1. Make sure that the glasses are clean. Place one on the table and fill it to the brim (not too overfull, just full).
2. Now ask the students: “How many pennies can I put in the glass before it overflows?” Anticipated answer: “5, 10, 15, even 20 maybe”.
3. Start putting the pennies in the glass of water, very carefully with its edge in first (vertically), and let the students count.
4. Surprised with the result? Now place the other glass on the table, in which you should put a drop of detergent beforehand (without the students noticing it), and also fill this to the brim with water.
5. Now ask a student to put just as many pennies in this glass. What happened here?

D: Anticipated Results:

Students should observe a difference in the amount of pennies added to both glasses before it overflows.

E: Thought Questions for Class Discussion:

1. How many pennies can go in the first glass? What about in the second glass?
2. What made the water overflow so easily in the second glass?
3. What kept the water from overflowing in the first glass?
4. What shape did the meniscus take form in the first glass?
5. How would the number of the coins compare if we used dimes instead of pennies? Nickels instead of pennies?

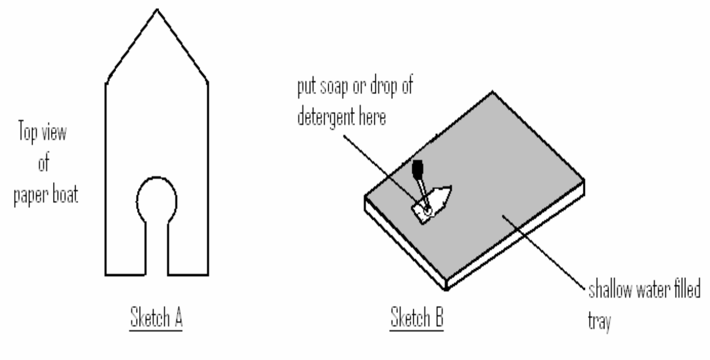
F: Explanation:

It is possible to put close to 50 pennies in the full glass of water, depending on how full the glass was filled. A thick-rimmed glass will look full even when the meniscus is a little below the rim. Then it is possible to put many more pennies in. A larger glass also increases the number of pennies that can be dropped. The water forms a convex meniscus due to the surface tension, which is nothing but a manifestation of cohesion of the surface molecules.

In the second glass, where the detergent was present, the surface tension of the water is broken. The cohesion between the surface water molecules is much smaller, and thus the water overflows much sooner. (Another way of secretly putting detergent in the second glass, is wetting the second bunch of pennies with a little detergent before giving it to the student.

THE DETERGENT PROPELLED BOAT

A. Question: *Can soap break tension of water?*



B. Materials Needed:

1. A paper card (3x5").
2. A shallow tray or sink.
3. A piece of soap or a few drops of liquid detergent.

C: Procedure:

1. Fill the shallow tray (or sink) with water.
2. Cut out a boat from the paper card in the form of sketch A.
3. Let the paper boat float on the water and touch a corner of the soap block to the water in the center opening of the boat (or place a drop of liquid detergent here).
4. Observe the movement of the boat.

D: Anticipated Results:

Students should observe movement of the paper boat when detergent or soap is added to the water.

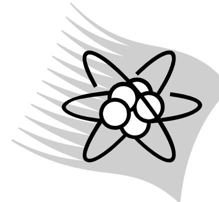
E: Thought Questions for Class Discussion:

1. Why does the paper boat move forward only when the soap touches the water?
2. What made the paper boat be pulled forward?
3. What did the soap or detergent do to the cohesive forces between the water molecules?
4. What other shapes of boats would work the same way?
5. Would it work without a hole in the paper card?
6. What would happen if we touched the soap to the side of the boat?

F: Explanation:

The soap touching the water or the drop of detergent in the water is breaking the surface tension. There are cohesive forces between the water molecules in front and in the back of the boat, as well as on both sides. By touching the soap towards the rear of the boat, these cohesive forces are broken in the rear of the boat but not in the front of the boat. This makes the boat to be pulled towards the front. Similarly, before the detergent was dropped, the water molecules on the surface of the water were pulling the boat on all sides with an equal force. After the detergent was dropped, the attracting force in the rear of the boat was eliminated, so that the resultant force is to the front. The shape of the boat is irrelevant. Any shape will do the same thing. When the surface tension on the left is broken, the paper boat will move to the right. The propelling can continue until the detergent has lowered the surface tension considerably.

HUMAN MOLECULES



KEY OPENING QUESTION: Can you pretend to be a molecule in a solid, in a liquid, and a gas?

PROCEDURE:

1. This is done in three parts, one for each state of matter.
2. Take the students outside or into the gymnasium where they will have room to move around.
3. Have the students stand in a straight line while linking arms, elbow to elbow.
4. Explain that each person is a "molecule"
5. Have students wiggle in place.
6. After they are all linked, say that they are now like a solid. You can have them try to move, but no one can move very far. Explain that this is why solids are generally hard and have a definite shape.
7. Next, you can turn the human molecules into liquid by heating them up.
8. This is done by having the students hold hands.
9. Now ask them to move; they will be able to slosh around and slide past each other.
10. Lastly, turn the human molecules into a gas. Explain that this is done by adding more heat.
11. Now instruct everyone to let go of each other's hand and move around.
12. Everyone can run freely, but collisions between human molecules may occur.
13. Have students observe where they are now standing.
14. VARIATIONS: Ask a group to stage a state and have the rest of the students guess what state the human molecules are in.

NSF/IERI Science IDEAS Project Grant #0228353

POURED GAS

KEY OPENING QUESTION: Can Gas Be Poured?

MATERIALS: Candle
Matches
1 tablespoon baking soda
2 tablespoons vinegar
Stirrer
Glass

PROCEDURE:

1. Put the baking soda into the glass.
2. Add the vinegar into the glass and stir.
3. Light the candle with the match.
4. As the bubbles in the glass recede, tip the glass towards the candle flame.
5. Record what happens in "Data/Observation".

OBSERVATIONS AND DATA:

Note: When vinegar and baking soda are mixed together, they produce carbon dioxide gas. Carbon dioxide does not allow burning to occur.

CONCLUSION: (Answer the question)

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STICKY WATER

<u>KEY OPENING QUESTION</u>: Can Water Be Sticky?

<u>MATERIALS</u>: Two sheets of paper
Water

<u>PROCEDURE</u>:

1. Hold the two pieces of paper together and then pull them apart.
2. Wet the two sheets of paper; put one sheet on top of each other.
3. Separate the two sheets of paper. Observe what happens.
4. Place the two sheets of paper in an area to dry completely.
5. Repeat Step 1. Observe what happens.

<u>OBSERVATIONS AND DATA</u>:

What causes paper to stick?

<u>CONCLUSION</u>: (Answer the question)

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The Shrinking Mixture of Liquids
Measurement Modification

This is a modified version of the “Shrinking Mixture of Liquids” activity in Tik Liem.

Materials

1. 250ml graduated cylinders and 1 100ml graduated cylinder.
2. Isopropyl alcohol.
3. Water (distilled if possible).

Procedure

1. In the 2 50ml cylinders, measure 50ml each of water and alcohol.
2. Ask your students how much liquid will be in the 100ml cylinder if you pour the contents of each of the 50ml cylinders into it. The students will likely predict that there will be 100ml of liquid.
3. Pour the liquids into the 100ml cylinder, and call a few students up to measure the final volume. It should read somewhere around 97ml.

Questions

1. How do you explain the missing liquid?
2. Did the water or alcohol evaporate?
3. Did the liquid shrink or contract?
4. How does the “Can the Container Hold More” activity (Liem p. 91) help you to explain this event?

Explanation

When the alcohol and water mixes, the alcohol molecules slip into the spaces between the water molecules, making the total volume of the two liquids less. The spaces between the molecules are too small to see, but this demonstration proves that they are there.

A'Mazing Water

Science IDEAS Project
Student Activity

Goal:

To demonstrate the cohesive forces that keep water molecules together in drops.

Materials:

- water
- isopropyl alcohol
- 2 small cups
- eyedropper
- maze photocopy
- wax paper
- popsicle stick

Procedure:

1. Put a small amount of water in one cup, and a small amount of the isopropyl alcohol in another. Put an eyedropper in each cup.
2. Place the maze photocopy down on a flat surface.
3. Lay a piece of wax paper over the maze.
4. Place a drop of water at the beginning of the maze.
5. Use the popsicle stick to maneuver the water drop through the maze. No cheating!
6. Try to repeat the maze, but this time use a drop of isopropyl alcohol.

Journaling Opportunities:

- How did the water act differently than the water. Why?
- Draw a picture showing the difference between the drop of water and the drop of alcohol on the wax paper.
- What substances could you add to the water to make it act like the alcohol?

What Happened?

Cohesive force between the water molecules kept them pulled tightly together. It is this force that causes water to stay in "drops." The force is strong enough that when the drop is pushed on, all of the water molecules in the drop hold themselves together. The **adhesive** force between the water and the wax paper is not nearly as strong as the cohesive force between the water molecules. There is some adhesion present though, as you see when you push on the drop and it bends and warps before moving.

There is very little cohesive force between the molecules of isopropyl alcohol. The adhesive force between the alcohol and the wax paper is stronger, so the alcohol tends to spread out more than it stays in drops.

NSF/IERI Science IDEAS #0228353

Stopping Water with Cheesecloth

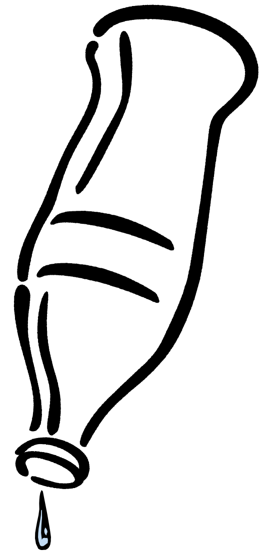
Science IDEAS Project
Teacher Science Demonstration

Goal:

To demonstrate the strength of water's cohesive and adhesive properties.

Materials:

- Water
- Cheesecloth
- Several bottles with different sized openings (soda bottle, Erlenmeyer flask, etc...)
- Index cards
- Bucket or sink to catch the water



Procedure:

1. Dunk the cheesecloth in water, making sure that the water soaks through.
2. Fill the bottle with the smaller opening with water, as close to the top as possible.
3. Stretch the cheesecloth over the opening, and hold it tight to the sides of the bottle with your hand.
4. Place the index card over the cheesecloth to hold the water in while you turn the bottle over.
5. Over the bucket or sink, slowly turn the bottle upside down and then slide the index card off of the opening. Other than a few drops, the water should stay in the bottle.
6. Repeat with the other bottles. If the opening is too large, the demonstration will fail.

Journaling Opportunities:

- Observe and record what happened to the water in each of the different bottles. What difference in the bottles caused the water to be held in or to escape?
- Why was it important to soak the cheesecloth in water first?
- Would this work with a regular drinking glass that has a wide opening?
- Would this work with substances other than water? Why or why not?

What Happened?

When you soaked the cheesecloth, the adhesive forces between the cloth and the water made the cloth damp. The water held onto the cloth. After you tipped the bottle over, the cohesive forces between the water in the bottle and the water soaked into the cloth created a "lid" over each of the squares of the cheesecloth. As long as the bottle opening is small enough, the cohesive forces holding water molecules together have enough strength to hold all of the other water in the bottle. If the opening is too big, then force of all of the water molecules being pulled down by gravity overwhelm the cohesive and adhesive forces and water gets through the cheesecloth.

NSF/IERI Science IDEAS #0228353

Magic Pepper Sinker

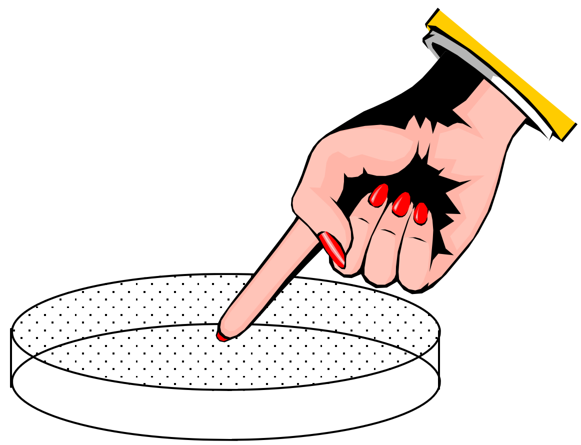
Science IDEAS Project
Student Activity

Goal:

To demonstrate how soap can eliminate water's **cohesive** properties.

Materials:

- Petri dish or other small, shallow container
- Water
- Pepper
- Soap (liquid dishwashing)
- Paper cup



Procedure:

1. In the paper cup, mix a strong solution of soapy water. Several students or groups can share one cup.
2. Clean the dish, and fill it half way with water.
3. Sprinkle pepper over the water so that it is evenly coated.
4. Dunk your finger in the solution of soapy water, taking some of the solution with you.
5. Gently touch the top of the pepper-coated water with your finger. Observe what happens, and record your observations in your journal.

Journaling Opportunities:

- What did you observe when your finger touched the water? How did the pepper move? Illustrate your observations.
- What force caused the pepper to move the way that it did?
- Can you think of any other time where you have seen something in water act the way that the pepper did?
- What other substances could you put on your finger that would make the water and pepper act in a similar way?

What Happened?

The pepper floats on top of the water due to cohesive properties of the water and the resulting surface tension. The pepper flakes (which are more dense than water, and therefore should sink) do not fall through the water's surface because of the strong bonds between water molecules there.

When the soap is introduced to the water, is breaks the cohesion between molecules. This affects the pepper in two different ways. First, as the soap moves from the center to the outside of the dish the cohesive forces break in the same pattern, and water molecules are pulled towards the edges of the dish. The water pulls the pepper with it, causing it to rush out from the center. In addition, because the surface tension of the water has been broken the pepper now sinks.

Merging Streams

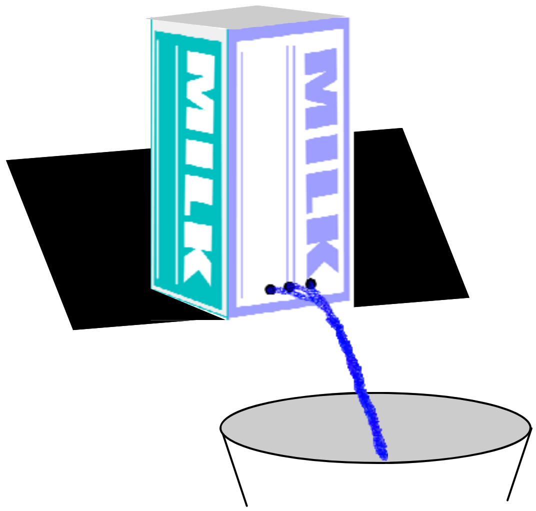
Science IDEAS Project
Teacher Science Demonstration

Goal:

To demonstrate the strength of **cohesion** between water molecules.

Materials:

- Empty milk carton or other similar sized container. Flat sides are better than curved sides
- Water
- A tool to punch a clean hole with
- A sink or bucket to catch the water in



Procedure:

1. Make three small holes 1/2 cm apart on a horizontal line across the bottom of the container.
2. Position the container on the side of a sink, or on a table edge with a bucket underneath.
3. Fill the carton with water, and observe the streams of water that come out of the holes.
4. Use your fingers to direct the two outer streams into the inner one. Observe what happens when you take your fingers away.

Note: You may want to have a student standing by with some extra water to refill the carton when it gets low.

Journaling Opportunities:

- What causes the water to squirt out of the holes?
- Observe what happens to the streams as the water level in the carton drops. Explain your observations.
- What force is responsible for the streams staying together once their paths have changed?

What Happened?

The pressure of the water above the holes pushing down to the bottom of the carton is responsible for the streams squirting out. Each individual water molecule is pushed out of the hole, and is pulled down by gravity. The individual streams are held together by cohesion. Without cohesion, the streams would break apart like a mist. Think of what would happen if you blew flour out of a straw.

When you move the streams towards each other, molecules from each stream get close enough for their cohesive forces to attract one another. The cohesion within and between the streams merge the water together into one stream.

NSF/IERI Science IDEAS #0228353

Pour Water Sideways

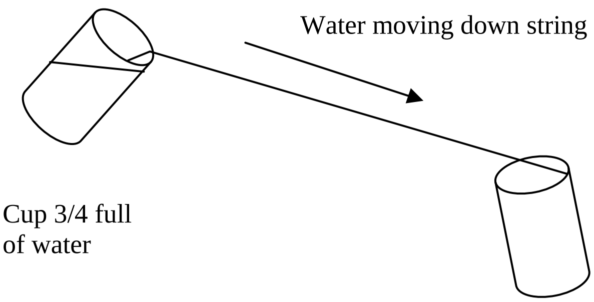
Science IDEAS Project
Teacher Science Demonstration

Goal:

Demonstrate the properties of **cohesion** and **adhesion** found in many liquids, including water.

Materials:

- Two small paper cups.
- Water absorbent (cotton) string or twine
- Water
- Food coloring (optional)



Procedure:

1. Fill one of the cups about 3/4 full of water.
2. Cut off a length of the string about 40 cm long and drop it into the water. Stir it around and make sure that it is fully soaked with water.
3. Remove the string from the water, and leave about 4 cm in the cup of water. Hold it to the rim of the cup with your finger. Do the same to the empty cup.
4. Turn the empty cup 180˚ so that the string is stretched over the cup as in the illustration.
5. Raise the cup of water slightly higher than the empty cup, and tip it so that water trickles down the string. The water should continue down the string until it hits the other cup and drops in.

Note: After you have practiced this a bit, you can try it over someone else's head. Students are good subjects, administrators are better. Also, a small amount of food color added to the water will make it more visible as it moves down the string.

Journaling Opportunities:

- Write a step-by-step description of what they saw happen. If you had students try this activity, ask them to write a narrative of what they did.
- Why was it important to get the string wet first? What would have happened if the string had been dry when you tried it.
- Draw a super close-up view of the string. Make the water that wet the string down a different color from the water that transferred between cups.
- Explain why the water did what it did using the words **cohesion** and **adhesion**.

What Happened?

Water molecules attached themselves to the string when it was initially dunked in the water using **adhesion**, the property some matter has to be attracted to things other than itself. It is this adhesive force that makes water stick to the side of a wall or window, and to be absorbed in a towel. Once there was water all around the string, other water molecules were attracted to them through the force of **cohesion.** Cohesive forces exist between a type of matter and itself.

The cohesive force between water molecules is stronger than the adhesive force between the water and the string. In order for the moving water to be supported, the stronger cohesive force is needed. If you tried this with dry string, the adhesive force between the water and string would not be strong enough, and the water would spill.

Where Does the Cork Float?

Science IDEAS Project
Student Activity

Goal:

Use a cork to demonstrate the adhesive and cohesive properties of water in a glass.

Materials:

- Water
- Drinking glass
- Cork
- eyedropper

Procedure:

1. Fill the glass half full with water.
2. From the side of the glass, observe the line made by the top of the water. What do you notice that is unusual about the line?
3. Gently place the cork in the center of the glass. Observe where it floats.
4. Take the cork out and fill the glass to the top with water. Use the eyedropper to get as much water in as you can without it spilling over the sides.
5. Observe the water line from the side of the glass. How is it different from when the glass was half full?
6. Gently place the cork in the middle of the glass. Some water may spill over, but that is OK.
7. Observe where the cork floats to this time.

Journaling Opportunities:

- How were the water lines as seen from the side different when the glass was half full and when the glass was overfull. Draw what it looked like to you.
- Where did the cork float to each time? What caused the cork to float to different places? Draw the cork's position for each part of the activity.
- What might happen if you repeated this experiment with a liquid that had different properties of cohesion and adhesion?

What Happened?

A cork, or other object that is less dense than the medium it is surrounded by, will always float up to the highest point of the medium. In both parts of this experiment, the point to which the cork floats is the highest point of the top of the water.

When the glass is part full, the adhesive force between water and the glass pulls the water a little bit up the sides of the glass. The cork floats to the edge of the water because this is the highest point.

When the glass is a little bit overfilled, the cohesive forces between the water molecules allow the water to "pile up" on top of itself , building the water in the middle of the glass into a mound without spilling over. Thus, the middle of the glass is the highest point, and the cork floats there.

NSF/IERI Science IDEAS #0228353

Water Drops on a Penny
(Magical Drops)

Science IDEAS Project
Student Experiment

Goal:

To demonstrate the properties of **cohesion**, **adhesion**, and **surface tension** of water.

Materials: (for each student / group)

- Cup of water
- Eyedroppers
- Paper towels
- Penny (cleaned and rinsed well!)
- Journal for data collection

Procedure:

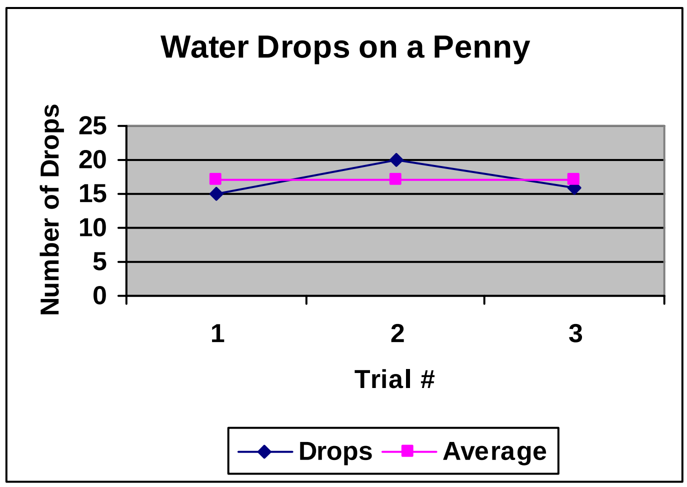
1. Place the penny on a flat surface.
2. Fill the dropper with water from the cup.
3. Carefully drop water from the dropper onto the penny one drop at a time, counting each drop.
4. Record the number of drops fit on the penny in your journal.
5. Repeat the experiment with the same penny two more times, recording the final number of drops each time.

Trial	Number of Drops
1	
2	
3	
Total	
Average (total / 3)	

Sample data table.

Journaling Opportunities:

- Have students predict how many drops of water their penny will hold before starting the experiment, and explain why they made their prediction.
- Students should create a data table and graph (samples shown below) to record their own experiments.
- Record each student or group's average number of water drops on the board and ask students to compute a class average
- What forces caused the drops to "stick" to each other and to the penny?
- What finally happened to cause the water to stop sticking to the penny?



Sample graph.

What Happened?

As drops of water are added to the penny, the **adhesive** force between the water and the penny keeps the water from falling off. The **cohesive** force between the water molecules is even stronger, and keeps the water together in one large drop. **Surface tension** is caused by the cohesive force between the molecules on the surface of the big drop, causing the surface to act like a skin and strengthen the hold on all of the water molecules.

Cohesive forces are strong, but not unbreakable. As the water drop builds up and out, usually bulging over the sides of the penny, the cohesive forces will eventually reach their breaking point. The "skin" will burst, and all of the water will spill out.

Propel the Boat

Science IDEAS Project
Student Activity

Goal:

To demonstrate cohesive forces in water and how these forces can be disrupted.

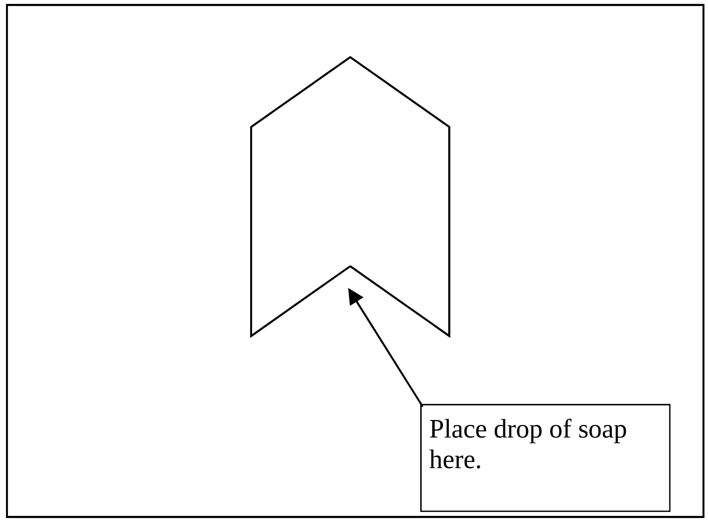
Materials:

- 3X5 index card
- Shallow tray
- A few drops of liquid soap

Procedure:

1. Fill the tray with water.
2. Cut out a boat as shown in the "boat pattern" diagram.
3. Place the boat onto the water so that it is floating in the middle of the tray.
4. Place a drop of liquid detergent in the center of the "V" shape at the rear of the boat.
5. Observe and record what happens to the boat.

Note: If you want to repeat the experiment, you can mix the water in the tray up so that the soap is more evenly distributed. Eventually there will be so much soap in the tray that you will have to replace the water.



Boat Pattern Diagram

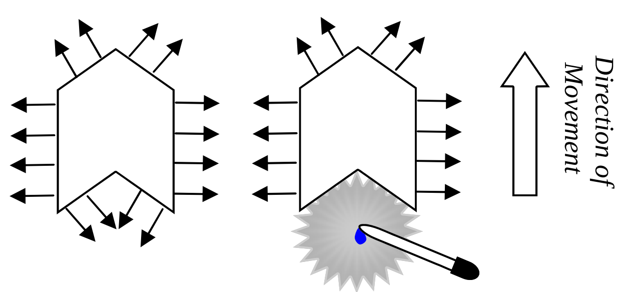
What Happened?

When you first place the paper cutout in the tray of water, adhesive forces between the water molecules and the paper pull the cutout equally in all directions. The result is that all of the forces balance out and the paper does not move.

When soap is added to the water, it eliminates most of the water's adhesive properties. With no more adhesion, the water in the area of the boat where the soap is dropped stops pulling on the paper. The water in front of the cutout still has its adhesive properties, and continues to pull on the boat, making the boat move forward.

Journaling Opportunities:

- What did you observe when the drop of soap hit the water behind the boat? Write and illustrate your observations.
- What does soap do to the water?
- How does removing the water's adhesive properties make the boat go forward?
- What other activities and / or demonstrations have we done in class that demonstrate the same properties of water in different ways?



A drop of soap removes the water's adhesive force pulling on the cutout, resulting in forward motion.