Part 2
What If?

Ask students: If you could change one thing about this investigation to learn something new, what would you try? When we change one part of an experiment to see how it affects our results, this change is known as a variable. What if we used different liquids? Use the chart in your journal to record your ideas about what might happen if you change some of the variables. Some possibilities are:

- What if you used different liquids in this experiment?
- Different spices (oregano, sugar, salt, flour, basil, rosemary)?
- How about different types of soaps? Different amounts of soap?
- Different temperatures of water? Salty water?
- How would your results change?

TIP
Rinse the pie tins and cups between each variable investigation to remove soap residue.

We encourage you to try these variables or other ideas suggested by the students. Invite students to share their questions and results with the group and record them in their student journals.

WRAP-UP

To wrap-up the investigation, bring your students together for a group discussion to help them understand why and how they achieved their results. It is important to share results so that everyone has a clear picture of what happened. To help you facilitate the discussion, review the explanation in "The Why and The How" using the Group Discussion questions as a guide.

Group Discussion
Explain to students that scientists learn from each other through discussion, and they build upon the work of others to make new discoveries. Just as scientists come to conclusions based on the findings of their experiments, they will now come together as a group to share their results and make conclusions about the investigations they've conducted. Have students record their final results and the explanation in their journals.

- What did you learn about water from this experiment?
- Did everyone have the same results?
- How did the detergent affect the water?
- Based on your observations from this experiment, how does dish detergent help clean dirty dishes?
- What did you like about this investigation?
- What variables did you try?
- What surprised you?
- What new questions do you have?

The "Why" and The "How"
Surface tension is the strength of the force that controls the shape of water. Water molecules on the surface of water are strongly attracted to each other, and feel a strong force of attraction from the molecules under the water's surface. These forces pull the surface molecules closely together and back towards the body of water creating an invisible skin. The stronger the bonds are between the molecules in water, the greater the surface tension.

Adding detergent to water weakens the bonds between the surface molecules, making them spread apart. When this occurs, the water's invisible skin breaks or pulls apart, similar to the popping of a balloon. When the detergent was added to the water, ths invisible skin at the surface was broken, and both the boat and the pepper were pulled along with the popping skin. Once the skin was broken, the weight of the paper boat and the pepper floating on the surface could no longer be supported, causing them to sink to the bottom.

Curriculum Match-Up

- Try changing one variable and test your paper boats again. Add oil to the water in place of detergent, or try using saltwater instead of freshwater.
- Create additional boats of your own design using different materials. Test your new boat and document your results.
- Create a chart or graph for different liquids, soaps, spices or water temperatures that you used.

References:
www.coolscience.org/CoolScience/KidScientists/FloatDivePaperClip.htm
launchpadscience.com/experiments.htm
pbskids.org/zoom/activities/phenom/soappoweredboat.html
www.wikimedia.com

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Below the Surface: Surface Tension II

Learning Objectives

Students will:

1. Demonstrate that the attractive forces between water molecules cause an invisible "skin", known as surface tension, to form on the surface of water.
2. Explain why certain objects are able to float on the surface of water.
3. Explain how detergents break the surface tension of water.

Vocabulary Ventures

atom
attraction
cohesion
elastic
hydrogen bonding
meniscus
molecule
sphere
surface area
surface tension
teddy bear molecule
water strider

We are learning that we can identify water by its physical and chemical properties. A **molecule** is made of several **atoms**, which are joined by a chemical attraction. Molecules behave depending on the atoms they contain and how these atoms bond to each other. In a water molecule, two hydrogen atoms with a positive charge are attached to an oxygen atom with a negative charge, with the resulting shape looking like the head of a teddy bear. The water molecule is known as the **"teddy bear molecule"**.

Water molecules behave much like a magnet, with a positive end and a negative end. The oxygen atom in one molecule of water is attracted to the hydrogen atom in another water molecule, which is known as **hydrogen bonding**. This force causes water molecules to be attracted to one another, a property referred to as **cohesion**.

Within a body of water, water molecules are in a constant tug of war with other surrounding water molecules. The water molecule is constantly pulled in every direction by other water molecules, canceling out the forces and causing it to remain stationary. This is known as "no net force".

However, on the surface of the water, molecules are being pulled by other molecules everywhere except from above. This causes the surface molecules to be pulled down strongly and held together very tightly, creating an invisible "skin" on the water's surface known as surface tension. The **attraction** between water molecules also causes water to pull itself into the shape with the smallest amount of **surface area** (the outside surface of the shape) which is a **sphere**, or on a flat surface, a dome shape called a **meniscus**.


hand breaking surface tension of water

This stretchy, **elastic** skin on the surface of water is strong enough to support insects like **water striders**. If you look closely at these insects walking on water you will notice that their feet make dents in the skin but do not break it. Amazing!

Time Needed to Conduct Investigations

Investigation 1: *This investigation has two parts.*
Organize and set up materials: 10 minutes
Introduce the lesson: 5 minutes
Conduct the investigation: 25 minutes
Student journaling/group reflection: 10 minutes
Total estimated time: 50 minutes

Investigation 2: *This investigation has two parts.*
Organize and set up materials: 10 minutes
Introduce the lesson: 5 minutes
Conduct the investigation: 25 minutes
Student journaling/group reflection: 10 minutes
Total estimated time: 50 minutes

Investigation 1: A Soapy Sloop

Materials

For groups of two
Student journals and writing tools

INVESTIGATION 1
Part 1
- ½ liter water bottle
- Pie tin
- Index cards
- Boat template (See Appendix)
- Ruler
- Scissors
- Liquid dish detergent
- Sponges for clean-up

Part 2
- Construction paper
- Aluminum foil
- Wax paper
- Cardboard
- Brown paper bag
- Printer / Copy paper
- Sandpaper
- Wrapping paper

INVESTIGATION 2
Part 1
- ½ liter water bottle
- 9 oz clear plastic cup
- Ground black pepper
- Liquid dish detergent
- Sponges for clean-up

Part 2
- Different types of soap (dish detergent, bar soap, liquid hand soap)
- Electric teapot (to make hot water)
- Bottles filled with other liquids (Salty, soapy, hot and cold water, white vinegar, Karo syrup, mineral oil, isopropyl alcohol, seltzer water)

Part 1
Floating Along

GET READY!

Explain to students that they will be conducting another experiment about surface tension, this one involving a boat. Review any relevant concepts/vocabulary from previous investigations, specifically the floating paperclip activity.

1. Break students up into groups of two.
2. Instruct students to create their boats by cutting a 2 ½ inch high and 1 ½ inch wide triangle out of their index cards.
3. Students should then cut a smaller triangle directly in the center of the back edge of the boat for the "motor." This is also where the boat's "fuel" (dish detergent) will go.
4. Students may use the template provided to create their boats.

PREDICT

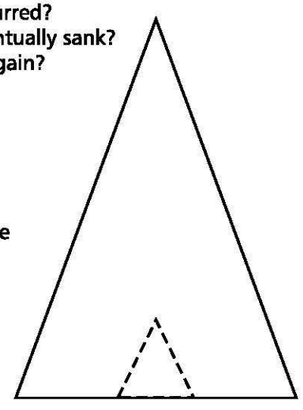
Invite students to make some predictions.
Ask students:
- What will happen when you place your boats in the water?
- Do you think that the boat will float or sink? Why?
- What do you think will happen when you add detergent to the water?
- Will you get the same results as with the floating and diving paperclip from the previous investigation?

OBSERVE

Students should then place their boats in the water near the edge of the pie tin and make observations.
Ask students:
- What happened to the boat when you first placed it in the water?
- Why do you think this happened?

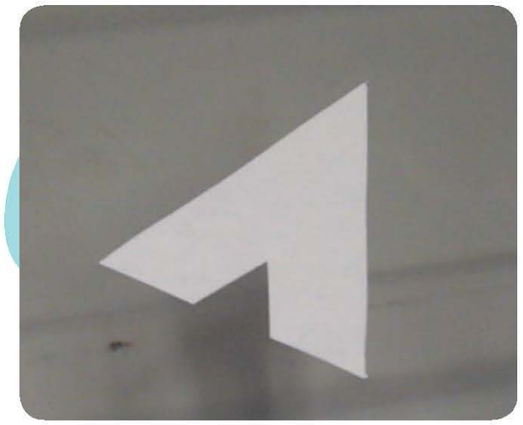
Next, have students place a small drop of fuel (liquid dish detergent) in the boat's motor (notch at the back of the boat).
Ask students:
- What happened to the boat just after adding the detergent?
- Why do you think that this occurred?
- Why do you think the boat eventually sank?
- Can you get the boat to float again?

boat template
(full size template in Appendix)



Part 2
A Different Boat

Try this investigation again with a different type of paper. Have students choose a different paper from the materials list and build a new boat. Have students conduct the investigation with the new boat and compare their findings.



boat floating on water

Investigation 2: Petrified Pepper

Part 1
A Dash of Pepper

GET READY!

Explain to students that they will be conducting another experiment to explore the surface tension of water. Review any relevant concepts/vocabulary from previous investigations.

pepper floating on water

PREDICT

- What will happen if you sprinkle some black pepper into the cup?
- Do you think it will float or sink?
- What do you think will happen to the pepper if you drop some dish detergent onto the surface of the water?

PROCEDURE

1. Have students fill their cups halfway with water.
2. Next, sprinkle some pepper on the surface of the water.

OBSERVE

Invite students to make observations about the pepper and the water. Next, have students place a drop of dish detergent in the center of the floating pepper. Invite students to record their observations.
- What happened to the pepper when you added the detergent to the water?
- Why do you think this occurred?
- Why do you think the pepper eventually sank?