Surface Tension

Illusion: “Can water defy gravity?”

For students in grades K through 6th

‘Impossible Science’ lessons aim to be 75-90 minutes long for grades 3 through 6, and 60-75 minutes long for grades K through 2. Lesson activities that are appropriate for K through 2 are highlighted in green. **All** lesson elements, including those highlighted in green, are appropriate for grades 3 to 6.

Objectives

By the end of this lesson, students will:

- **know** the basic concepts of surface tension and the effects of soap on these properties.
- **understand** how surface tension allows water to form droplets, support small objects, and create a "skin" on its surface that can resist certain forces.
- **be able to** demonstrate their understanding of surface tension through hands-on experiments, such as the Upside-Down Water and Drops on a Penny, and articulate their observations and explanations.

Big Ideas:

- Water is made up of **molecules**.
- Water molecules are **hydrophilic,** meaning they are attracted to each other. This is also known as **molecular cohesion.**
- At the surface of water, the lack of water molecules above allow the surface molecules to form stronger bonds with each other. This creates **surface tension.**
- The surface tension of water is strong enough to support or resist certain types of forces. This permits bugs to walk on water, and water to support its own weight inside of an upside-down container.
- Some substances, like dish soap, can be used to change the surface tension of the water. Soap reduces the tension by interfering with the bonds between the molecules.

Essential Questions:

- What is water made of?
- What is the property of water that allows for the surface to be stronger than the water beneath it?
- How does surface tension make it possible for water to hold up things that seem to defy gravity?
- What changes occur at the molecular level when soap is added to water?

Engage:

Warm Up Activity

Ask the students to help you make a list of the different ways in which you can jump into a pool. Answers will likely include cannon ball, dive, belly flop, etc. Then, ask them to identify which one is the least likely to hurt by voting. Record their results on the board.

Impossible Science Demo

Includes "Teach Like A Magician" progression of steps with recommended script.

- *[TLAM]: "Today, we are going to defy gravity."*
- Pour water into the meshed lid jar.
- *[TLAM]: "To do this, we will need a little bit of water inside of a mason jar. Typically, water just wants to fall to the floor if we turn this jar over."*
- Demonstrate that you can easily pour the water out.
- Refill the jar.
- *[TLAM]: "But if we tell water to hold on for a second and reconsider its choices, we can get it to stay in place.*
- Place a card over the lid so that the entire opening is covered.
- Tip the jar over so that it is completely upside-down, keeping the card in place. Then, remove your hand from the card.
    - *The card should remain in place, and the water should remain inside of the jar.*
- *[TLAM]: "Now that we've calmed the water down, it wants to stay in its container, defying gravity."*
- Remove the card from the upside-down jar.
    - *The water should remain in place.*

Think | Pair | Share

- *Think [1-2 min]:* Ask students to, individually, consider how they think this illusion works. Then, under Prompt #1 in their workbooks, have them model their answer.
- *Pair [1-2 min]:* Students pair up and take turns sharing their thoughts. They ask each other questions after sharing and formulate their combined responses to the question prompts.

- *Share [2-3 min]:* The larger group comes together and the pairs take turns summarizing their combined responses. On the board or chart paper, write down a couple of statements that summarize the group's various hypotheses.

Explore:

Activity 1 - Drops on a Penny [15 minutes]

Students will work in pairs for this activity. Distribute the materials for "Activity 1" from the Materials page.

Students will use a dropper to see how many drops of water they can fit on top of a penny before it spills over.

- Fill the dropper with water.
- Place the penny on a flat surface.
- One drop at a time, carefully add water droplets to the surface of the penny. Make sure to keep count!
- Take turns, observing how many drops each partner can get on top of the penny.
- Try adding drops in the following ways to see how it affects the overall results.
    - Squirt the water droplets out quickly
    - Poke the tip of the dropper into the bubble of water on the penny and add droplets
    - Release droplets slowly on top of the bubble of water forming atop the penny
- *If time permits, allow students to experiment with another type of coin (Nickel, Dime, Quarter)*

Activity 2 - Drops on a Clean Penny [10 minutes]

Students will work in pairs on this activity. Distribute the materials for "Activity 2" from the Materials Page.

Students will retry Activity 1, this time with pennies that they have washed with dish soap. They will compare the results with Activity 1 and attempt to understand how soap affects surface tension, reducing the strength such that the penny no longer holds as many drops as in Activity 1.

- Clean a penny with soapy water.
- Completely dry off the penny.
- Repeat the steps from Activity 1
    - Fill the dropper with water.
    - Place the penny on a flat surface.
    - One drop at a time, carefully add water droplets to the surface of the penny. Make sure to keep count!
    - Take turns, observing how many drops each partner can get on top of the penny.
    - Try adding drops in the following ways to see how it affects the overall results.

        - Squirt the water droplets out quickly
        - Poke the tip of the dropper into the bubble of water on the penny and add droplets
        - Release droplets slowly on top of the bubble of water forming atop the penny
- Repeat the activity 2 more times, washing the penny each time. Record the results visibly so students can see the overall performance of the class.
    - *Students should observe the penny is increasingly unable to support water droplets due to the soap's impact on surface tension.*

Activity 3 - Upside Down Water [15 minutes]
Students will work in pairs on this activity. Distribute the materials for "Activity 3" from the Materials Page.

Students will work to recreate the upside-down water Impossible Science Demo, demonstrating the strength of water's surface tension to even resist gravity!

- Take the lid off of the mason jar. If there is a solid top inside of the lid ring, set it aside.
- Take the screen mesh and place it on top of the rim of the mason jar.
- Place the rubber band over the screen mesh and wrap the band around the screen, securing the screen to the top of the mason jar.
- Pour water into the mason jar through the screen.
- Place the plastic card on top of the mason jar.
- While holding the plastic square securely on the top of the mason jar, flip the jar upside-down. Do this part over the water container to avoid making a mess.
- Once the water settles, you can let go of the plastic card, and it will stay there without falling.
- With the mason jar still upside down, remove the card from the lid of the mason jar.
    - *A small amount of water may fall out, but almost all of the water should stay in the jar, even though it is upside down!*
- Add a small amount of dish soap to the tip of the cotton swab
- Gently rub the cotton swab across the mesh surface while the jar is still upside-down. Observe what happens.
    - *The soap should break the surface tension of the water, releasing the water*

At this point, have students return to their workbooks and, under Prompt #2, attempt to explain with a model and words why the water seems capable of resisting gravity in the Impossible Science Demo until the soapy cotton swab touches it.

Modified Activity 3:

In lieu of doing Activity 3 as a group, complete Activity 3 as a demo for K-2 learners. Alternatively, invite some students to serve as demonstration volunteers to help conduct the activity.

BRAIN BREAK - Red Rover

Students will form two teams for this activity.

The students will play the classic game "red rover". To do so:

- Each team forms a line by holding hands. The team lines should face each other at a distance of about 20-30 feet.
- One team starts by calling out "Red rover, red rover, send [opposing player name] over."
- The called player on the opposing team runs towards the opposing team's line and tries to break it by causing a link between two players to separate.
    - *If they break the link: the player who successfully separated the opposing team's line can choose one person from the opposing team to bring back to their team*
    - *If they don't break the link: the player joins the opposing team*

Explain:

Watch and Discuss [10 minutes]

Link: ***Constance Zimmer Defies Gravity With The Science of Surface Tension! \| Impossible Science At Home***

After watching the video, guide students through a brief reflection:

- What did they notice in the video?
- How was Jason able to make the illusion work?

Define and clarify the following terms while watching the above video. Pause video and elaborate on definitions as deemed necessary based on student engagement, using the "Big Ideas" and "Essential Questions" as a guide:

- Molecules
- Force of attraction between molecules
- Surface tension

The Reveal: The surface tension of the water is strong enough that, with the help of the wire mesh, it can support the weight of the water above it in the mason jar, much like a chair supports you - preventing you from falling to the ground! Soap is a substance that actually weakens the strength of the bonds between water molecules on the surface of the water. By applying soap, we weaken the bonds so much that the water can no longer support itself at the surface.

At this time, have students return to their journals and, under Prompt #3, explain with models and words how the three Activity experiments demonstrated the use of surface tension to create the Impossible Science illusion.

Elaborate:

Experiment - Break the Tension [20 minutes]:

Students will work in pairs on this activity. Distribute the materials for "Experiment" on the Materials Page.

Students will break the surface tension of water in exciting ways to observe how doing so affects objects resting atop the surface.

Test One: Floating versus Sinking Paperclip

- Fill the container with water
- Bend one paper clip as shown in the Impossible Science video
- Using the bent paperclip, gently lower another paperclip onto the surface of the water such that it appears to float
- Observe how the water behaves where it is touching the paperclip
- Apply a small amount of dish soap to the tip of a cotton swab
- Lower the cotton swab tip gently into the water. Observe what happens to the paperclip
    - *It should sink*
- Remove the paperclip from the water and empty the container.

Modified Experiment Consideration

Teachers may elect to do Test One as a demonstration with the whole class.

Test Two: Runaway Pepper

- Fill the container with water.
- Sprinkle a generous amount of pepper onto the water, so that it spreads out all over the water's surface
- Apply a small amount of dish soap to the tip of a cotton swab
- Gently touch the tip of the cotton swab to the surface of the water in the middle of the container. Observe what happens to the pepper.
    - *The pepper will seem to run away from where the cotton swab touches. Some pepper will start to sink.*
- Move around the water, gently touching the cotton swab in various places.
    - *Students may need to flip the swab around or get a new one to continue applying soap.*
- Once done, empty the container of water

Test Three: Boat Race

- Use the provided index card to create a 'boat'
- Fill the container with water
- Gently place your boat on the surface of the water so that floats
- Apply a small amount of dish soap to the tip of the cotton swab
- Gently touch the cotton swab tip to the surface of the water and observe what happens.
    - *The boat should appear to 'race' away from the tip*
- Race your boat around the outer edges of the container!

Modify / Extend:

Extension Activity 1 - Operation Overflow [10 minutes]:

Students will work in pairs on this activity. Distribute the materials for "Extension 1" on the Materials Page.

Students will observe how surface tension allows for a surprising number of paperclips to be submerged in a container before it overflows.

- Fill the container with water all the way up to the top. Get it as close to full as you can!
- One by one, gently add paperclips to the container.
- Keep count! How many do you think you can add before the container overflows?
- How is this a demonstration of the surface tension of water?
- What would happen if we added a droplet of dish soap to the water?

Evaluate:

Under Prompt #4 in their workbooks, challenge students to return to their answers to the Warm Up Activity and, with a model, explain why it hurts less to dive into a pool than it does to belly flop. Encourage older students to include written explanations using the new vocabulary from the lesson.

Materials

Impossible Science Demo (one per class)

- Mason Jar
- Mesh
- Card
- Water

Activity 1 (one per student pair)

- Water

- Dropper
- Penny
- *Additional coins*

Activity 2 (one per pair)

- Reuse the materials from Activity 1
- Dish soap

Activity 3 (one per pair)

- Mason Jar
- Water
- Mesh
- Card
- Cotton swab
- Dish soap

Experiment (one per pair)

- Water
- Two paper clips
- Container (reuse mason jars from Activity 3)
- Pepper
- Index card
- Three Cotton swabs
- Dish soap

Modify 1

- N/A

Extension 1

- Mason Jar
- Water
- Box of paperclips