Capillary Action

Impossible Science Topic - Magical Movement of Water

Imagine you're a tiny ant, venturing through a lush, green jungle. As you climb up a towering blade of grass, you notice something incredible: water droplets are climbing up beside you, defying the pull of gravity as if they're on a secret mission to reach the top. How can these tiny water droplets move upwards against all odds?

For students in grades K through 6th

Materials Note: Be sure to reuse plastic cups, paper plates and clear straws, if possible, from one classroom to the next

Objectives

By the end of this lesson, students will:

- **know** …the basics of capillary action and its role in nature and technology.
- **understand** …how adhesion, cohesion, and surface tension contribute to capillary action.
- **be able to** … demonstrate and explain capillary action through experiments and creative activities.

Big Ideas:

- Water can move in seemingly magical ways due to the forces of adhesion, cohesion, and surface tension.
- Capillary action is a fundamental principle that allows plants to draw water from the soil and distribute it to their leaves, and it's used in various technologies.

Essential Questions:

- How can water move upwards against gravity?
- In what ways do we observe capillary action in our daily lives and the natural world around us?

- How do the properties of water contribute to the magic of capillary action?

Engage:

Warm Up Activity

Ask students if they believe water can mysteriously disappear from one container and reappear in another, hinting at unseen forces at work. Encourage guesses and theories, emphasizing open-ended scientific inquiry.

Think | Pair | Share

- Think [1-2 min]: Pose questions related to the warm-up activity, such as "Can water move invisibly from one place to another? How might that happen?" Prompt students to consider their own experiences with water absorption or unexpected movement.
- Pair [1-2 min]: Students pair up, sharing their thoughts and speculating on the possibilities. They discuss, challenge, and refine their ideas to form a consensus or an intriguing theory to share.
- Share [2-3 min]: Reconvene as a class, allowing pairs to share their theories. Lead a discussion that celebrates their creativity and segues into the lesson's scientific focus, highlighting the diversity of their ideas and introducing the concept of capillary action as a possible explanation.

Impossible Science Demo

- **Objective:** Demonstrate the concept of fluid dynamics using a homemade straw siphon to create a visually engaging experiment that simulates water magically changing color.

- **Step 1: Set the Scene**
    - Begin by intriguing students with the setup, "Prepare to be amazed as we explore how water can seemingly change its very nature before your eyes, from clear to a brilliant color. Is it magic at work, or is there a scientific explanation waiting to be uncovered?"
- **Step 2: Introduce the Straw Siphon**
    - Explain the mechanism briefly, "For today's experiment, we'll be using a magical setup that can turn this water into an entirely different color. I hope that by the end of this you have some ideas into the magical setup behind this curtain.
- **Teacher's Note**: This demonstration uses a homemade straw siphon, crafted from multiple bendy straws cut and connected to form a rough "M" shape. This specific design allows the siphon to start automatically when placed correctly into the cups. While this is not an example of capillary action, it serves as a powerful demonstration of fluid dynamics and the surprising effects that can be achieved with a simple scientific setup. For detailed instructions on how to create this siphon, refer to the video provided here

(the auto siphon is number 3 in the video). Other siphon designs are also demonstrated in the video, which you are welcome to explore, keeping in mind they may require more effort to achieve the desired effect.

- **Step 3 and 4: Execute the Experiment**
    - Carry out the experiment by placing the straw siphon into the cups in the specified manner, allowing the clear water to interact with the hidden colored liquid. The water in the clear cup will start to change color, creating a mesmerizing effect that will capture the students' attention.
- **Step 5: Discuss the Science**
    - After the initial surprise and excitement, ask students to attempt to explain the science behind the demonstration, gather ideas and rationale behind those ideas.

Explore:

Activity 1:
Objective: Simplify the concept of capillary action to make it understandable and engaging for younger students, using materials and methods that are suitable for their level of comprehension and motor skills.

Materials:

- Paper towels
- Small cups or bowls
- Water
- Food coloring

Preparation:

1. Fill two small cups halfway with water. Add a few drops of food coloring to make the water easily visible.
2. Place the two cups close to each other on a tray or waterproof surface.

Prediction: Ask students to predict what will happen if they connect the two cups with a paper towel bridge (one end of the paper towel in each cup).

Experiment:

- Group up Students into groups of 2-3
- Help students fold a paper towel into thirds then place one end of a paper towel into one cup and the other end into the second cup.
- Watch as the colored water begins to travel along the paper towel, eventually reaching the other cup.

Observation and Recording:

- Encourage students to observe the color moving through the paper towel.
- Ask them to describe or draw what they see in their notebooks or on a piece of paper.

Discussion: Discuss why the water moved through the paper towel (capillary action) and how this is similar to how water moves through plants.

Support for K-2 Students:

- Use clear, simple language and visual aids to explain the concept.
- Provide step-by-step guidance during the experiment, ensuring that each student can participate fully.

Discussion Points:

- Reflect on the video and the live experiment. Discuss the capillary action observed in both scenarios and how it illustrates the movement of water through narrow spaces against gravity.
- Encourage students to consider how the video's visual demonstration helped them understand the real-life application in the plant experiment.

Activity 2:

Activity: Toothpick Animation: Exploring Water's Movement

Objective: Learn about how water moves on surfaces and interacts with objects by observing toothpicks on a paper plate.

Materials:

- Glossed paper plates
- Toothpicks
- Pipettes or droppers
- Water
- Food coloring (optional)

Steps:

1. **Set Up**: Group Students into pairs and break toothpicks in half without completely separating them, the place toothpicks in a shape or pattern on the paper plate with the splintered slides touching
2. **Predict**: Guess what will happen when water touches the toothpicks.

3. **Experiment**: Use the pipette to drop water onto the toothpicks and watch them move.
4. **Observe**: Note how the toothpicks shift and why you think it happens.
5. **Change It Up**: Try different patterns or water amounts and see what's different.

Discussion:

- Talk about how the water made the toothpicks move and what this shows about water's behavior.

Share:

- Show your designs and what you discovered to the class.

Watch this video for a guide on doing the activity: Toothpick Animation Activity.

Explain:

Key Terms and Concepts:

Capillary Action: This is how water can move up and around, even going upwards against gravity, like magic! Imagine if you used a tiny straw to sip a drink, and the drink climbed up the straw all by itself. That's what water does in tiny spaces because it loves to stick together and to the sides of things.
Adhesion: This is when water sticks to other things. Like when you see water droplets stick to a window or the side of a glass. It's like water giving a hug to whatever it touches!
Cohesion: This is when water sticks to itself. Have you ever noticed how water drops can form into little balls or how they stick together when you pour them slowly? That's cohesion, showing how water likes to be together.
Surface Tension: This is like an invisible skin on top of water that makes it a bit stretchy. It's why some insects can walk on water without sinking. The water is strong enough at the top to hold them up!

Explanation Strategy:

Use Visual Aids: Support your explanation with diagrams, images, or simple animations that depict capillary action, adhesion, cohesion, and surface tension. Visuals can help students grasp these abstract concepts more concretely.
Relatable Examples: Draw on examples from everyday life or nature that the students might have observed, like how a paper towel absorbs a spill, plants drawing water up from their roots, or insects walking on water.

Interactive Questions: Throughout the explanation, ask questions to engage students and encourage them to think about how these concepts appear in their daily lives. For example, "Have you ever seen water climb up something by itself? Where?"
Demonstrations: If possible, include a quick, live demonstration of water adhering to a surface or moving through a narrow space to reinforce the concept of capillary action.
Conclusion: Wrap up this section by summarizing how capillary action is a fascinating and powerful force in nature that allows plants to drink water from the ground and helps us in many ways. Emphasize that understanding these basic scientific principles helps us appreciate the wonderful and sometimes 'impossible' ways that water moves around us.

Elaborate:

Objective: Observe how water moves through a narrow space by having students craft their own capillary tubes using napkins and straws!

Materials:

- Clear plastic straws
- Water
- Food coloring
- Clear Cups
- Napkins

Procedure:

1. Fill four cups with water and add food coloring. This will be water you distribute to student groups' cups
2. Group the students into groups of 3 or 4 and distribute 3-4 cups, 2 straws and 4 napkins to each group
3. Fill each students cup roughly one inch, or to a measurable line on the cup
4. Have the students cut their straws in half to start, so they have a total of 4 short straws
5. Then have the students cut the length of the napkins into roughly ½ inch, ¾ inch and 1 inch width strips,
6. Next, have the students twist each strip of the napkins into coils, by grabbing one end of the strip of paper with one hand, and twisting the length of the strip with the other hand
7. Once they have done this, have them stick each coiled strip into a straw, so there is a short end sticking l/4 of an inch out of the straw, and a long end dangling from the other end

NOTE: Have the students trim the coiled strips of paper so the paper is only sticking about 1 inch out of the straw

8. DISCUSSION: Based on what students know about capillary action,
    a. What do they think will happen when the straws are placed in the cup?
    b. Which paper thickness do they think the water will travel to the end fastest?
    c. Why do they think this?
9. Have students place their straw into the cup, with the short end of the paper going into the water and watch as the colors in each cup race to the end of the paper material!
10. Have students observe the water's movement through the straw and how the water is moving through the paper
11. Once a winner is declared, repeat these steps, and use the winning paper material housed in a straw, competing against the same width paper strip unhoused in a straw
12. Continue repeating with experimentation if students are enjoying and engaged with the activity

Keep the cups filled with colored water for the race activity at the end!

Discussion:

- After the demo, ask students to share their observations on how paper type, coil tightness and width of strips impacted the speed.
- Once capillary action is explained, discuss their observations again.
- Was the speed impacted by not having the coil housed in a straw? Why do they think this is the case?

Extension (if time allows)

Going back to the coiled paper and straw activity, have students craft their own coil of any napkin strip size that they choose to craft the fastest water moving vessel. The only constraint is once paper is coiled, they must measure 7 inches in length, and all water inside the competing cups are at roughly the same fill line.

Evaluate:

Objective: Use creative expression to reinforce understanding of capillary action by having students design their own “Impossible Science” trick, demonstrating their grasp of how water can move in surprising ways.

Activity Description:
Duration: Allocate the final 15 minutes of every 90-minute lesson plan for this activity.
Materials: Paper, crayons, markers, colored pencils.

Procedure:
Introduction: Briefly recap the key points about capillary action, emphasizing the 'magical' way water can move through materials and plants.

Activity Launch: Challenge students to imagine and draw their own “Impossible Science” trick that showcases capillary action. Encourage them to think of how they can make water move in unexpected ways, similar to how they observed water travel through plants or napkins.

Creative Process: As students work on their drawings, circulate around the room to offer encouragement and ask guiding questions. For example, "How does your trick make the water move?" or "What part of what we learned today is being used in your trick?"
Share and Reflect: Allow time for students to share their drawings and explain their “Impossible Science” trick to the class or in small groups. This sharing process helps reinforce their understanding and allows them to see capillary action concepts from different perspectives.

Support for K-2 Students:
- Offer examples to spark ideas, such as water climbing up a mysterious tower or flowers changing colors.
- Provide assistance as needed to help them articulate their ideas through drawing.

For Grades 3-6:
Objective: Summarize the lesson’s key concepts through workbook activities that reinforce understanding of capillary action, adhesion, cohesion, and surface tension.

Activity Description:
Materials: Workbooks containing a variety of activities such as matching definitions to terms, fill-in-the-blanks, diagram labeling, and short answer questions related to the experiments conducted during the lesson.

Procedure:

Workbook Activities: Students complete the workbook activities individually or in small groups. These activities should cover the definitions of key terms (capillary action, adhesion, cohesion, surface tension), the role of capillary action in nature and technology, and a reflection on the experiments conducted during the lesson.
Reflection: Include prompts that encourage students to reflect on what they found most surprising or interesting about capillary action and how they might observe it in their daily lives.
Discussion: After completing the workbooks, facilitate a class discussion where students can share their answers, discuss any challenges they faced, and ask questions about aspects of capillary action they wish to explore further.

Support for Grades 3-6 Students:

- For struggling students, offer hints or provide a glossary of key terms to help them complete their workbook activities.
- For fast-working or advanced students, include additional challenge questions or extension activities that require them to apply the concepts of capillary action to new scenarios or experiments.

Procedure:

Introduction: Begin by summarizing the concepts learned so far about capillary action, including its principles and the factors that influence it, such as adhesion, cohesion, and surface tension. Briefly recap the experiments conducted in Activities 1 and 2.

Demonstration Setup: Introduce the demonstration setup, explaining its components and the expected outcome. Engage students by asking them to predict the results based on their newfound knowledge of capillary action. This encourages critical thinking and application of their understanding.

Observation and Discussion: After the demonstration, facilitate a discussion about what was observed. Encourage students to describe the process in their own words and relate it back to the scientific principles of capillary action. Ask them to consider how this phenomenon occurs in nature and technology, reinforcing the lesson's objectives and the real-world relevance of their learning.

Discussion Points:

- How does the demonstration show us capillary action at work?
- Think about the ways this demonstration helps you understand the importance of capillary action. How does it help plants live? Can you think of gadgets or tools that use this same water-moving trick?
- Reflect on the demonstration again. What part of it surprised you the most, and why?

- How do you think understanding capillary action can help us solve problems or create new things?

The Reveal: Conduct the demonstration, allowing the setup to showcase capillary action vividly. For example, if using interconnected tubes, students can observe how water moves through the system, defying gravity and expectations.

Materials

The following list outlines all necessary materials and equipment needed for the "Impossible Science" lesson activities, including the demo, main activities, the experiment, and both modified and extension activities. Materials are indicated as needed per student (PS), per student group (PG) - with suggested group sizes, or per instructor (PI).

Impossible Science Demo

- **Bendy Straws**: Multiple straws will be needed to construct the siphon. Ideally, 3-5 straws per siphon should suffice. (PI)
- **Scissors**: To cut and connect the straws into the desired "M" shape for the siphon. (PI or 1 per PG)
- **Clear Cups**: Two per setup. One to hold the colored liquid and one for the clear water. It's essential that at least one cup is transparent to observe the color change. (2 per PG)
- **Water**: Enough to fill the clear cups halfway. (PI)
- **Food Coloring**: A variety of colors can be used to demonstrate the color change more vividly. (PI)
- **Ruler or Measuring Tape**: To assist in the construction of the straw siphon, ensuring the straws are cut to the appropriate lengths. (1 per PG)
- **Paper Napkins or a Tray**: To manage any spills during the experiment. (PI or 1 per PG)
- **Non-transparent Container**: This is optional but can be used to conceal the colored liquid for a more dramatic reveal. The container should fit inside the non-transparent cup or be placed beneath it if the setup allows. (1 per PG)
- **Notebook and Pencil**: For students to record predictions, observations, and conclusions. (PS)

Activity 1:

- **Paper Napkins**: 1 per student (PS)
- **Clear Cups**: 2 per student (PS)
- **Water**: Sufficient quantity for all cups (PI)
- **Food Coloring**: A few drops for each set of cups or bowls (PI)
- **Tray or Waterproof Surface**: 1 per student or group, depending on setup (PS or PG)

- **Notebooks or Paper**: 1 per student (PS)
- **Pencils or Crayons**: 1 per student (PS)

Activity 2: Water races

- **Napkin:** 1 per student (PS)
- **Clear Cups**: 1 per student (PS)
- **Water**: Sufficient quantity for all cups (PI)
- **Food Coloring**: A few drops for each set of cups or bowls (PI)
- **Tray or Waterproof Surface**: 1 per student or group, depending on setup (PS or PG)
- **Notebooks or Paper**: 1 per student (PS)
- **Straws:** 2 per student group of 4

Activity: Toothpick Animation: Exploring Water's Movement

- **Glossed Paper Plates**: 1 per student (PG)
- **Toothpicks**: A handful per student (PS)
- **Pipettes or Droppers**: 1 per student (PS)
- **Water**: Available for all students (PI)

For the Impossible Science Trick (Creative Expression Activity)

- **Paper**: 1 sheet per student (PS)
- **Crayons, Markers, Colored Pencils**: Enough for the class to share (PI)

For Grades 3-6 Workbook Activities

- **Workbooks**: 1 per student (PS), containing activities related to capillary action (definitions, diagram labeling, fill-in-the-blanks, short answer questions)