Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

Over the course of one 50-minute class period, students will determine how many drops of water, rubbing alcohol, and vegetable oil can be placed on a penny before the liquid spills over.

Correlations to NC Science Standards

ESS.8.2.1 Use models to explain the structure of they hydrosphere including: water distribution on earth, local river basins, estuaries, and water availability.

Learning Target

Students will demonstrate knowledge and understanding of the following water properties:

- cohesion
- adhesion
- polarity
- surface tension

Students demonstrate this knowledge and understanding by comparing the three liquids.

Brief Science Background

Water molecules form bonds of attraction, and they form some of those bonds *between each other.* The bonds are electrical, like the static electric attraction between a balloon and the wall. The hydrogen parts of the molecule have a bit of extra positive charge, and the oxygen part has a little extra negative. These parts are like positive and negative "poles." That's why water is called **polar**. Each end of a water molecule is attracted to the oppositely charged end of another water molecule. This is called **hydrogen bonding**. The hydrogen bonds make water tend to stick to itself, a quality called **cohesion**. Cohesion shapes the way water behaves. It causes water to form drops. It also produces the skin-like surface on top of water called **surface tension**. When insects walk on water, they walk on surface tension. The static charges can also make water stick to other things (like glass), a quality called **adhesion**.

Oil is not polar, so it attracts itself very little. Because of this, oil spreads out on a penny to form a thin layer. Rubbing alcohol molecules are slightly polar, with a weak attraction between molecules. On a flat surface, a drop of rubbing alcohol forms a flatter and smaller drop than water. The difference in 'polarness' among the three liquids makes them behave differently when you drop them carefully on the surface of a penny. You can pile water into a dome shape before it spills over. You can also pile up rubbing alcohol, but it spills over before it forms much of a dome. Oil will barely pile up at all. As a result, you can put much more water on a penny.

How Many Drops?

Materials

Materials for the whole class

- rubbing alcohol
- vegetable oil
- water (supplied by teacher)
- paper towels (supplied by teacher)

Materials for groups of 2 students

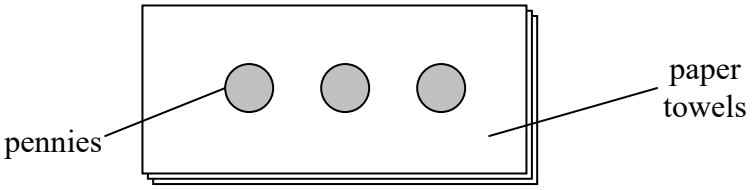
- 3 disposable pipettes
- 3 pennies
- 1 9-oz squat cup containing about 1/4 inch of water
- 1 9-oz squat cup containing about 1/4 inch of rubbing alcohol
- 1 9-oz squat cup containing about 1/4 inch of oil
- 3 paper towels
- 2 student instructions (SD 1)
- 2 student activity sheets (SD 2)

Preparation
allow for 20 min.

1. Pour three 9-oz cups for each group: one with about 1/4 inch of water, one with 1/4 inch of rubbing alcohol, and one with 1/4 inch of vegetable oil. Set out remaining materials for each group.

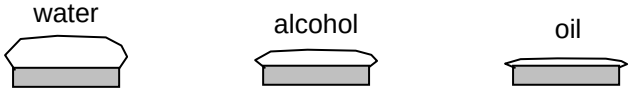
Procedure

1. Have students put a pipette in each of the three plastic cups with the three different liquids. During the activity, students **must keep each pipette with its own liquid and not use it with any other liquid.**
2. Have students place their folded paper towels in front of them in a neat stack, smoothed flat. Place the three pennies a few inches apart in the middle of the paper towel. Ask students to discuss how they arranged their pennies. Same sides up? Which sides? Different sides up? Why?



An alternative could be to require all students to set up their pennies exactly the same way—all heads up or all tails up—and to label each penny with the liquid it will get. This would reinforce the notion of uniformity and labeling in experimental design. On the other hand, a discussion of the variability of results might bring out the same points.

3. On their student activity sheet (SD 2), have students predict a) which of the three liquids will allow them to put the most drops on penny, and b) which of the three liquids will allow them to put the fewest drops on a penny. Give their reasons for each prediction.
4. Allow students to follow the student instructions (SD 1) and get to work. Emphasize to students that they will draw table-level views of the pennies and liquids on the last trial of each liquid. The drawings may looks like this:



Procedure cont.

5. After students have tested all three liquids, ask "Which aspects were we able to control? Which aspects were we not able to control? How did this impact our data?"
   Aspects such as coin type, side of coin used, temperature, humidity, time of day, liquids used, types of pipettes, etc., are usually controlled. Condition of pennies, dropping techniques, and cleanliness of pipettes, etc., are usually uncontrolled.

6. Discuss the following as a class:
   - Compare their results to their drawings. What do they notice?
     For each liquid, have a student place their drawing on the board. Students will notice that water seems to hang off the side of the penny.
   - Compare their results to their predictions.
   - Which liquid had the highest median number of drops on the penny? Lowest? In between?
   - Why do you think the medians are different?
     Dive into the ideas about why water holds the most drops on a penny. Many will say "thickness" or weight. Some will even say “water has a skin on it.” The "thickness" of liquid can be defined as the viscosity. Students may say that oil is more viscous, so it oozes off the penny. They might say the "heaviest" liquid comes off the penny with the fewest drops. This could lead to a good discussion of density.

7. Ask students to explain their ideas of how to test their explanations on why the medians are different. If time permits, allow testing.
   To test viscosity, they can race drops of the liquids down an inclined plane. To test the "heaviest" liquid they can weigh the same volume of each liquid and calculate the density. If they say oil is the densest, so the penny holds less of it, they might test this by layering the three liquids. If oil were densest, it would be on the bottom. On the contrary, it will be on top. This doesn't support the explanation, but the test does shed light on the explanation, so it is a success.

Content Connection

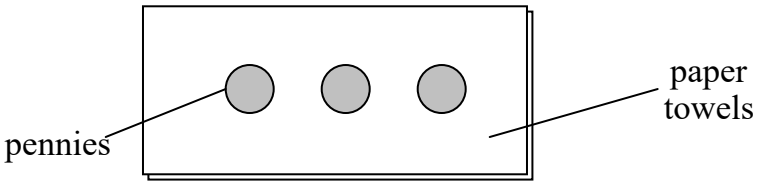
1. Discuss with students that water has unique properties. In this activity they were able to see:
   - water has a completely different shape on the penny. It appears to “pile up” on the penny and often appears to “hang over” the side of the penny, often looking like a muffin top. This is caused by the polarity of the water molecules.
   - water can be attracted to another substance. This is called **adhesion**
   - water can be attracted to itself. This is called **cohesion.**
   - the surface of water can have a "skin like" top. Cohesion is very strong at the surface of water creating a tension. This is called **surface tension**

2. Ask students to look at their drawing of water on a penny and label where adhesion, cohesion, and surface tension would be.

SD 1

How Many Drops? Student Instructions

1. Put a pipette in each of the 3 plastic cups with the three different liquids. **Keep each pipette with its own liquid and do not use it with any other liquid.**
2. Keep your paper towels folded and pile them in a neat stack, smoothed flat. Set the 3 pennies a few inches apart in the middle of the paper towel.



3. On your student activity sheet, predict a) which of the three liquids will allow you to put the most drops on penny, and b) which of the three liquids will allow you to put the fewest drops on a penny. Give your reasons for each prediction.
4. Drop water on a penny slowly and gently. Note how far you are dropping from. Is it near the penny or higher up? How high? **Count the drops.** Stop when a drop makes the water overflow the edge of the penny and don't count the drop that caused the overflow. Record the number of drops under trial 1 for water. Wipe off the penny and repeat 2 more times. Circle the middle number. **On the last trial, before the water overflows, place your eye at table level. View the penny and water from the side. Draw what you see on your student activity sheet.**
5. Repeat step 4 with rubbing alcohol. Again record the number of drops for 3 trials. Circle the middle number from the 3 trials. **On the last trial, view the penny and rubbing alcohol from the side at table level, draw what you see on your student activity sheet.**
6. Repeat step 4 with oil. When finished, your student activity sheet should contain a record of all 3 trials of each liquid with the median, middle number, indicated. It should also contain drawings of the three pennies with liquids as seen from table level.
7. When you are done, use clean spots on the paper towels to wipe up any liquid that has soaked through to the tabletop.

SD 2

How Many Drops? Student Activity Sheet

Name:

1. Predict which of the three liquids will allow you to put the most drops on a penny. Give a reason for your prediction.

2. Predict which of the three liquids will allow you to put the fewest drops on a penny. Give a reason for your prediction.

3. Record your results for each liquid below.

Substance	Trial 1	Trial 2	Trial 3	Drawing
Water				
Rubbing Alcohol				
Oil				

4. Compare your results to your drawings. What do you notice?

5. Compare your results to your prediction.

6. Which liquid had the highest median number of drops on the penny? Lowest? In between?

7. Why do you think the medians are different?

8. Design a way to test your explanation from #7. You won't have to do the test, so it can include materials not on hand. However, the test should show if your explanation makes sense.