

# The Young Scientist Program Surface Tension Teaching Kit Student Handout

Washington University Medical School  
Funding provided by The Leon Lowenstein Foundation  
<http://ysp.wustl.edu>

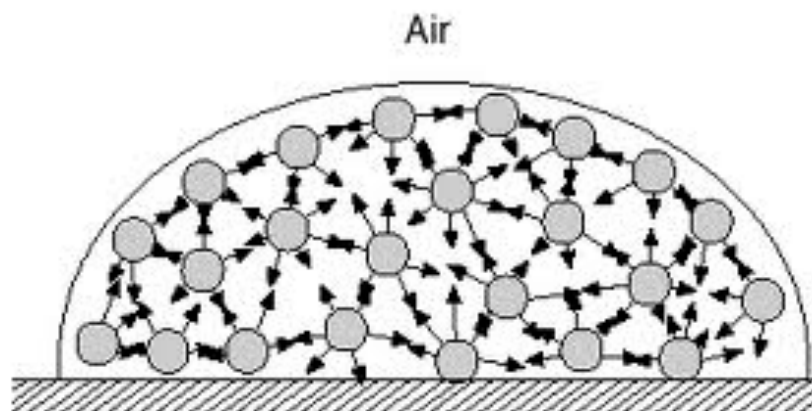
## Goals:

1. To understand the concept of surface tension.
2. To demonstrate that surface tension is a physical property of liquids (i.e. water)
3. To demonstrate that surfactants can reduce the surface tension of a liquid.

## Background information:

**What is surface tension?** Surface tension is a phenomenon in which the surface of a liquid acts like a thin elastic sheet when it is in contact with an external force, such as a gas. This physical property allows the surface of a liquid to “resist” the pressure of the external force by reducing its interaction with the force. The optimal shape for limiting this contact is a dome like structure, visualized as the liquid “beading up”.

In a drop of liquid, attractive forces pull molecules together (cohesion). An example of this is the bonding of water molecules to each other between partial negative (due to oxygen atoms) and positive (hydrogen atoms) components. This cohesion results in an optimized surface where the molecules pack closely together instead of towards air. This intermolecular force results in the surface molecules being pulled inward, forming a bubble, illustrated below. The surface tension is related to the strength of the forces at work (which are relatively weak) and the area over which they are exerted. Because the attraction of surface molecules inwards is much stronger than the attraction to air, surface tension is created and the liquid beads up to maintain the liquid-air interface with a minimum surface area.



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Water has very strong surface tension, and this is one of water's most important properties. It is the reason that water collects in drops, but it is also why water can travel up a plant stem, or get to your cells through the smallest blood vessels. It even allows insects to walk on water!

**Insects walking on water.** Several insects are able to walk on water, such as the water strider (right). Their legs are shaped to distribute their weight over a larger surface area so that the insect's weight is better balanced. The strong surface tension of the water can then hold the insects weight and prevent the bug from sinking due to gravity.



**What is a surfactant?** A surfactant is the scientific name for any molecule that reduces surface tension. Surfactants are made up of polar parts that are attracted toward water (hydrophilic) and other non-polar parts that repel water (hydrophobic). When such a molecule is placed in a system of opposing forces (i.e. air-water or oil-water), the hydrophilic groups orient toward the water, and the hydrophobic groups orient away (towards air or oil). This lowers the surface tension because now the water can interact with both other water molecules *and* the water loving portions of the surfactant. This means the molecules of water are no longer forced into a tight cohesion with each other but can spread into a wider area. You can observe this effect by watching the dome structure formed by drops of water on a surface collapse with the addition of a surfactant.

Surfactants have many commercial uses and depending on the use can be called by many names, including: -wetting agents, emulsifying agents, solubilizing agents, and detergents or soap. Surfactants also play an important role in the body. For example:

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phospholipids are a key component in cell membranes, which act as a protective surface against the environment

We can observe surfactants at work in everyday life when attempting to combine two not easily mixed liquids such as oil and water. The reason that these liquids do not mix together is because when they come into contact they tend to maintain as small a surface as possible: resulting in surface tension! However, a surfactant can enable these two liquids to mix more readily by reducing the surface tension. A good example of this is an oil and vinegar salad dressing where the addition of a proper surfactant will lower the tension between the two liquids and allow them to mix: creamy salad dressing contains egg yolk or an artificial surfactant to do just that.

Surfactants are also widely used in pharmaceuticals. Surfactants are commonly added to drug suspensions to hinder caking of medications during storage, for reconstitution of powdered forms of medication into water at later use, or as an additive to tablets to aid in the penetration of moisture into the tablet for ready disintegration upon administration.

## **Experiment #1: Visualizing Surface Tension on a Penny**

In this experiment, you will visualize the surface tension of water by dropping water onto a penny with an eyedropper. Soap (a surfactant) will then be added to the water to test if this changes how many drops can be held on the penny.

### **Materials:**

Penny  
2 Eyedroppers  
1 cup with water  
1 cup with soapy water  
Paper towels.

### **Protocol:**

- 1) Take a clean penny and place it on a paper towel.
- 2) Load your eyedropper with water.



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- 3) Carefully add water to the penny, one drop at a time. Count each drop and observe the shape.
- 4) After 5 drops, write down how many drops you think can be held on the surface of the penny.
- 5) Continue dropping water onto the penny until the surface tension can't hold the water together anymore and the bubble collapses.
- 6) Dry off your penny and repeat the experiment with the soapy water and a different eyedropper. Drop 5 drops, observe the shape, and guess how many drops the penny will now be able to hold.

Challenge: see who can get the most water on the pennies!

## Discussion Questions

- 1) Were you able to add more or fewer drops to the penny with the soapy water?
- 2) Were you surprised by how many drops of water the penny could hold?
- 3) How does surface tension explain how rain comes down in droplets instead of in a sheet?
- 4) Question for thought: Why does the water become a sphere? Why not a triangle or a rectangle?



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#### **Experiment # 3: The Strength of Surface Tension**

In this experiment you will see how surface tension can hold the weight of a paper clip, such that it floats upon the water.

#### **Materials:**

1 cup of water  
Soap  
2 small paper clips  
Paper towels

#### **Protocol:**

1. Place the cup of water on a paper towel. Take one paper clip and drop it into the cup. Observe if it floats or sinks.
2. Tear off a piece of paper towel that is slightly larger than the size of a paper clip. Place this flat on top of the water.
3. Carefully place the paper clip on the widest side on the piece of paper towel. Once the paper towels get wet, observe if it sinks or floats.
4. Add a drop of soap into the cup of water.

#### **Discussion Questions**

1. Is a paper clip more or less dense than water? Will it sink or float?
  
  
  
  
  
  
  
  
  
  
2. What was different about the paper clip that was dropped into the cup versus the one that floated?
  
  
  
  
  
  
  
  
  
  
3. What happened with the addition of soap?

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4. What else might be able to float on water? How about in water with soap?
  
5. How do some insects walk on water? Could YOU somehow walk on water?

#### **Experiment #4: The Great Effect of Surfactants on Surface Tension**

This experiment from the 1800's was quite popular, as it shows what seems to be sudden movement caused by no actual observable forces. Using surface tension and surfactants, pepper can be made to move across a bowl of water.

#### **Materials:**

Pepper  
Soap  
A large tin  
Water

#### **Protocol:**

1. Fill the bowl or pan with water
2. Sprinkle the pepper so that it floats evenly on the surface of the water.
3. Put a drop of oil or soap in the center of the pan.
4. Observe what happens!

#### **Discussion Questions**

1. What happened to the pepper?

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2. How did this happen?
  
  
  
  
  
  
  
  
  
  
3. What caused the pepper to stop?

## **Teacher Demo: Putting out a Candle with a Soap Bubble**

Watch your teacher perform this experiment, where they use a soap bubble to blow out a candle, then think about the following questions.

## **Discussion Questions**

1. How was the air generated?
  
  
  
  
  
  
  
  
  
  
2. What force caused the air to blow out the candle?
  
  
  
  
  
  
  
  
  
  
3. How else could surface tension be used to generate a directional force, like the air through the funnel? What could this be used for?