Soap: How does it Work?
Primary Audience: Elementary, Middle, and High School

Video: [COVID-19 Science Now](#)

Part 1 (Early Childhood/Elementary)

**Description:** Talk about how soap gets rid of germs with this simple but fun demonstration.

**Materials:**
- 1 shallow bowl, pie dish, or plate
- Water
- Pepper
- Dishwashing soap

**Instructions:**
1. Pour water into a shallow bowl, pie dish or plate.
2. Sprinkle pepper on top. This represents germs.
3. Have child stick their finger into the “pepper germs.” What do they observe?
   - a. The “germs” probably got all over the child’s finger!
4. Now, have child stick a finger from the other hand into dish soap. Then stick that finger into the “germs.” What do they observe? Discuss.
   - a. The soap causes the pepper to rapidly move away from the child’s finger. This represents how soap gets rid of germs!

**Possible Interactive Questions:**
- Why do we use soap to wash our hands?

**What’s going on?**
Pepper is *hydrophobic*, meaning that it does not mix with water. Pepper flakes are also not very dense, and the surface tension of the water holds the pepper on top. But soap breaks that surface tension, and the water will move away from the soap (carrying the pepper with it)!
Part 2: (Elementary/Middle/High)

Materials:
- 1 shallow bowl, pie dish, or plate
- Whole milk (you want the fat in there)
- Food dye, any color(s)
- Q-tip(s)
- Dishwashing soap

Key Words:

Hydrophilic – Water-loving; a molecule or material that readily bonds with water

Hydrophobic – Water-fearing; a molecule or material that will not bond with water

Polar – A molecule is polar if it is electrically neutral overall but has a separation of charge: one end is slightly positively charged while the other end is slightly negatively charged.

Nonpolar – A nonpolar molecule does not have a distribution of charge across the molecule. Fats and oils are examples of nonpolar substances. Nonpolar molecules can be described as hydrophobic.

Amphipathic – An amphipathic molecule is defined as having both hydrophilic and hydrophobic parts. Soap is amphipathic.

Micelle – A structure that is formed when amphipathic molecules like soaps or detergents are added to water. Due to the hydrophilic-hydrophobic interactions, the hydrophobic tails will cluster together, protected from the surrounding water by the hydrophilic heads.

Concepts:
The molecular structure of soap is amphipathic, which is different from that of water (which we call polar) and fats and oils (nonpolar). When you wash your hands, the soap surrounds viruses, bacteria, microorganisms, dirt, and anything else on your hands with packages of soap molecules called micelles. These micelles are easily rinsed down the drain by water.

Did you know? Viruses like SARS-CoV-2, also called the “novel coronavirus,” are packed in their own package of amphipathic molecules – called a lipid bilayer. The amphipathic soap molecules will get into this lipid bilayer, breaking it open and destroying it!
Instructions:

1. Cover the bottom surface of the shallow bowl, pie dish, or plate with whole milk.
2. Have child drop a few drops of food dye onto the surface of the milk. Do not stir.
3. Dip one end of the Q-tip into dishwashing soap and gently touch that end into the milk. Observe what happened and record your observations.
4. Repeat as much as you’d like, with more or less of any ingredient.

What’s going on?
Milk is mostly water, which is polar. But it has fat (nonpolar) suspended in it. Whole milk has more fat than other types of milk like skim or 1%. When the soap is added to the mixture, all of a sudden the molecules will start moving around! The soap molecules are racing around to create micelles that hold nonpolar fat on the (hydrophobic) inside and keep polar water on the (hydrophilic) outside of the micelle. The food dye helps us to observe all of this rapid activity that’s happening on the molecular level!

Extension 1: Did all of the fat molecules get packaged into micelles? Try adding a little more dish soap to see!

Extension 2: What do you think will happen if you changed a variable?

1. Design an experiment that would change just one variable in this experiment. Be sure to write down what you’re going to do BEFORE you do it. For example…
   a. Are you going to test other substances besides whole milk?
   b. Are you going to test different container shapes?
   c. Are you going to test different amounts of any ingredient?
   d. Are you going to test different soaps?
2. Once you have designed your experiment, carry it out carefully! Be sure to use a notebook to keep track of your observations during the experiment.
3. Share your results! What happened? Based on what you have learned, why do you think that happened?
Part 3: (Middle/High)

Materials:
- Printouts of soap molecules and fat molecules, cut into individual pieces

Concepts:
Once you have performed the milk, food dye, and soap demo, you have an idea of what is going on. In this piece, we are going to zoom in on the molecules to show in detail what is actually happening!

Instructions:

1. First, be sure to complete Part 2 of this lesson.
2. Now, we will show what is happening on a molecular level. Find a surface to represent your milk. Milk is mostly water, so add plenty of paper H₂O molecules to the surface.
3. Whole milk also has fat in it. Add some fat molecules to the table. (They’ll be dispersed throughout the water).
4. Now we are going to add soap to the table. Remember what happens when the soap is added? Have your child take some time to arrange the soap molecules according to the following rules:
   a. The nonpolar side of the soap can only touch the fat molecules
   b. The polar side of the soap can only touch the water molecules


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Additional Resources:
Reach out to the COSI Department of Science Content by emailing sciencequestions@cosi.org if you have any questions or comments!
Printouts:

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Diagram of water molecules (H₂O):
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