GRADES K–2

TIME
10–15 minutes

COLOR-CHANGING MILK

Science

CHILDREN'S MUSEUM INDIANAPOLIS®

COLOR-CHANGING MILK

The Children's Museum's lessons are designed to weave classroom experiences and museum education together. All lessons are interdisciplinary and can be used as individual classroom experiences or in combination to create a cohesive unit. Lessons are optimized when used in connection with museum field trips.

Soap plays a big role in keeping us clean and healthy. But how does soap work? In this lesson, students will review states of matter and learn that we can also characterize materials by how they respond to water. Soap's ability to both attract and repel water makes it a powerful tool for cleaning away dirt and germs. By using a few household items, students can observe a molecular dance play out in a burst of color. Get ready to explore what a tiny drop of soap can do.

***This lesson pairs well with our lesson Tie Dye Paper. Check out both lessons for a double helping of colorful science.*

FOCUS QUESTIONS

- What are the properties of solids, liquids, and gasses?
- How do different materials respond to water?
- Why does the food coloring move around within the milk?
- How does soap work?

STATES OF MATTER

Matter is anything that has mass and takes up space. Matter is made of tiny particles called atoms, which can combine to form other particles called **molecules**. Matter can take a variety of forms, or states. Below are three common states of matter.

Solid: In a solid, the molecules are very close together and do not move very much. A solid keeps its shape. The plates and cotton swabs in this lesson are solids.

Liquid: In a liquid, molecules are close together (but not as close as molecules in solid) and move around a little bit. A liquid takes the shape of its container. The food coloring, milk, and dish soap in this lesson are liquids.

Gas: In a gas, the molecules are far apart and move around a lot. The air you are breathing is a gas.

INDIANA ACADEMIC STANDARDS

Science: 1.PS.1, 2.PS.1

OBJECTIVES

Students will:

- Discover that some materials attract water and some materials repel water.
- Make and test predictions about how various materials will respond to water.
- Discover that soap is hydrophilic and hydrophobic, which allows it to clean away dirt and germs.

MATERIALS

- Milk (whole or 2%)
- Large plate or shallow dish
- Small plate or bowl
- Food coloring (red, yellow, green, and blue)
- Dish soap
- Cotton swabs

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Color-Changing Milk Experiment

PROCEDURES

1. Show students the materials for the lesson and explain that they will use these materials to learn about how soap works. Ask students to characterize the materials for the lesson as a **solid**, a **liquid**, or a **gas** and to explain their reasoning.
2. Explain that, in addition to characterizing materials by their states of matter, we can characterize them by other properties. For example, some materials repel water, and others attract water. Materials that repel water are called hydrophobic (water-fearing), and materials that attract water are called hydrophilic (water-loving).
3. Explain that food coloring is made mostly of water, while milk is made of water, fat, and protein. Ask students to make predictions in response to some of the following questions.
   a. What do you think will happen if you add food coloring to milk? Will the milk attract or repel the food coloring?
   b. What do you think will happen if you add soap to food coloring? Will the soap attract or repel the food coloring?
   c. What do you think will happen if you add soap to milk? Will the soap attract or repel the milk?
4. Guide students through the color-changing milk experiment. Encourage students to observe how the different liquids respond to each other.
5. Discuss students' observations about how the milk, food coloring, and soap responded to each other and how these observations compare to their predictions.
6. Explain that milk fat is hydrophobic, so the food coloring floated on top of the milk rather than fully mixing with it. Soap molecules, on the other hand, have two parts: a hydrophilic head and a hydrophobic tail. Because the hydrophobic tails of the soap molecules want to avoid water, they race to bond with the milk fat. As they race around, they drag the food coloring with them, which causes the colors to move around the plate. Because soap molecules are both hydrophilic and hydrophobic, they help us clean away dirt and germs.
7. Encourage students to repeat the experiment and make additional observations. Students can also experiment with different techniques and materials.

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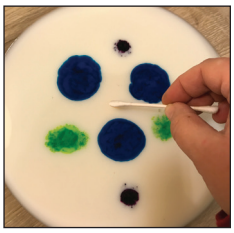
1 Pour a small amount of soap onto the small plate.

2 Pour milk onto the large plate. The milk should cover the entire plate and be about a quarter of an inch deep.

3 Squirt one drop of each of the four colors of food coloring onto the milk. Keep all four drops close together.

4 Ask students to predict what will happen if they touch the tip of a fresh cotton swab to the drops of food coloring on the milk. Test the prediction and ask students if they think the reaction will be different with soap.



5 Dip the tip of a fresh cotton swab into the dish of soap.

6 Touch the soapy cotton swab to the drops of food coloring on the milk.

Move Like A Molecule

Use this kinesthetic activity to deepen understanding of states of matter.

Instruct students to make two fists. Explain that each fist represents a molecule. Use the directions below to model how molecules behave in different states of matter.

1. Ask students to press their fists together so that their knuckles are touching, then keep their fists still. This is how molecules behave in a solid.
2. Ask students to keep their fists touching and slide them up and down against each other. This is how molecules behave in a liquid.
3. Ask students to move their fists far apart and move them around quickly. This is how molecules behave in a gas.

Say "solid," "liquid," or "gas" at random and ask students to model each state of matter with their fists.

WHAT'S HAPPENING IN THE MILK?

The short answer: a lot. Milk is made of water, fat, and protein. When soap enters the milk, the soap molecules have many choices about what to do next. Some use their hydrophobic tails to bond with the fat molecules. Others use their hydrophilic heads to bond with the water molecules. Still others bond with protein molecules. As all these molecules race to find each other, they bump each other around. Normally, we would not be able to see all of this activity because molecules are too small to see with our naked eyes. However, as the soap and milk molecules move around, they move the food coloring molecules around with them. The food coloring's movement highlights the molecular dance going on inside the milk.

IT'S GREEK TO ME

Materials that **repel** (push away from) or do not mix well with water are called **hydrophobic**. Materials that **attract** (stick to), mix well with, or are mostly made of water are called **hydrophilic**. Many scientific terms have Greek roots. For example, the prefix *hydro-* stems from the Greek word for "water." The suffix *–phobic* stems from the Greek word for "fear," and *–philic* stems from the Greek word for "love." Therefore, hydrophobic means "water-fearing," and hydrophilic means "water-loving."

VOCABULARY

- **Matter**
- **Solid**
- **Liquid**
- **Gas**
- **Repel**
- **Attract**
- **Hydrophobic**
- **Hydrophilic**

HOW SOAP WORKS

Soap is a simple substance capable of great things. Soap molecules have two parts: a hydrophilic (water-loving) head and a hydrophobic (water-fearing) tail. These two parts allow soap to join, or bond, with water and other things at the same time. The head bonds with water. The tail avoids water and bonds with fat and oil.

Oils and fats belong to a group of organic compounds called lipids. Some viruses and bacteria have lipid membranes. When soap molecules encounter one of these microbes, their hydrophobic tails wedge themselves into the microbe's membrane, which breaks the microbe apart. Soap molecules then surround the microbe fragments with their tails and trap them in tiny bubbles. Soap can also trap dirt this way. Meanwhile, the hydrophilic heads of the soap molecules bond with water. When water washes the soap away, the soap pulls microbes and dirt away with it.

CHANGE IT UP!

Encourage students to experiment with different techniques and materials. For each change below, encourage them to make predictions and compare them to their observations.

- Change the spacing of the food coloring drops (far apart versus close together).
- Apply all the food coloring drops directly on top of each other in the center of the plate. When students add the soap, the food coloring should spread out towards the edge of the plate. They can then add soap to the edge of the plate and observe what happens.
- Vary the amount of fat in the milk. Try using skim or one percent milk. You could even try using half-and-half or heavy cream.
- Use different types of soap (hand soap, laundry detergent, shampoo, etc.)