



Mission: Can we draw lines to control how materials move?

Age: 5+

Materials: \$8

Time: 30 min

(Set-up: 5 min Activity: 20 min Clean-up: 5 min)

What you need:

Materials:

- 4 coffee filters (or paper towels)
- Sharpie marker
- Food coloring (at least 2 colors)
- Water

Equipment:

- Ruler
- Scissors
- Small cups

What to do:

1. Cut a 2-inch square from a coffee filter. Using a Sharpie marker, draw the lines shown in Figure A on the next page. Cut away the shaded area to leave two tabs (A and B) on the bottom.
2. Pour water into the cups, filling them close to the top. Add one color of food coloring to each cup, enough to make the colored water very dark (10 drops or more). If you want to try different color combinations, you are definitely welcome to do so! Swirl gently to mix.
3. Place the coffee filter into the cups so that tab A dips into one color and tab B dips into the other. You can hold the paper device by hand or using a clamp (clothes pin) or tall glass to support it. (See figure B.)
4. Watch as the colored water moves up the filter. What happens as the path divides? Try drawing other designs!

Notes:

- Paper towels work just as well as coffee filters.
- To avoid color-leakage issues, make sure the boundaries drawn by the sharpies are dark enough.
- If you want the fluid to go faster, you can try to make the device smaller than 2 inches. Also, you can sit the device flat on the two cups, like in figure C on the next page.
- Why not draw your favorite pattern and see how flow can color them. See Figure D for some examples we made to inspire you.

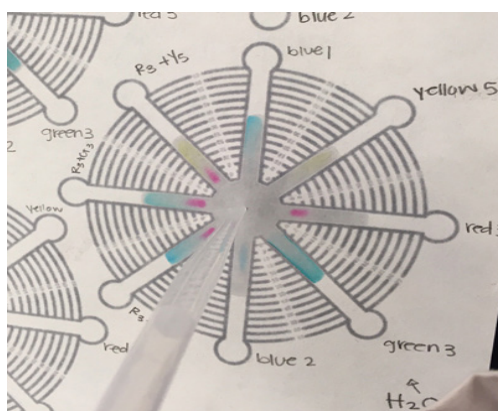
Clean-up:

Colored water can be poured down the drain. Throw coffee filters in the trash. Please be aware that the Sharpie can leave a stain on the desk, which can be cleaned up with isopropanol or alcohol.

What's Happening?

You may have noticed that the colored water stayed inside the lines as it moved up the strip. Different materials have different chemical properties that affect how they behave with water. Hydrophilic materials attract water, making contact and mixing easily. Hydrophobic materials repel water, beading up or separating out. In this case, the ink in the Sharpie marker is hydrophobic and repels water, so the colored water cannot cross the lines you drew. This allows you to control how the water flows and where the colors mix. Also, since paper has a porous structure, the colored water can freely flow through the pores.

So What?



This behavior is important for materials scientists because they can use the hydrophobic/hydrophilic boundary to direct fluid flow and design different mixing effects. Also, since paper is widely available and easy to use, it is an ideal material to use for building inexpensive devices.

For example, chemicals can be added to the paper that can react with a certain solution when it comes into contact. This can be used for building devices such as pregnancy tests or blood glucose measuring kits. Currently, new paper-based materials are being developed to perform many kinds of medical testing which can be used at low cost in parts of the developing world or for detecting harmful environmental toxins like lead and other heavy metals.

Figure A

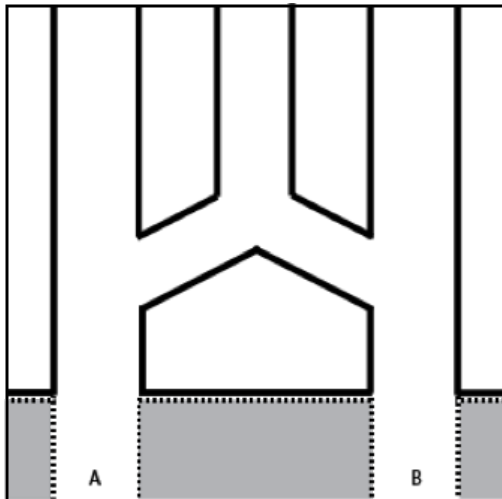


Figure B



Figure C

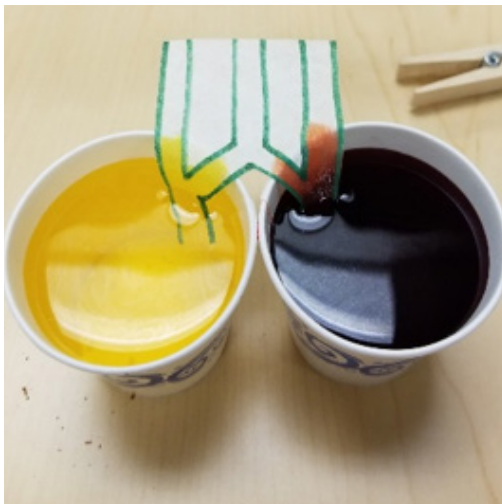


Figure D



NGSS Alignment of Color Control Activity

The information below may not include every area that this activity can be linked to NGSS concepts

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Grade 2
 - ◇ Different Properties are suited to different purposes.
- Grade 5
 - ◇ Measurements of a variety of properties can be used to identify materials.
- Middle School
 - ◇ Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Performance Expectations

2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

5-PS1-3 Make observations and measurements to identify materials based on their properties.

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Crosscutting Concepts

Cause and Effect

- Grade 3-5
 - ◇ Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Middle School
 - ◇ Cause and effect relationships are routinely identified, tested, and used to explain change.

Engineering and Science Practices

Planning and Carrying Out Investigations

- Grade 3-5
 - ◇ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
 - ◇ Make observations and/or measurements to produce data to serve as the basis for an explanation of a phenomenon or test a design solution.
- Middle School
 - ◇ Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
 - ◇ Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.