# Candy Chromatography: What Makes Those Colors?

## Kit Contents

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petri dish</td>
</tr>
<tr>
<td>Pipets, 2</td>
</tr>
<tr>
<td>150 ml glass beaker</td>
</tr>
<tr>
<td>400 ml glass beaker</td>
</tr>
<tr>
<td>Filter paper, pack of 10</td>
</tr>
<tr>
<td>Isopropyl alcohol, 30ml</td>
</tr>
<tr>
<td>Wooden splints</td>
</tr>
<tr>
<td>M&amp;Ms</td>
</tr>
<tr>
<td>Skittles</td>
</tr>
<tr>
<td>Food coloring</td>
</tr>
<tr>
<td>Binder clips, 2</td>
</tr>
<tr>
<td>Colored markers</td>
</tr>
<tr>
<td>Permanent black marker</td>
</tr>
</tbody>
</table>

## You will also need from home:

- Scissors
- Pencil
- Plastic wrap
- Metric ruler
- Measuring cup and container for 4 cups of water
- 1/8 or 1/4 teaspoon (tsp) measuring spoon
- Salt
- Water
- Lab notebook

## Summary

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>No issues</td>
</tr>
</tbody>
</table>

## Introduction

Have you ever had a drop of water spoil your nice print-out from an inkjet printer? Once the water hits the paper, the ink starts to run. The water is absorbed into the fibers of the paper by capillary action. As the water travels through the paper, it picks up ink particles and carries them along. This same process that spoils a perfect print-out can also be put to good use. There is even a name for it: paper chromatography.

Chromatography is a group of techniques, including paper chromatography, that are used to separate the various components in a complex mixture or solution. In each chromatography apparatus there is generally a mobile phase, which is a fluid the solution is dissolved in, and a stationary phase, which is a material the fluid moves through. For example, in paper chromatography, water is the mobile phase and filter paper is the stationary phase. The mobile phase is also called the solvent.

How does the chromatography setup separate the components in the solution? The components ideally move at different speeds as they travel through the stationary phase. This is done by adjusting the mobile and stationary phases so that they interact with different properties of the solution's components, such as their molecular size, electrical charge, or other chemical properties, to distinguish and separate them from each other. In paper chromatography, different pigments can be separated out from a solution based on the solubility of the pigments. A pigment that is more soluble (or more hydrophilic) than another pigment will generally travel farther because it will be easier for it to dissolve in the mobile phase (water) and be carried with the mobile phase along the stationary phase (filter paper). A pigment that is less soluble (or more hydrophobic), or interacts more with the filter paper than the water, will generally travel a shorter distance.

Another example of a chromatography system is a glass column filled with tiny, inert beads (the stationary phase). The solution to be separated is added to the column, and is then "washed out" with some type of fluid (the mobile phase). In this case, the separation is based on molecular size. Smaller molecules will pass through the spaces between the beads more easily, so they will come out of the column more quickly. Larger molecules will take more time to pass between the beads, so they will come out of the column later. You can separate the smaller molecules from the larger molecules by collecting the liquid that comes off such a column in a series of separate containers.

You can probably now imagine how chromatography can be used to separate (purify) specific components from a complex mixture and identify chemicals, for example crime scene samples like blood, drugs, or explosive residue. Highly accurate chromatographic methods are used for process monitoring, for example to ensure that a pharmaceutical manufacturing process is producing the desired drug compound in pure form.

In paper chromatography, you can see the components separate out on the filter paper and identify the components based on how far they travel. To do this, we calculate the retention factor \( R_f \) value of each component. The \( R_f \) value is the ratio between how far a component travels and the distance the solvent travels from a common starting point (the origin). For example, if one of the sample components moves 2.5 centimeters (cm) up the paper and the solvent moves 5.0 cm, as shown in Figure 1 below, then the \( R_f \) value is 0.5. You can use \( R_f \) values to identify different components as long as the solvent, temperature, pH, and type of paper remain the same. In Figure 1, the light blue shading represents the solvent and the dark blue spot is the colored solution sample.

## Abstract

Quick, what is your favorite color of M&Ms® candy? Do you want to know what dyes were used to make that color?
Figure 1. $R_f$ values are how different components are compared to each other in paper chromatography. $R_f$ values are calculated by looking at the distance each component travels on the filter paper compared to the distance traveled by the solvent front. This ratio will be different for each component due to its unique properties, primarily based on its adhesive and cohesive factors.

When measuring the distance the component traveled, you should measure from the origin (where the middle of the spot originally was) and then to the center of the spot in its new location. To calculate the $R_f$ value, we then use Equation 1 below.

Equation 1:

In our example, this would be:

Note that an $R_f$ value has no units because the units of distance cancel.

In this food science project, you will use the $R_f$ value to compare the "unknown" components of colored candy dyes with the "known" components of food coloring dyes. Since there are only a small number of approved food dyes, you should be able to identify the ones used in the candies by comparison to the chromatography results for food coloring.

Terms and Concepts

- Capillary action
- Paper chromatography
- Solution
- Mobile phase
- Stationary phase
- Solvent
- Solubility
- Hydrophilic
- Hydrophobic
- Retention factor ($R_f$)

Questions

- Why do different compounds travel different distances on the piece of paper?
- How is an $R_f$ value useful?
- What is chromatography used for?

Bibliography


Experimental Procedure

1. Do your background research so that you are knowledgeable about the terms, concepts, and questions listed in the Backgroud tab.
2. Choose three colors of candies you want to test.
   a. For example, you could test red M&M’s®, brown M&M’s®, and blue Skittles®.
3. Cut the filter paper into strips approximately 2.5 centimeters (cm) wide by 8 cm long. You will need a total of 30 chromatography strips.
   a. Science Buddies Kit: The kit comes with 10 circles of filter paper. Three strips can be cut from each circle for a total of 30 chromatography strips.
4. Use a pencil to lightly label which candy color or food coloring will be spotted on each paper strip. Label 5 chromatography strips.
5. Draw a pencil line 1 cm from the edge of each strip of paper, as shown in Figure 2 below.
   a. This will be the origin line.
   b. You will spot the candy color for each strip right on this line, as shown in Figure 2.

Figure 2. Each chromatography strip will have an origin line. The dye to be tested will be spotted in the middle of the origin line.

6. Next you need to extract some dye from each candy you wish to test.
   a. Fill the 150 mL beaker with some water.
   b. Use the pipet to put a single drop of water in the petri dish, as shown in Figure 3 below. Set one candy in the drop of water.
   i. Tip: If you use too much water, the dye will not be concentrated enough to see on the
chromatography strip.

ii. How to use the pipet: Squeeze the pipet at its widest point. While continuing to squeeze, insert the narrow end into the beaker of water. Release the wide end and the pipet will fill with water. Put the narrow end of the pipet directly over the petri dish. Gently squeeze the wide end of the pipet to release one drop of water.

iii. Leave the candy in the drop of water for three minutes to allow the dye to dissolve.

iv. Remove the candy, then dip a clean wooden splint tip into the now-colored drop of water.

ev. Spot the candy dye solution onto the chromatography strip by touching the wooden splint to the strip, right in the center of the origin line as shown in Figure 4 below.

f. Allow the spot on the strip to dry completely (this should take approximately 1 minute).

g. Repeat steps 6c to 6f three more times. You want to make sure to have enough dye on the chromatography strip so that you can see the dye components when they separate out on the paper.

h. Repeat steps 6b to 6g with four more strips and four new candies that are the same type and color (e.g., all red M&Ms®).

Figure 3. To extract the candy dye, leave a piece of candy in a single drop of water for three minutes. When you remove the candy, a puddle of dye will be left behind.

7. Repeat step 6 for the other two colors of candy you want to test. In the end you should have 15 spotted chromatography strips—5 for each colored candy type.

8. You also need to prepare chromatography strips with food coloring dyes.

a. These will be your known compounds, with which you will compare the "unknown" candy dyes.

b. For each food coloring color put a drop of coloring in the bottom of the petri dish.

c. Dip a clean wooden splint tip into the drop of food coloring.

d. Spot the food coloring onto a chromatography strip by touching the wooden splint to the strip, right in the center of the origin line.

e. Repeat steps 8c to 8d until you have 15 chromatography strips spotted with food dye—5 red, 5 blue, and 5 green. Also repeat step 8b if needed.

9. Prepare a 0.1% salt solution for the chromatography solvent.

a. Add 1/8 teaspoon of salt to 4 cups of water (approximately 1 gram [g] of salt to 1 liter [L] of water).

i. If you only have a 1/8 teaspoon measuring spoon fill that spoon half full of salt—that will be close enough for this project.

b. Shake or stir until the salt is completely dissolved.

10. Pour a small amount of the salt solution into the 400 mL beaker.

a. Clip two of the prepared chromatography strips to a wooden splint. Make sure the two strips do not touch each other or the beaker and that their bottoms are aligned. Rest the splint on top of the beaker so that the strips hang straight into the beaker.

b. If necessary, add more of the salt solution. The goal is to have the end of the chromatography strips just touching the surface of the solvent solution (salt solution), as shown in Figure 5 below.

Figure 5. Your chromatography setup should look similar to this example. The edge of the chromatography strips should just barely touch the solvent.

11. Let the solvent rise up the strip (by capillary action) until it is about 0.5 cm from the top then remove the strip from the solvent. Keep a close eye on your chromatography strip and the solvent front—if you let it run too long the dye may run off the paper and become distorted.

12. Use a pencil to mark how far the solvent rose.

13. Allow the chromatography strip to dry, then measure (in centimeters) and calculate the R_f value for each candy color (or food coloring) dye component. Record your results in your lab notebook.

a. Tip: Use Equation 1, which is given in the Introduction (located in the Background tab), for calculating the R_f value.

14. Repeat steps 10–13 until you have run all of the chromatography strips.

a. Each time you run the experiment make sure there is enough solvent in the beaker. The chromatography strips should be just touching the surface of the solvent. Add more solvent (salt solution) as needed.

15. Using the five repeated strips for each candy color (or food coloring), calculate the average R_f for each dye component.

16. Compare the R_f values for the candy colors and the food coloring dyes. Can you identify which food coloring dyes match which candy colors? How many dye components does each candy color have? Do your results make sense to you?

a. Hint: You can look at the ingredients on the packaging to see which food coloring dyes may have been used to help you answer these questions.
For a chromatography experiment on separating the ink components from markers, see the Science Buddies project Paper Chromatography: Is Black Ink Really Black? (http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p009.shtml).

Try this project with a variety of candies— for example, does the red in Skittles® look the same as the red in M&M's® when processed with chromatography? Is the average Rf value nearly the same? Look in the ingredients on each package to try and determine if the same dyes were used.

You could try this science project again but this time compare using different kinds of solvents (e.g., salt water, water, vegetable oil, isopropyl rubbing alcohol, etc.). Does a dye travel different distances depending on the solvent you use? What do you think this tells you about the solubility of that dye in the different solvents?

Do the dyes you tested in this science project travel differently on different kinds of filter paper? You could repeat this project to try and find out. For example, you could compare lightweight paper towels, heavyweight paper towels, white coffee filter papers, and other types of filter paper. Do they all work? Do some work better than others? Why do you think this is?

For more advanced chromatography experiments, see these Science Buddies projects:


If you like this project, you might enjoy exploring these related careers:

**Chemist**

Everything in the environment, whether naturally occurring or of human design, is composed of chemicals. Chemists search for and use new knowledge about chemicals to develop new processes or products. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Chem_chemist_c001.shtml)

**Food Scientist or Technologist**

There is a fraction of the world’s population that doesn’t have enough to eat or doesn’t have access to food that is nutritionally rich. Food scientists or technologists work to find new sources of food that have the right nutrition levels and that are safe for human consumption. In fact, our nation’s food supply depends on food scientists and technologists that test and develop foods that meet and exceed government food safety standards. If you are interested in combining biology, chemistry, and the knowledge that you are helping people, then a career as a food scientist or technologist could be a great choice for you! Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/FoodSci_foodsciencetechnician_c001.shtml)

**Food Science Technician**

Good taste, texture, quality, and safety are all very important in the food industry. Food science technicians test and catalog the physical and chemical properties of food to help ensure these aspects. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/FoodSci_foodscietifician_c001.shtml)

**Chemical Technician**

The role that the chemical technician plays is the backbone of every chemical, semiconductor, and pharmaceutical manufacturing operation. Chemical technicians conduct experiments, record data, and help to implement new processes and procedures in the laboratory. If you enjoy hands-on work, then you might be interested in the career of a chemical technician. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Chem_chemicaltechnician_c001.shtml)

**Credits**

Andrew Olson, Ph.D. and Sandra Slutz, Ph.D., Science Buddies

**Sources**

This project idea is based on:


**Contact Us**

If you have purchased a kit for this project from Science Buddies, we are pleased to answer any question not addressed by the FAQs on our site. Please email us at help@sciencebuddies.org (mailto:help@sciencebuddies.org?subject=Candy%20Chromatography%20What%20Makes%20Those%20Colors!) after you have checked the Frequently Asked Questions for this project at http://www.sciencebuddies.org/science-fair-projects/project_ideas/FoodSci_p006.shtml#help.

In your email, please follow these instructions:

1. What is your Science Buddies kit order number?
2. Please describe how you need help as thoroughly as possible:
   - **Examples**
     - **Good Question** I’m trying to do Experimental Procedure step #5, “Scrape the insulation from the wire….” How do I know when I’ve scraped enough?
     - **Good Question** I’m at Experimental Procedure step #7, “Move the magnet back and forth…” and the LED is not lighting up.
     - **Bad Question** I don’t understand the instructions. Help!

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