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BASIS Lesson Plan

Lesson Name: CSI: Chromatography Science Investigation

Grade Level Connection(s)

NGSS Standards: Grade 5, Physical Science (5-PS1)
FOSS CA Edition: Grade 5, Physical Science: Mixtures & Solutions

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

Someone has been stealing all the donuts from the city! Can we figure out who the guilty party is just by using the pen and ink messages that they leave behind? In this hands-on lesson, students first learn about the basics of chromatography and build an understanding of how this process helps us to study mixtures and molecules. Then, using these concepts, students solve the mystery of who is responsible for stealing all the donuts around town. They will use chromatography to analyze the color spectrum of the ink from a note found at the scene of the crime!

Lesson Objectives

- Students will conduct simple experiments to understand that molecules of different sizes will travel through filter paper at different rates.
- Students will perform tests to compare different types of filter paper and different solvents to examine their effectiveness for a specific purpose.
- Students will examine and compare patterns of experimental results to figure out and solve the answer to a mystery.

Vocabulary Words

- **Chromatography**: a separation method for a mixture of molecules (chroma = color; graphein = to write)
- **Hypothesis**: educated guess in science, based on knowledge that can be tested
- **Solution:** a liquid mixture where the minor component (the solute) is uniformly distributed within the major component (the solvent) (e.g. salt water = salt (the solute) + water (the solvent)
- **Solvent**: the liquid part of a solution
- **Rate:** how quickly or how slowly something moves in relation to another object
- **Molecule**: a group of atoms making an individual unit of a chemical
- **Replicate**: repeats; a way to build stronger evidence to support or reject a hypothesis

Materials

Scientist Volunteers will bring:

- Copies of the lesson plan (4)
- PowerPoint presentation on Chromatography
- Paper towels
- Lab paper, each with a black smiley face ☺ from the "criminal" in the bottom left corner (16)
    - *You may want to prepare these just before Activity #2 so that the ink separates well*

Materials for Activity #1 (8 sets needed):

- Black, Red, Green, and Blue Sharpie ® Flip Chart markers (1 of each color)
- Coffee filters, cut into 2.5" x 3.5" rectangles (2)
- Laboratory filters, cut into 2.5" x 3.5" rectangles (2)
- Coffee stirrer (2)
- Binder clip, small (4)
- Plastic 4-cup container (2)
- Water
- Isopropyl Alcohol

Materials for Activity #2 (8 sets needed):

- Black pens: Uni-ball Roller Fine, PaperMate Flair Medium, Sharpie Ultra Fine, Additional black pen (1 of each type, labeled with corresponding color circle for later identification)
- Laboratory filters, cut into 2.5" x 3.5" rectangles (2)
- Coffee stirrer (2)
- Binder clip, small (3)
- Plastic 4-cup container (2)
- Water

Materials teacher should provide:

- Sink or other water source
- Projector

Classroom Set-Up

Please have students split into groups of 4 students each. Each group should have a "station" consisting of a table or couple of desks pushed together. We will need access to a projector and access to a sink or other water source. Nametags for students are always helpful.

Background

Chromatography is a physical method of separating a mixture by passing it in a solution or suspension through a medium in which the components move at different rates. The experiment today uses paper chromatography, which separates dried liquid samples using a liquid solvent (mobile phase) and a paper strip (stationary phase). Other types of chromatography include liquid chromatography which separates liquid samples with a liquid solvent (mobile phase) and a column composed of solid beads (stationary phase). Gas chromatography separates vaporized samples with a carrier gas (mobile phase) and a column composed of a liquid or of solid beads (stationary phase).

Classroom Visit

1. Introduction (10 minutes)

Role Model Introduction:
Being a role model is an important part of being a BASIS volunteer! Begin your lesson by explaining who you are and what you do as a scientist. Feel free to tell your "story" as if giving an elevator pitch to elementary school students: Why did you become a scientist? What questions are you trying to figure out? What do you do in your job? Why should students relate to you? Feel free to bring in photos, specimens, and other props. Let your personality shine through!

Topic Introduction:
After you introduce yourselves as role models, take some time to introduce the topic of this lesson: *chromatography and molecules*. It may be helpful to keep the suggested take-away in the back of your mind throughout the lesson: **Colors that separate through chromatography correspond to different molecules that travel through filter paper at different rates.**

Your topic introduction should introduce students to the phenomena they will explore. As much as possible, try to frame this information as questions posed to the class, rather than as a lecture. This helps activate students' prior knowledge and facilitates student-guided conversation.

1. Introduce the phenomenon that the class will explore: chromatography and color separation
    - What is **chromatography**? [Write and define chromatography on board]
    - Have students take some guesses based on word they already know. Then break down the word for students "chroma" = color and "graphein" = to write
    - Chromatography is a method in science that allows us to separate **molecules** and help us to understand **solutions**. [Define and write on board – molecules, solutions]
    - Show and provide students with the example of chromatography used to separate the colors from a leaf.

- Has anyone noticed what happens to the colors of leaves when the weather gets chilly? They turn different colors – red, orange, yellow.
- So all those colors are within a single leaf and we can study that using chromatography. We can grind up a leaf, put that onto filter paper, and then stick that into a **solvent** [Define, write on board]
- Show students picture of leaf chromatography. What do you notice about this picture? Are all the pigments green?
- Why do you think we can see all the different colors? Why are there certain colors at the top of the paper and certain colors at the bottom? [Discuss molecules and **rates** of travel with the students]
- In today's **experiment**, we're first going to use different colors of markers and different **solvents** so that you all understand how chromatography works. Then after you all do that, we're going to solve a crime together!

Teaching Tip: Say, Write, Show

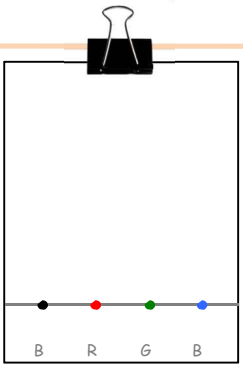
- Bring in photos and props to illustrate the topic intro
- Write new vocabulary words, key terms, and brainstorm lists on the board
- Help students make sense of vocab through root words, eg chroma + graphein
- Refer back to the board to engage visual learners and English Language Learners

2. Learning Experience (30-40 minutes)

Students should be in groups of 4. Remember that both of these activities are designed to address the take-away in a particular way: **Colors that separate through chromatography correspond to different molecules that travel through filter paper at different rates.**

Activity 1: Solvent & Filter Paper Testing

1. Before we try to figure out who committed the crime, we need to figure out which materials will work best for our investigation. A big part of being a scientist and engineer is testing materials to see which ones work the best.
2. Today, you will be testing two different types of filter paper (lab filter paper and coffee filters) and two different **solvents** (water and isopropyl alcohol).
3. When you get your filter paper, you will take each of the four colors of markers and make a small dot towards the bottom of the paper, about ¼" above the edge. Make sure to leave some space between the colors so that they do not mix with one another. See image for experimental set-up.



4. You will have the colors of black, red, green, and blue. The water or alcohol will travel up the paper and carry the color with it. Do you **hypothesize** that each color will appear as one color once it travels up the filter paper? Or are some of the pens made up of combinations of different **molecules**? [Gather input from students. They should be familiar with the concept of primary and secondary colors (e.g. blue & yellow mixed together will create green)]
5. Pass out materials to each group of students. Each group of 4 should have two containers (1 water, 1 alcohol) and 4 pieces of filter paper (2 coffee, 2 lab). Each student can be in charge of one of the filter papers.
6. Instruct students to put one dot of each color on their filter papers about ¼" from the bottom edge.
7. Pass out coffee stirrers (2) and binder clips (4) to each group. Each student group should put one type of filter into both the water and alcohol. The paper should be just barely touching the bottom of the solvent, and the bottom of the paper should be horizontal. There should be enough solvent in the bottom of the container such that the bottom of the paper is immersed, but the colored dots do not touch the solvent.
8. Invite students to make observations and comparisons.
9. Once colors have traveled up the length of the filter papers, call back students to share what they have observed. Which type of filter paper worked the best? Which liquid worked the best? What did they notice about what happened to the different colors? Which ones separated into different colors? What is happening here? Why are some lower down on the filter paper while others are up at the top? What causes these colors to separate? Engage students in a conversation about molecules and how they are traveling through the filter paper at different rates.
10. After our experiment, we have decided that the best **solvent** to use for our chromatography investigation is water and the best filter paper is the lab filter paper.

Classroom Management Tips: Encourage Participation

- Wait 3 seconds before calling on students to answer a question. You'll be impressed with how many more (and often, more diverse) hands go up.
- It's tempting to call on eager students, but give everyone a chance!
- Be flexible in how you communicate questions and responses, reiterating information in different ways if needed.
- For more classroom management tips, visit www.crscience.org/volunteers/volunteertools

Activity 2: Chromatography Crime Scene!

Note: You can involve the teacher and see if he/she is willing to be one of the suspects (and maybe take the fall for the crime!) If you'd like, you can make the stolen item candy that you can 'recover' from the thief at the end of the lesson and give to the students. But make sure to check in with the teacher first to make sure that this is allowed in their classroom!

1. Now let's figure out if we can solve the mystery and figure out who has been stealing all the donuts all over town. This particular criminal is so happy after they eat all the donuts, that they leave a "calling card" at the crime scene – a smiley face – written using a black pen. There are four suspects (4 of the volunteers, or involve the classroom teacher) and each of them has a different black pen. Each suspect has been identified with a different color dot on their pen.
2. Discuss with students how, just as the black marker from the first experiment had different colors, different black inks can contain different pigments with different sized molecules. Each pen will therefore have a unique "fingerprint" of ink, and using chromatography, we can see if the ink from the crime scene matches the ink from one of our suspects!
3. In your group, you will be getting one smiley face "calling card". You will also be getting blank filter paper and four different black pens, corresponding to our suspects. When you get your pens, draw a smiley face at the bottom, just like the calling card. Also, make sure to write the color dot that is on that marker at the top of the filter paper. That way we can know which smiley face corresponds to which pen!
4. Pass out materials and help students set up. Each group will be running the experiment twice simultaneously – they will have two pieces of filer paper, so that they have more support, more evidence for who the donut thief is! Repeats like this in science experiments are called **replicates**.
5. Have students set up their filter paper and make sure each group now just uses the container with water as the solvent.
6. Can they figure out who the donut thief is? Why or why not? What's the evidence? How do they know? [The "calling card" smiley face left at the scene of the crime will have the same color distribution as one of the pens that they run the experiment on. This is the thief!]

3. Wrap Up: Review and Discuss the Learning Experience (5-10 minutes)

It's important to leave time to **review** and **discuss** the learning experience at the end of the lesson. This might take the form of discussing conclusions from an experiment; or review of the take-away of the lesson

- Discuss the molecules and chromatography and why some of the colored markers separated into different colors on the filter paper.
- Discuss how the students figured out the correct criminal. Different colors can separate, but also different types of the same color (in this case black) pens will also have a signature color distribution.
- Discuss the importance of repetition in experimentation (replicates) and how that relates to the support or rejection of a hypothesis.

4. Connections & Close (5 minutes)

Wrap up as a role model by leaving a few minutes for students to ask questions about science, about being a scientist, and about becoming a scientist. Then, thanks and goodbye!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- http://www.crscience.org/educators/helpfulreports
- http://www.crscience.org/educators/treasuretrove

Standards Connections

NGSS:

- Connections by topic
  Physical Science: 5. Structure and Properties of Matter
- Connections by disciplinary core ideas:
  Physical Science: 5-PS1 Matter and Its Interactions
- Connections by scientific & engineering practices
  1. Asking questions and defining problems
  3. Planning and carrying out investigations
  4. Analyzing and interpreting data
- Connections by crosscutting concepts
  1. Patterns
  2. Cause and effect: Mechanism and explanation
- Connections by performance expectation:
  5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.
  5-PS1-3. Make observations and measurements to identify materials based on their properties.

FOSS NGSS Edition: Grade 5 Physical Science: Mixtures and Solutions