

Case of the Missing Diamond Maker

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 Subject: Chemistry
 Level: Middle School
 Standards: *New York State-Physical Setting/Chemistry* (www.emsc.nysed.gov)
 Standard 1- Analysis, Inquiry and Design
 Standard 4 - The Physical Setting
 Standard 6 - Interconnectedness: Common Themes
 Standard 7- Interdisciplinary Problem Solving
Schedule: Two 40-minute periods

Objectives:

Learn about techniques of forensic science including: fingerprint identification, chromatography, and chemistry.

Students will:

- Use fingerprinting, chromatography, and chemistry to gather and analyze evidence left behind at a crime scene.
- Use deductive reasoning to evaluate the evidence and determine the criminal's identity.

Vocabulary:

Chromatography

Materials:

For the Class:

| | |
|--|-----------------------|
| Power Point presentation | Gatorade |
| Station directions | Orange Juice |
| 4 Different black pens | pH paper |
| Coffee filters or filter paper | Powdered Sugar |
| Paintbrush (small) | Baking soda |
| Crystal clear plastic cups | Baking powder |
| Cocoa powder | Vinegar |
| Clear tape | 4-5 Perfumes |
| 6 Different fabrics (cotton, silk, Colors, etc.) | 4-5 Film canisters |
| Magnifying lenses | Binder clips |
| Alka seltzer | Wood dowels |
| | Dropper bottles |
| | Small plastic Baggies |
| | Spoons |
| | Fingerprint Guide |

Safety:

There are no safety concerns for this lab.

Science Content for the Teacher:

Fingerprints: Fingerprints have been used for hundreds of years as an identifying characteristic of people. No two fingerprints are alike (not even in identical twins). Fingerprints can be classified according to their patterns (arches, loops, etc). Most countries have fingerprint databases where they store fingerprint images. Although fingerprints used to be examined and compared by hand, this is no longer the case. In the United States, a computer system called the Automatic Fingerprint Identification System (AFIS) searches the database looking for fingerprint matches in just minutes. For more information see <<http://www.fingerprints.tk/>>.

Chromatography: Chromatography is the process of separating the parts of a complex mixture. In this lesson, we are separating the pigments that make up the black inks in a variety of pens. Chromatography works by passing a material through a medium in which the parts migrate at different rates, for example filter paper. Chromatography is used frequently in biochemical labs to separate proteins or chemicals. Liquids, solids and gases can all be used to separate out materials. For more information about chromatography see <<http://www.rpi.edu/dept/chem-eng/Biotech-Environ/CHROMO/chromintro.html>>.

Fiber Analysis: Fibers are the small pieces of materials from which textiles are composed. Fibers can be woven, knitted or pressed together to make a fabric. There are a wide variety of fibers from natural and man-made sources. Often fibers that look similar to the naked eye can be easily distinguished when magnified. Fibers can become evidence in a crime if they are left behind by the criminal. For more information see <<http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm>>.

Smells: Although humans do not have the most acute sense of smell compared to other mammals, we can differentiate thousands of odors. Smell is detected by olfactory receptors in our nasal cavity just below our eyes. For a discussion on human smell see <http://www.sirc.org/publik/smell_contents.html>.

Liquids: pH stands for the “potential (or power) of hydrogen” and describes the concentration of hydrogen atoms in a substance. If a material has a pH of 7 it is considered neutral. A pH above 7 is said to be basic and a pH below 7 is acidic. The pH scale is a logarithmic scale from 0-14. This means that each increase in number (from say 7-8) is a tenfold increase in the number of hydrogen atoms present. Strong acids and strong bases are very corrosive and can burn skin and other materials; this is due to the high reactivity of the H⁺ ions (and OH⁻ ions in the case of a base). pH can be tested using pH paper as we do in this activity.



Powders: There are two reactions that take place in the powders portion of the activity: the reaction between baking powder and water and that between baking soda and vinegar. In each case the reaction occurs between an acid and a base, producing water and a gas, CO₂, which bubbles. For more information on these reactions see <<http://science.howstuffworks.com/question57.htm>>.

Preparation:

Note: These preparations are designed to implicate Malcolm, but evidence can be rearranged to implicate a different suspect as needed.

Fingerprints Materials:

- Suspect fingerprints and evidence handouts
- Magnifying glasses
- Crystal clear plastic cups
- Small paintbrush
- Cocoa powder
- Clear tape
- Fingerprint Guide

Chromatography Materials:

- Filter paper cut into 1x3 inch strips
- Small tub of water
- Wooden dowels
- Binder clips
- 4 Different black pens labeled A, B, C, D
- Prepare an “evidence” strip using pen C, place it in a plastic bag labeled “evidence”

Fiber Analysis

- Six different fabrics cut into 2-inch squares (use fabrics of similar color schemes but different materials and different manufacture such as woven, knitted, pressed).
- Put each square into a different bag and label one for each character (Maria, Randy, Sandra, Malcolm, Dr. Evil, and Dr. Squeeze). Take a piece of fiber from Dr. Evil and Dr. Squeeze and place them in bags labeled Evidence 1 and Evidence 2 respectively.
- Magnifying lenses



Smells

- Cut strips of filter paper and spray each with a different perfume. Close each and seal in a film canister. Label canisters with names of the suspects. In the evidence canister, place a piece of filter paper scented with Sandra's perfume.

Spilled Liquid

- 4 Plastic cups labeled orange juice, water, alka seltzer, and Gatorade with the respective liquid inside
- Place some Gatorade in the evidence container.
- pH paper
- Paper towels

Spilled Powder

- Black construction paper
- Spoons
- Dropper bottle of water
- Dropper bottle of vinegar
- Powdered sugar
- Baking soda
- Baking powder



Classroom Procedure:

Day 1

Engage (Time: 10 mins)

- Ask the class what they know about forensic science, fingerprinting, and chromatography. Go through the Power Point presentation and discuss these concepts.
- Describe the crime and tell students they are needed to help police solve it. (Note: stop at slide 13).

Explore (Time: 30 mins)

- Describe the basics of each station, especially explain how chromatography works.
- Divide the class into six equal groups and let them work together as detective teams to solve the crime. Each team will start at a different station and rotate clockwise through the stations in 8-10 minute intervals. See Supplemental Information for station instructions.

Day 2

Explore (Time: 25 mins)

- Let the students finish visiting the stations and prepare their *Evaluating the Evidence* worksheets.

Explain (Time: 15 mins)

- Have each group present who they think the criminal is; they should use evidence from the stations to support their answers.
- After all groups have gone, show the last few Power Point slides to reveal the solution to the crime.



Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

- 1= exceeds expectations
- 2= meets expectations consistently
- 3= meets expectations occasionally
- 4= not meeting expectations

| | Engage | Explore | Explain |
|---|--|--|--|
| 1 | Shows leadership in the discussion and offers creative ideas reflecting a good understanding of forensics. | Completes work accurately while providing an explanation for what is observed. Works well with partners. | Provides an in-depth explanation of findings, makes excellent use of evidence from the crime. Fills out worksheet clearly. |
| 2 | Participates in the brainstorm and shows an understanding of forensics. | Completes work accurately. Works well with partners. | Provides clear explanation of findings, uses evidence from the crime well. Fills out worksheet clearly. |
| 3 | Contributes to the brainstorm, but shows little understanding of forensics. | Makes some mistakes with the procedure, gets along with partners. | Provides a limited explanation of findings, uses some evidence. Fills out some of the worksheet. |
| 4 | Does not participate in brainstorm. Shows no understanding of forensics. | Does little to complete the procedure. Does not work well with group. | Is not clear in explanation of findings, does not use evidence from crime. Does not fill out worksheet. |

Safety:

- There are no safety concerns associated with this activity.



Supplemental Information: Station Instructions

Chromatography:

For this station you'll need filter paper cut into thin strips (~1 inch wide by 3 inches long), a small tub of water, pencils or wood dowels, binder clips, and four different black pens. *You'll want to test a number of different pens beforehand to be sure that each has a different chromatography pattern.* The chromatography is run by drawing a line about ½ inch up from the bottom of the filter paper strip. Slip the binder clip onto the pencil or wooden dowel and clip the filter paper into the binder clip. Suspend the filter paper in the water so that the water starts to move up the filter paper. Be careful not to immerse the paper below the black line (this will dilute the results). Label the pens A-D. Ask the students to write the letter of the pen they used at the top of the filter paper so that they can keep track. Prepare an "evidence" strip using Malcolm's pen (C) and place it in a plastic bag labeled "evidence." The students will compare their results to the evidence to determine which pen was used at the crime scene.



Chromatography Answer:

Malcolm used the pen to write the note left at the crime scene.

Fiber Analysis:

Gather six different fabrics and cut them into squares (~2 inches). It may be helpful to choose fabrics with similar color schemes but different materials (cotton, polyester, silk) and different manufacture (woven, knitted, pressed). Fray the ends of the textiles a bit so that single fibers can be examined. Put each fabric square in a small plastic bag and label the bags (Maria, Randy, Sandra, Malcolm, Dr. Evil and Dr. Squeeze). Take a piece of fiber from the fabrics of Dr. Evil and Dr. Squeeze and place them in bags labeled Evidence 1 and Evidence 2 respectively. It is helpful to have students leave the fabrics in the bags as they examine them. They may need to use hand lenses if the fabric is very delicate.



Fiber Analysis Answers:

Evidence 1: Dr. Evil

Evidence 2: Dr. Squeeze

(Both these suspects had frequent regular access to the lab)

Smells:

Cut strips of filter paper and spray each with a different perfume. Close each scented filter paper strip in a tightly sealed small plastic canister. Label the canisters with the names of the suspects. Label another canister "Evidence" and insert a strip of filter paper scented with Sandra's perfume. *Instruct students in the proper way to smell chemicals, by wafting the smell towards their noses rather than inhaling directly into a bottle.*



Smells Answer:

Sandra Dee (she put on perfume because she had a date that night).

Spilled Liquid:

Set out 4 plastic cups labeled orange juice, water, alka seltzer and Gatorade. Pour the corresponding liquids into each cup. Provide pH paper and paper towels. Students will dip the pH paper into each drink to determine its pH. The pH of the evidence is 3.0.



Spilled Liquid Answer:

The evidence matches Malcolm's Gatorade in pH (which he drank following his basketball game).

Spilled Powder:

Students will spoon a small mound of each powder onto a sheet of black construction paper. Using a dropper bottle the students will drop a few drops of water and vinegar onto each pile to see if the powder reacts with the liquid.



Spilled Powder Answer:

The powdered sugar best matches the evidence. (Randy ate a powdered donut in the lab).



Acknowledgments:

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- <http://www.rpi.edu/dept/chem-eng/Biotech-Environ/CHROMO/chromintro.html>
- <http://www.fingerprints.tk/>
- <http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm>
- http://www.sirc.org/publik/smell_contents.html
- <http://science.howstuffworks.com/question57.htm>

