

# Ink Analysis

Part of: **Dartmouth Rural STEM Educator Partnership**  
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<p><b>Driving Question</b>          Single big question addressed by this lesson.  <b>How can we analyze components/properties of ink as evidence to determine which pen was used to write a note?</b></p>	<p><b>Overview</b>          Brief (1-2 sentence) description of the lesson.          A ransom note is left in the classroom. Students are tasked with collecting pens from suspects and using chromatography/component analysis to determine who wrote the note.</p>
<p><b>NGSS Standards</b>  <a href="#">NGSS</a> standards addressed</p> <p>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.</p> <p><b>SEP:</b>          MS-PS1-2. Analyze and interpret data to determine similarities and differences in findings.</p> <p><b>CCC:</b>          MS-PS1-2. Macroscopic patterns are related to the nature of microscopic and atomic-level structure.</p>	<p><b>Objectives</b>          Through this lesson, students will (2-3 measurable objectives):</p> <ol style="list-style-type: none"> <li>1. Understand that ink is composed of solutes in a solvent</li> <li>2. Practice separating ink into components by chromatography</li> <li>3. Utilize pattern matching to identify the source of ink from the ransom note</li> </ol>

## Materials

What materials are needed to run the lesson?

### Per Class

1. Ransom note (on coffee filter)

### Per Group

1. Strips of ransom note with ink
2. Strips of coffee filter paper or intact coffee filters for students to cut
3. Warrant template
4. Ruler(s)
5. Water
6. Clear plastic cups
7. Tape
8. Pens/Markers of different brands
9. Pencils

Per Student

1. Laboratory notebook
2. Ink Chromatography Data Collection handout (print multiple copies per group to have enough space for each chromatography strip).

## Preparation

What needs to be prepared before the lesson?

1. Teacher should hide laptop (or other missing item)
2. Markers distributed to participating teachers
3. Ransom note written
4. PowerPoint ready to be presented
5. Materials distributed to groups
6. Data collection worksheets printed (multiple copies needed per group to have enough spaces for chromatography strips)

## Background information

Any background information that may be helpful to the teachers?

\*\*\* There is an accompanying PowerPoint which contains much of the information needed to teach this lesson. Additional resources and information can be found below in the “Appendices” section.

The expected results might look something like this:



Example from: <https://www.ingridscience.ca/node/322>

## Story line to frame the lesson

Our resilient teacher has *just* mentally recovered from the drama that encompassed the fingerprinting lesson - having their morning cup o' joe replaced with something awful. They are very glad that they were able to identify the culprit and confront them so that nothing like that is likely to happen again!

Our teacher settles in at their desk with their coffee, ready to start the day. BUT ALAS! Their laptop is missing! "It was just here ... I know I had it this morning before I went to make my coffee ..." stammers our teacher, searching high and low for the missing laptop.

Then, they spot it. The note. The note, written on odd paper, in black ink says "-----I HAVE YOUR LAPTOP. IF YOU WANT IT BACK, LEAVE COOKIES IN TEACHER'S LOUNGE. -----" with no additional clues or directions. The handwriting is unfamiliar.

How will our teacher find their laptop? Should they report this to the principal? Should they give up, call in a substitute, and go home?

No! Our teacher will persevere and identify the thief using the very note that was left for them and a technique called ink chromatography.

## Lesson

Detailed description of the lesson with sub-headings as needed.

1. Teacher tells or acts out story of missing laptop (or other item)
  - a. Shows students ransom note
2. Discussion on whether there is a way to use the note to identify the culprit
  - a. Teacher can hint that her colleagues all use unique specific markers in their classrooms.
3. Content - Use PowerPoint slides to discuss chromatography, solubility of molecules, structure and function of molecules.
4. Students will perform chromatography experiments (see directions below and in PowerPoint)
  - a. Students will analyze and data from each marker
  - b. Students will identify the marker used on the ransom note
  - c. Students will identify thief
5. Exit ticket

## Procedure:

1. Cut coffee filter note into strips about 2 inches wide and 4 inches long.
  - a. You will want one strip per marker
2. Draw a line across the width of the strip with a pencil. The line should be about 1 inch up from the bottom of the strip, running parallel to the paper's bottom edge, with a small gap between the line and the edges.
3. The pencil line will indicate the starting position of the sample.
4. Draw another line covering the pencil line with your marker.
  - a. Do this for each marker. Students will need as many strips as there are different markers.
5. Tape the marked filter paper strip to the coffee stirrer. Balance the coffee stirrer on the rim of the cup, with the filter paper dangling in the middle of the cup.
6. Put enough water in the cup that the bottom of the filter touches the water, but the line is not submerged in water.
7. Let the water run up the strip for approximately 20 minutes.

8. Remove the chromatography strips from the water. Let dry briefly, then tape to the chromatography analysis worksheet (attached handout).
  9. Use the attached handout to calculate Rf values for each pigment in each sample.
  10. Identify the culprit using the data collected.
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## Evidence of Learning

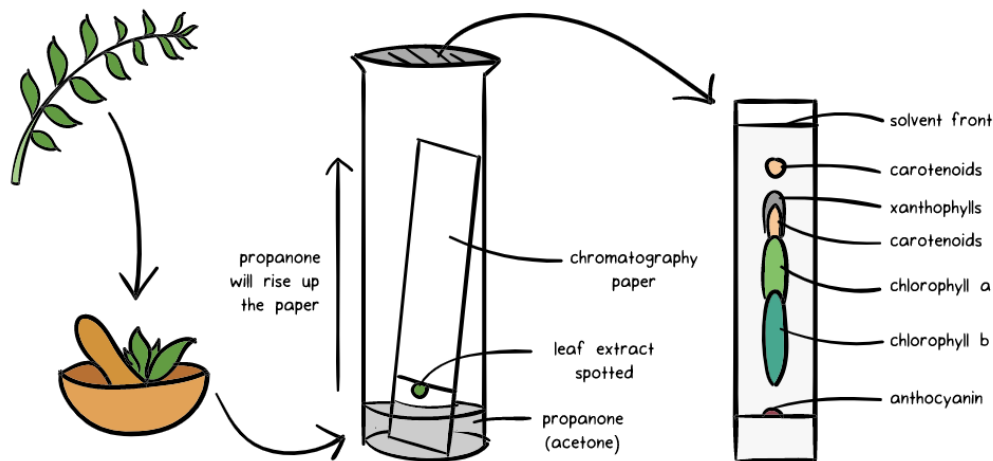
How will students demonstrate their learning? Exit questions?

- Exit ticket (see last PowerPoint Slide)
- Optional formal assessment:
  - Use CER model – “The jury’s finding” or lawyer’s closing statement
    - Claim - Mr. Johnson is guilty
    - Evidence
      1. Chromatography analysis of ransom note
      2. Chromatography analysis of Mr. Johnson’s marker
      3. Different markers show distinct Chromatography patterns
    - Reasoning
      - We the jury are confident that Mr. Johnson is guilty because of our chromatography analysis. We know that, based on our evidence, that different brands of pens/markers show different chromatography patterns. Because Mr. Johnson’s marker analysis matches the ransom note, we can be confident that he is guilty because no other pen/marker should show the same result.

## Extensions

How could this lesson be extended?

- Students could see whether the markers they are testing separate differently when isopropyl alcohol is used as a solvent.
- Students could be required to write a “search warrant” to justify obtaining pens from various teachers. This could be a form of informal assessment before the experiment to make sure students understand how/why chromatography can be used to identify a suspect.
- Experiment could be completed with different markers including permanent markers (which won’t dissolve in water, but may in isopropanol).
- Students could try chromatography with plant extract to visualize plant pigments (spinach leaves work well).



Example of plant pigment experiment (<https://www.khanacademy.org/science/class-11-chemistry-india/xfbb6cb8fc2bd00c8:in-in-organic-chemistry-some-basic-principles-and-techniques/xfbb6cb8fc2bd00c8:in-in-methods-of-purification-of-organic-compounds/a/principles-of-chromatography>)

## Glossary of terms

Include a glossary of terms if needed.

**Solution:** A mixture in which a minor component (solute) is uniformly distributed within the major component (solvent)

**Solvent:** Substance that dissolves the solute particles during the formation of a solution. Usually a liquid, but doesn't have to be.

**Solute:** A solute is a substance that is added to a solvent to form a solution.

## Appendices

References or other materials as needed.

- <http://www.chemhume.co.uk/AS%20AQA%20CHEM/Organic/3.16%20Chromatography.pdf>
  - Section on TLC (Thin Layer Chromatography) includes information about solubility and adsorption)
- <https://healy.create.stedwards.edu/Chemistry/CHEM30/organicCD%28Mitzel%29/chapter4/pages3and4/page3and4.htm>
  - Information on polarity of molecules in relation to adsorption and chromatography
- [https://chem.libretexts.org/Ancillary\\_Materials/Laboratory\\_Experiments/Wet\\_Lab\\_Experiments/General\\_Chemistry\\_Labs/Online\\_Chemistry\\_Lab\\_Manual/Chem\\_9\\_Experiments/02%3A\\_Paper\\_Chromatography\\_of\\_Gel\\_Ink\\_Pens\\_\(Experiment\)](https://chem.libretexts.org/Ancillary_Materials/Laboratory_Experiments/Wet_Lab_Experiments/General_Chemistry_Labs/Online_Chemistry_Lab_Manual/Chem_9_Experiments/02%3A_Paper_Chromatography_of_Gel_Ink_Pens_(Experiment))
  - Additional text and images describing similar experiments and calculation of  $R_f$