

Be a Chemist!

Be a Forensic Chemist

Educator Guide



Big Question:

How can forensic chemists analyze substances to solve mysteries?

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*Find a summary of the content, as well as a QR code to the *Be a Chemist!* webpage.*

Be a Chemist! Big Ideas

These are the themes you'll find running through all five *Be a Chemist!* activities.

Chemistry is the “study of stuff”—what things are made of, how they behave, and how they change.

- What chemicals make up the materials in the world around us?
- How are substances alike or different?
- What happens when we mix substances together—do they stay the same or create something new?

All substances in our world are made of chemicals—and chemists help us understand and use them safely and effectively.

- How can we use chemistry to solve problems or invent something new?
- How can we test products to make sure they are safe for us to use?

To learn more about the forensic chemist career and the science behind this activity, look for the “Background” section at the end of the activity procedure.

Core Four Strategies

Use the Core Four Strategies as you guide your learners through this activity.

- **Ask questions** to spark curiosity and encourage new ideas
- **Encourage scientific thinking** with chances to observe, make predictions, and test ideas
- **Cultivate rich dialogue** with chances to talk together, share ideas, and use science words
- **Make connections** between learners' experiences, science careers, and this activity



Ask Questions



Encourage Scientific Thinking



Cultivate Rich Dialogue



Make Connections

Be a Forensic Chemist



Big Question: How can forensic chemists analyze substances to solve mysteries?



Materials:

Per class:

- Forensic chemist career card
- Pitcher of water
- Dot stickers
- Adult scissors
- Bin or bucket for waste (optional)
- Lab notebooks
- Pencils
- Science skills stickers

Per group of 3–4 learners:

- Coffee filters (1-2)
- Set of 5 black-ink writing utensils:
 - Classroom marker (any brand other than Crayola Washable)
 - Sharpie permanent marker
 - Sharpie flipchart marker
 - Papermate Flair felt-tip pen
 - Ballpoint pen (any brand)
- Pipettes (2)
- 9 oz clear plastic cups (2-3)
- Small binder clips (2-3)
- Unsharpened pencils (2-3)
- Plastic tray (1)
- Sheet of white paper (optional)



Prepare:

1. Pre-cut coffee filters into long strips about $\frac{3}{4}$ -inch wide and 5 inches long. See the photos for an example of where to cut the filters. The measurements don't need to be exact, but keep the strips as similar in size as possible. Each group will need at least 8-10 strips.
2. Use the dot stickers to label each type of writing utensil with a different number and/or color. Create sets of writing utensils containing one of each type.
3. For each group, add about $\frac{1}{2}$ inch of water (a finger's width) to each of 2-3 plastic cups.





Engage (10 min)

Describing the career photo out loud assists learners who are blind or low vision, provides vocabulary support for language learners, and helps with visual processing.

Example: “This photo shows a scientist wearing safety glasses and gloves standing by a counter full of bottles and lab tools. They are holding a glass container in one hand and using a pipette to put some clear liquid into a different container on the counter.”

1. Introduce the forensic chemist career by showing the group the career card and describing the picture on the card. Ask questions to encourage learners to think about what a forensic chemist might do:
 - ❓ What do you notice about this picture? What do you think this person is doing?
 - ❓ Where do you see chemicals in this picture? Where do you see science tools?
 - ❓ What do you think of when you hear the words “forensic” or “chemist”? What does the name “forensic chemist” make you think of?
 - ❓ What do you think a forensic chemist might do or study? What makes you think that?
2. Explain that a forensic chemist uses science to help solve crimes by studying evidence left at crime scenes. They examine things like powders, stains, and unknown substances to figure out what they are made of. These clues can help people solve crimes.
 - ❓ How do you think a chemist can tell what something is made of without tasting or touching it?
 - ❓ Why do you think it’s important for forensic chemists to be very careful and accurate?
 - ❓ Why is it important to have scientists helping solve crimes?

3. Introduce the storyline like this:

- Imagine we are a team of forensic chemists and we’ve been asked to help solve a crime!
- A mysterious note was discovered at the scene of a crime, and the detectives want to figure out who wrote it.
- Look at the evidence photo on page 9 of your lab notebook. What do you notice? What could we do to figure out who wrote it?
- Our job is to see what we can find out about the ink and the type of pen that was used to write it. Identifying the pen could bring us one step closer to finding the writer!

Note: Learners may have varied personal experiences with crime and law enforcement. Adjust the storyline as needed to match your learners’ needs and interests. For example, the “crime” could be something lighthearted—like someone swiping cookies from the cookie jar. Or you might choose a more realistic case, such as a burglary or missing valuables.

Explore (40 min)

Part 1: Determining Ink Solubility



1. Establish safety guidelines.

Explain that while all the materials in this activity are safe to touch, it's still important to follow basic lab safety rules:

- Don't touch your face and eyes. Some materials might cause irritation if they get into your eyes.
- Wash your hands with soap and water when you're finished.
- Never taste or put any of the materials in your mouth. These are for experimenting, not eating!
- The plastic tray will be your "lab" space. All the liquids and other materials should stay inside the lab (on the tray).

2. Divide learners into groups of 3–4. Explain that their first task is to test how different pens react with water and compare their results to the note in evidence to see which pens could be a match.

3. Pass out the set of writing utensils, strips of coffee filter, pipettes, and one cup of water to each group. Explain and demonstrate the steps of the testing procedure:

- Draw a thick dot or short line using one type of writing utensil in the center of a strip.
- Use a pencil to label the top of the strip with the number of the utensil.
- Use a pipette to place 1-2 drops of water directly on the ink mark.
- Repeat for each of the different utensils.

4. Ask learners to test their samples, observe what happens, and record it on page 9 of their lab notebook:

- ❓ What do you notice happening to the ink when it gets wet?
- ❓ Did the ink dissolve or stay the same?
- ❓ Did the colors change?

5. Gather the group to discuss their results. Ask:

- ❓ How did the different pen inks interact with water?
- ❓ Which ones behaved like the ink in the evidence note?
- ❓ Which ones can we rule out?

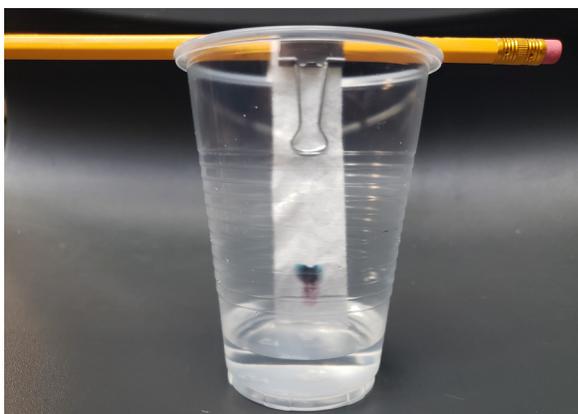
Note: Highlight that people can experience color in different ways. If some learners have challenges with distinguishing or naming colors, remind them that scientists work in teams, and they can rely on the rest of their team for that piece of the work!



Part 2: Running a Chromatography Test

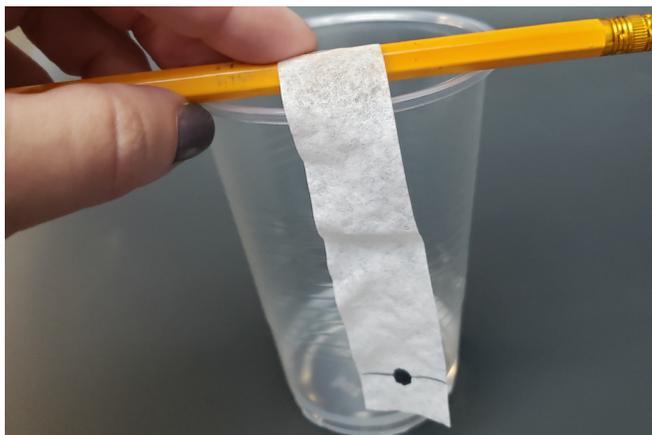
1. Explain that next they will run further testing to figure out which pen wrote the note by using a technique called **chromatography** (kro-ma-TOG-ra-fee). Explain that chromatography is a technique that separates mixtures – like ink – into their different color components.
2. Have learners turn to page 10 in their lab notebooks and look at the chromatography results from the evidence note (Evidence Ink Test). Explain that these results were obtained by analyzing the ink on the note itself. The pen that wrote the note will have a color pattern identical to the one on the chart.
 - ❗ What do you notice about the chromatography results?
 - ❗ How many colors make up the ink from the mystery note?
3. Collect any writing utensils that were ruled out in the previous discussion and distribute the following to each group:
 - 1-2 remaining cups of water
 - Unsharpened pencils (2-3)
 - Binder clips (2-3)
 - Fresh coffee filter strips (2-3)

Note: Only one strip should be tested in each cup. If learners have more utensils to test than cups, they should test them one at a time.



4. Instruct learners to look at the diagram on page 10 of their notebooks (Chromatography Test Setup) and explain the procedure:
 - Use a pencil to draw a line across each strip, about the width of their thumbnail from the bottom.
 - Draw a thick dot in the center of each line, using a different writing utensil on each strip.
 - Label the top of each strip with the number of the utensil, using a pencil.
 - Fold the top of the strip around the unsharpened pencil, so that the dot end hangs down.
- Add it carefully to the cup. Adjust it so that the pencil rests on the top of the cup, and the **water just covers the bottom of the strip but doesn't touch the ink dot.** (This is different from what they did in the first test!)
- Clip a binder clip over the filter strip to hold it in place.
- Let the water slowly rise up the strip, taking the ink with it, until it gets half-to two-thirds of the way up the strip. This should take about 3-4 minutes.
- If ink from the dot does bleed into the water in the cup, it will change the results. Empty and refill the cup with clean water and try again with a new filter strip.

Note: Adjusting the position of the filter strip takes practice! Measuring the strip against the outside of the cup first can be helpful. Encourage learners to work together to hold the pencil and strip in place while adding the binder clip. Remind them that there's nothing wrong with trying again—it's part of science!



5. Once their tests are complete, have learners remove the strips and lay them flat on the table (away from any puddles of water). If the table surface is dark colored, putting a piece of white paper underneath will make the results easier to see. Guide them to observe and compare the strips:
 - ❓ What do the different strips look like?
 - ❓ What colors do you see? Are they in the same order or different between strips?
 - ❓ Which strips are most like the evidence photos? Which are most different?

Reflect (10 min)

1. Bring the group back together to discuss their chromatography results:
 - ❓ Which ink matched the evidence sample the best? What evidence supports your conclusion?
 - ❓ Were there any inks that didn't match at all? Why do you think that is?
 - ❓ What surprised you about the way the inks separated?
 - ❓ What can we say about which kind of pen was used to write the note?
2. Encourage learners to reflect on how they were like forensic chemists during this activity. Refer to the career card and science skills stickers:
 - ❓ What are some things you did today that a forensic chemist might do?
 - ❓ How did you think like a scientist during this investigation?
 - ❓ What did you do that made you feel like a scientist? What science skills did you use?
3. Allow time for learners to draw or write their reflections on page 11 of their lab notebooks. Invite them to choose a science skills sticker that represents a skill they used and add it to their notebooks.

Cleanup

- Liquid waste can be safely poured down the drain.
- Used filter strips can be disposed of in the trash.
- Plastic cups can be rinsed with water and reused as needed.

Background

Forensic chemists use chemistry to help solve crimes. They analyze evidence from crime scenes—like ink, fibers, powders, or unknown substances—to figure out what they are and where they might have come from. This information can help investigators identify suspects, confirm stories, or understand what happened. Forensic chemists often use tools like chromatography to separate and identify the different substances in a sample. To learn more about careers in forensic chemistry, visit the American Chemical Society's page for forensic chemistry careers: <https://www.acs.org/careers/chemical-sciences/fields/forensic-chemistry.html>

Water solubility means how well a substance can dissolve in water. Some things, like sugar or salt, dissolve easily in water. Others, like oil or plastic, do not. In forensic chemistry, testing water solubility can help identify unknown materials or figure out what kind of ink or substance was used in a piece of evidence. Inks, for example, can be either water-soluble (they dissolve in water) or water-insoluble (they don't). If a mystery note is written in a water-soluble ink, forensic chemists might use water-based chromatography to separate and analyze the ink. If the ink doesn't dissolve in water, they know to try a different method. Understanding solubility also helps chemists think about how substances might move through the environment, how they can be cleaned up, or how they might react in the body. That's why even a simple water test can reveal important clues.

Chromatography is the method of separating the parts of a mixture so scientists can figure out exactly what it's made of. Even though something like ink might look like just one color, it's often made from a combination of different colored dyes. Chromatography lets you see those hidden colors. That's why forensic chemists often use it to compare inks found at a crime scene with different pens or markers—they're looking for a match.

- **How it works:** a drop of ink is placed on a strip of filter paper, and the end of the filter paper is dipped in a liquid (usually water or alcohol). As the liquid moves up the paper, it carries the ink with it. The different dyes in the ink move at different speeds and spread out, creating a unique pattern called a **chromatogram**. Each pen or marker creates a different pattern, like a fingerprint made of color. By comparing the chromatograms of different pens to the ink from a mystery note, forensic chemists can make evidence-based conclusions about which pen was likely used. Chromatography isn't just for solving crimes—it's also used in food science, medicine, and environmental studies.

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Be a Forensic Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
<p>Introduce Career</p> <ul style="list-style-type: none"> • Use career card • Ask discussion questions • Explain what forensic chemists do 	<p>What do you notice about this picture?</p> <p>What do you think this person is doing?</p> <p>What do you think a forensic chemist might do or study?</p>	<ul style="list-style-type: none"> • Make observations about the image • Make connections to their own experience • Share their ideas
<p>Introduce Story</p> <ul style="list-style-type: none"> • We're a team of forensic chemists and we've been asked to help solve a crime! • A note was discovered at the scene, and the detectives want to figure out who wrote it 	<p>What do you notice about the note?</p> <p>What could we do to figure out who wrote it?</p>	<ul style="list-style-type: none"> • Imagine being a forensic chemist • Observe the evidence photo • Share ideas about analyzing the note

***Quick Guide continues on the following page.*

Be a Forensic Chemist Quick Guide



EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
EXPLORE		
<p>Part 1: Ink Solubility</p> <ul style="list-style-type: none"> • Distribute pens and testing materials • Demonstrate water drop test procedure • Discuss results 	<p>What do you notice happening to the ink when it gets wet?</p> <p>Which inks behaved like the one in the evidence note?</p> <p>Which ones can we rule out?</p>	<ul style="list-style-type: none"> • Make test strips for 5 pen types • Observe how ink samples interact with water • Draw conclusions about ink solubility
<p>Part 2: Chromatography</p> <ul style="list-style-type: none"> • Distribute test materials • Demonstrate preparing test strips • Demonstrate pencil and cup set-up 	<p>What colors do you see?</p> <p>Are they in the same order or different between strips?</p> <p>Which strips are most like the evidence photos?</p>	<ul style="list-style-type: none"> • Create test strips for 2-3 pen types • Run chromatography test on test strips • Observe and compare results
REFLECT		
<p>Share Group Results</p>	<p>Which ink matched the evidence sample the best?</p> <p>What surprised you about the way the inks separated?</p> <p>What can we say about which kind of pen was used to write the note?</p>	<ul style="list-style-type: none"> • Share and compare results • Reflect on the process • Draw conclusions
<p>Make Career Connections</p>	<p>What did you do today that made you feel like a forensic chemist?</p> <p>How did we think like scientists?</p> <p>What science skills did we use?</p>	<ul style="list-style-type: none"> • Use skills stickers • Draw/write reflections

