



Spy Training Summer Camp Unit 2: Forensic Chemistry

Time: 3 hours

Ages: 4-10

Learning Objectives:

- What is forensic chemistry?
- How do spies use forensic chemistry to solve mysteries?
- What is chromatography and how do spies use it to solve mysteries?
- How does disappearing ink work?

Word of the Day: FORENSIC

Overview: Activities, Materials & Prep

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Opening Calisthenics (5 mins)	2
Big Demo of the Day: Disappearing Ink (10 mins)	2
Materials:	2
<input type="checkbox"/> Bottle of disappearing ink (Amazon.com, Oriental Trading or similar).....	2
<input type="checkbox"/> 2 clear cups.....	2
<input type="checkbox"/> Vinegar - 1 cup.....	2
<input type="checkbox"/> Water - 1 cup.....	2
<input type="checkbox"/> 1 white shirt, cloth or similar	3
Prep:.....	3
<input type="checkbox"/> None	3
Experiment with Disappearing Ink (20 mins).....	3
Materials:	4
<input type="checkbox"/> Disappearing ink – 1 bottle for every 2 campers	4

<input type="checkbox"/> Wax paper – 1 6"x6" square per camper.....	4
<input type="checkbox"/> White fabric – 1 6"x6" square per camper.....	4
<input type="checkbox"/> Pipettes – class set.....	4
<input type="checkbox"/> Clear plastic cups or beakers – class set.....	4
<input type="checkbox"/> Vinegar – ¼ cup plus 1 Tablespoon per camper.....	4
<input type="checkbox"/> Baking Soda – 1 Tablespoon per camper.....	4
<input type="checkbox"/> Styrofoam bowl – 1 for every 4 campers.....	4
<input type="checkbox"/> Plastic spoon – 1 for every 2 campers.....	4
Prep:.....	4
<input type="checkbox"/> Cut the wax paper and white fabric into approximately 6"x 6" squares.	4
<input type="checkbox"/> Pour ¼ cup of vinegar into clear cups or beakers. Prepare one cup/beaker per camper.	4
<input type="checkbox"/> Pour 1 Tablespoon vinegar into enough cups/beakers to allow one or two per table.	4
<input type="checkbox"/> Put baking soda into bowls – one for each table – along with 2 spoons.	4
Experiment with Disappearing/Reappearing Ink (20 mins).....	5
Materials:.....	5
<input type="checkbox"/> Pilot Frixion erasable pens – 1 class set (Amazon.com).....	5
<input type="checkbox"/> White printer paper – 1 sheet for every 2 campers.....	5
<input type="checkbox"/> Heat source – iron, portable space heater, etc.....	5
<input type="checkbox"/> Cold source – a bag of ice or similar.....	5
<input type="checkbox"/> Regular pens – 1 class set.....	5
Prep:.....	5
<input type="checkbox"/> Cut one-half sheet of white printer paper per camper.	5
Chromatography Experiment (10 mins).....	6
Materials:.....	6
<input type="checkbox"/> Clear cups or beakers – 1 class set.....	6
<input type="checkbox"/> Cone-shaped (flat) coffee filters – 1 for every 2 campers.....	6
<input type="checkbox"/> Washable markers in various colors – 1 class set.....	6
<input type="checkbox"/> 1 permanent black marker.....	6
<input type="checkbox"/> ¼ cup rubbing alcohol.....	6
Prep:.....	6

<input type="checkbox"/> Cut the coffee filters into strips that are approximately 1” wide and 4” long. Cut enough for each camper to get two.....	6
<input type="checkbox"/> Pour about 1/2 inch of water in the bottom of the cups/beakers. Prepare one for each camper.	6
Make Chromatography Art (20 mins)	7
Materials:	7
<input type="checkbox"/> Flat coffee filters – 1 per camper.....	7
<input type="checkbox"/> Cups or beakers – 1 class set.....	7
<input type="checkbox"/> Pipettes – 1 class set	7
<input type="checkbox"/> Wax paper – one 6”x6” piece per camper	7
<input type="checkbox"/> Washable markers in various colors – 1 class set.....	7
<input type="checkbox"/> Ballpoint pens – 1 class set.....	7
<input type="checkbox"/> Water	7
<input type="checkbox"/> Plastic sandwich baggies – 1 per camper (optional)	7
Prep:.....	7
<input type="checkbox"/> None.	8
Snack Break (10 mins)	8
Mystery of the Day (5 mins)	8
Materials:	8
<input type="checkbox"/> Crime scene tape or rope.....	8
<input type="checkbox"/> Borax – at least 3 cups. (This a laundry booster found at Walmart and many grocery stores.)	8
<input type="checkbox"/> Small plastic baggies – class set.....	8
<input type="checkbox"/> Index cards – class set.....	8
Prep:.....	8
<input type="checkbox"/> Set up an area in the room to look like a crime scene with crime scene tape or a rope. Make sure that the crime scene tape or rope is high enough for the campers to be able to stoop underneath.	8
<input type="checkbox"/> Strategically place the mystery powder (borax) in a few piles in the crime scene area. Make footprints in the borax.....	8
<input type="checkbox"/> If you didn’t do so on day 1, print out and laminate pictures of at least four different suspects. These can be different teachers or adult helpers at your facility, different cartoon characters that the campers are familiar with, or similar.	8
<input type="checkbox"/> Print out today’s clues that describe each suspect. See attached printable.....	8

<input type="checkbox"/> Create today's suspect board. First, choose a culprit and put the description that matches the evidence in today's crime scene next to the culprit. Put the rest of the descriptions next to the other pictures.....	9
<input type="checkbox"/> If you are using other teachers or adult volunteers as suspects, tell the person you have chosen as the culprit about today's mystery powder mess in the room. You can interrogate that person later, and when "convicted" make that person clean up the room.....	9
<input type="checkbox"/> If you are using cartoon characters, it will be enough for the kids to test the powders to determine which of the characters is the culprit.....	9
Solve the Mystery: Examine Mystery Powders (25 mins).....	9
Materials:	9
<input type="checkbox"/> Small Dixie cups – 6 cups per pair of campers	9
<input type="checkbox"/> Clear cups or beakers – class set	9
<input type="checkbox"/> Baking soda – ¼ teaspoon per pair of campers.....	9
<input type="checkbox"/> Borax (laundry booster – Walmart, Amazon.com, many grocery stores) – ¼ teaspoon per pair of campers	9
<input type="checkbox"/> Instant snow powder (Sodium Polyacrylate) (Amazon.com) or diaper polymer (just rip apart a diaper and use the powder inside) – ¼ teaspoon per pair of campers	9
<input type="checkbox"/> Salt – ¼ teaspoon per pair of campers	9
<input type="checkbox"/> Water – 1 Tablespoon per pair of campers	9
<input type="checkbox"/> Vinegar – 1 Tablespoon per pair of campers	9
<input type="checkbox"/> Popsicle sticks – 5 per pair of campers.....	9
<input type="checkbox"/> Bottles of washable school glue – class set.....	9
<input type="checkbox"/> Pipettes – class set	10
<input type="checkbox"/> Goggles (optional) – class set. If you have an especially messy group of kids, this may be a good idea.....	10
Prep:.....	10
<input type="checkbox"/> Add 1/4 tsp of each of the 4 powders to a separate small Dixie cup. Make enough so that each pair of campers will have 1 prepared cup of each of the powders. For younger campers, consider using only 3 powders (skip the salt).	10
<input type="checkbox"/> Label the cups so that the campers (and you) know what is inside.....	10
<input type="checkbox"/> Add 1 Tsp each of water and vinegar to separate cups/beakers and label these according to the liquid inside. Prepare a set of cups for each pair of campers. Put 1 pipette in each cup.....	10
Optional: Interrogation (10 mins).....	11

Materials:	11
<input type="checkbox"/> Chair	11
<input type="checkbox"/> Bright light (optional)	11
<input type="checkbox"/> Printer	11
<input type="checkbox"/> Laminator	11
<input type="checkbox"/> Laminating sheets – 4 sheets.....	11
Prep:.....	11
<input type="checkbox"/> For camps with younger children, print out the words: Who? What? Where? When? on sheets of white paper (or use the sheets you create on camp day 1). Laminate these as necessary.	11
Use a Chemical Reaction to Create a Spy Diversion (15-25 mins)	12
Safety note:	12
Children should stand a safe distance from the popping canister, as it will go flying when it pops. If this is not possible, they should all be wearing goggles.....	12
Materials:	12
<input type="checkbox"/> Film canister with lid. This should be type of canister where the lid fits inside the lip – these are usually white vs. black with a grey lid. (Amazon.com or Ebay are good sources.)	12
<input type="checkbox"/> Alka-Seltzer or similar tablets- ½ tablet needed for each demonstration	12
<input type="checkbox"/> Cold water – 1 teaspoon needed for each demonstration	12
<input type="checkbox"/> Teaspoon measuring spoon.....	12
<input type="checkbox"/> Towel or similar (optional)	12
<input type="checkbox"/> Goggles – class set (optional)	12
Prep:.....	13
<input type="checkbox"/> Test this at least once to make sure you know how to do it and to test how far the away the kids should stand to be safe.	13

Introduction to Camp (15 mins)

<Skip this if you have done it on a previous day with the same group of kids and increase your other activity times by a few minutes.>

Welcome to Spy Training Camp! This week we will be attending the Spy Training Academy, as we learn all about spies and what they do. Each day we will use what we have learned to solve a mini mystery. (If this is a week-long camp, you can have a special closing event, where you can set-up stations to show what the campers have learned during the week and have the campers “graduate” from the Spy Training Academy).

Each day we will have a theme and a “Word of the Day.”

Invite the campers to say their name and something they would like to share about themselves. This can be anything from what grade they are going into, what their hobbies are, what their favorite spy gadget is, etc. Make sure that all of the kids know each other and are familiar with the teacher and TA.

During camp there are some important camp rules that we must follow:

1. Listen when the teacher is talking so that no one misses any important instructions.
2. Raise your hand and wait for the teacher to call on you before speaking.
3. NEVER put anything in your mouth unless the teacher says it is ok.
4. NEVER leave the lab at the end of camp unless there is a parent present to pick you up!

Introduction to the Subject & Word of the Day (15 mins)

Ask the campers some questions to get them excited about the camp: Have you heard of forensic chemistry before? How about a crime lab? Do you think spies use chemistry to solve mysteries? Have you ever heard of chromatography? Have you used disappearing ink before? Do you know how it works?

Word of the day: FORENSIC

The Science: What is forensic chemistry?

Forensic refers to using scientific methods in investigating a crime. Forensic chemists use their knowledge of chemistry (the study of matter) to help solve mysteries. They analyze evidence such as hair samples, paint chips, blood stains, and powders in what are often called “crime labs.” For example, because different paints have different formulas, a forensic chemist might analyze a paint chip from an accident scene to find out more about what happened, or who was there. From a small paint chip, he or she can determine the make and model of the car that left the paint behind. From ink, a forensic chemist can determine what type of pen was used to write a ransom note. Or from a powder found at the scene, a forensic chemist can derive who was there and what they might have been doing.

Spies also use chemistry -- to write disappearing or invisible messages, to create popping diversions or even to make someone fall asleep!

Show Videos.

Show videos about forensic chemistry, including one that shows chemists analyzing inks using chromatography. Suggested videos are available on the Curiosity Zone YouTube channel: <https://www.youtube.com/user/CuriosityZone/featured>.

Opening Calisthenics (5 mins)

At the beginning of each day of camp, we will start with calisthenics to get everyone warmed up, just like REAL spies in training would do. We will have the campers do a call and response while they are doing their exercises. Today's call and response will be "We love chemistry, yes we do, we love chemistry how 'bout you?" – because today we will be learning about how spies use chemistry to solve mysteries. Do a few seconds of the following exercises:

- Jumping jacks – have the campers do 10 jumping jacks
- Running in place – have the campers run in place as fast as they can for 20 seconds. You can do a count-down.
- Stretches- have them touch their toes and stretch from side to side.

Feel free to add in some exercises, but it is important that no child feel that they are not athletic enough to do any of these activities, so NO PUSH UPS!

Big Demo of the Day: Disappearing Ink (10 mins)

The Science: How does disappearing ink work?

Disappearing ink works because of a chemical reaction. The original blue color of the ink comes from a compound called Thymolphthalein. Thymolphthalein is an acid/base indicator (an indicator is a substance that changes colors in acids and bases). When the disappearing ink comes out of the bottle, carbon dioxide in the air reacts with the water in the solution creating an acid. This lowers the pH of the solution, causing the Thymolphthalein to turn clear and disappear! We can see the disappearing ink turn from blue to clear instantly when we drop a few drops into a cup of vinegar, which is also an acid.



Materials:

- Bottle of disappearing ink (Amazon.com, Oriental Trading or similar)
- 2 clear cups
- Vinegar - 1 cup
- Water - 1 cup

- 1 white shirt, cloth or similar

Prep:

- None

Procedure:

- Begin the demonstration by showing the bottle of disappearing ink and asking if any of the campers have seen this or experimented with this before.
- Show how the disappearing ink works by tracing out a word on the white cloth. Wait a few seconds and watch how the color slowly changes from blue to clear. This will take about 30 seconds.
- Ask the campers: How do you think this works? Talk about how disappearing ink works using the information above. Make sure to mention that when the disappearing ink interacts with things that are neutral, it stays blue, but when it interacts with an acid, it becomes clear and disappears.
- Now pour vinegar into one of the cups/beakers and water into the other until each is about 1/3 full. Ask the campers what they think will happen when we drop a few drops of the disappearing ink into the beaker with the water versus the beaker of vinegar. Is one of these an acid? (Vinegar is an acid. Water is neutral.)
- Drop a few drops of disappearing ink into the cup of water first. Make sure that you keep the cup still. What happens? The ink should remain blue and just make the water cloudy.
- Now drop a few drops of the ink into the cup of vinegar. What happens? It should instantly disappear.
- Explain that they will have the chance to experiment with disappearing ink during camp today.

<If you have two groups, split them up now.>

Experiment with Disappearing Ink (20 mins)

The Science:

In this experiment, we will create carbon dioxide using a chemical reaction between vinegar and baking soda and use it to make ink disappear.

We learned in today's Big Demo that disappearing ink works because of a chemical reaction. A chemical reaction is when two or more ions, molecules or atoms interact to produce a reaction of some sort: fizzing, color-change, temperature change or even an explosion!

This experiment involves two chemical reactions. The first is an acid-base reaction between vinegar (an acid) and baking soda (a base), which produces carbon dioxide gas. The second is a reaction between the acid/base indicator in the invisible ink and the carbon dioxide gas and vinegar (both acids). This reaction produces a color change.

Materials:

- Disappearing ink – 1 bottle for every 2 campers
- Wax paper – 1 6"x6" square per camper
- White fabric – 1 6"x6" square per camper
- Pipettes – class set
- Clear plastic cups or beakers – class set
- Vinegar – ¼ cup plus 1 Tablespoon per camper
- Baking Soda – 1 Tablespoon per camper
- Styrofoam bowl – 1 for every 4 campers
- Plastic spoon – 1 for every 2 campers

Prep:

- Cut the wax paper and white fabric into approximately 6"x 6" squares.
- Pour ¼ cup of vinegar into clear cups or beakers. Prepare one cup/beaker per camper.
- Pour 1 Tablespoon vinegar into enough cups/beakers to allow one or two per table.
- Put baking soda into bowls – one for each table – along with 2 spoons.

Procedure:

- Pass out the wax paper squares to each camper and have them put this on the table in front of them.
- Pass out the white cloth squares to each camper and have them put this on top of their piece of wax paper.
- Pass out the bottles of disappearing ink and have the campers take the top off of the bottles and get them ready to use.
- Pass out the cups/beakers with ¼ cup vinegar to the campers.
- Have the campers put 1 spoonful of baking soda into their beakers to get the chemical reaction going.
- Have everyone squirt a fair amount of disappearing ink onto the middle of their white fabric square.
- Once the reaction in the beaker has calmed down (i.e. it is no longer bubbling close to the top), have each camper stretch their ink-stained white fabric square over the top of the beaker.
- The ink should disappear right before their eyes! This happens because the CO₂ gas created by the chemical reaction lowers the pH of the solution (making it acidic), making the ink clear!
- Have the campers put this off to the side.

- For the next part of this experiment, have the campers squirt out a few drops of invisible ink out onto their wax paper square.
- Pass out the beakers with 1 Tablespoon of vinegar, along with pipettes.
- Explain to drop ONE drop of vinegar onto the disappearing ink drops and watch what happens. What do they see?
- Allow them to drop additional drops of vinegar onto the disappearing ink drops.
- They can repeat this experiment a couple times to observe what happens, as time allows.

Experiment with Disappearing/Reappearing Ink (20 mins)

The Science: How does erasable ink work?

In this experiment, we will use a different kind of spy ink – the kind that is erasable. The ink is actually thermochromic (temperature sensitive) ink that changes color when exposed to different temperatures. The ink “disappears” when an eraser is rubbed over the ink because the eraser creates friction.

Friction is a force that resists motion. The more friction there is, the slower something moves. For example, smooth surfaces have less friction and can speed things up. Bumpy and sticky surfaces create more friction and can slow things down or stop them completely.

Friction also creates heat. You can experience this by rubbing your hands together quickly. Also, when we use an eraser on paper, the friction creates heat. This increase in temperature from the rubbing of the eraser on the paper is enough to change the ink from black to clear. This makes the ink appear to disappear. In this experiment, we will use other sources of heat to make the ink disappear.

You can also make the ink reappear by exposing it to colder temperatures, such as in a freezer.

Materials:

- Pilot Frixion erasable pens – 1 class set (Amazon.com)
- White printer paper – 1 sheet for every 2 campers
- Heat source – iron, portable space heater, etc.
- Cold source – a bag of ice or similar
- Regular pens – 1 class set

Prep:

- Cut one-half sheet of white printer paper per camper.

Procedure:

- Explain that in this experiment, they will get a chance to experiment with another type of disappearing ink, only this ink will also reappear.

- Start with a quick demonstration by writing a message or drawing a picture on a piece of white paper with the Frixion pens. Show the campers the message.
- Subject the message to a heat source by ironing the paper with a hot iron or holding it in front of a portable heater. The message will disappear.
- Now subject the same message to a cold source. The message will reappear!
- Now allow the campers to repeat your experiment themselves. Allow them to come up to a heating station run by a teacher. They can apply bags of ice themselves.

Chromatography Experiment (10 mins)

The Science:

We've used some cool inks today. But how can a spy figure out what kind of ink is being used? Chromatography. Chromatography is a scientific method used to separate out the various parts of a solution. For example, chromatography can separate the different dyes in an ink. Even though an ink may look black, when chromatography is used to separate the dyes, there are usually red, pink, blue and other color dyes mixed into the ink. Ink chromatography can be done with various solvents such as water, alcohol or acetone (found in nail polish remover), depending on the ink being tested.

Chromatography can help spies examine the ink on a ransom note or a secret message. They can look at the individual pigments in the ink and determine whether the pen is water soluble, or what kind of dyes are in the ink. If the spy can figure this out, he or she might be able to figure out what pen was used, which could lead to a suspect.

Materials:

- Clear cups or beakers – 1 class set
- Cone-shaped (flat) coffee filters – 1 for every 2 campers
- Washable markers in various colors – 1 class set
- 1 permanent black marker
- ¼ cup rubbing alcohol

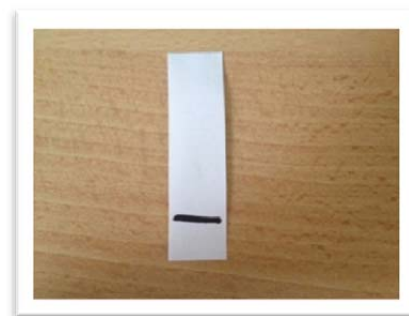
Prep:

- Cut the coffee filters into strips that are approximately 1" wide and 4" long. Cut enough for each camper to get two.
- Pour about 1/2 inch of water in the bottom of the cups/beakers. Prepare one for each camper.

Procedure:

- Introduce chromatography to the campers
- Explain that, in this experiment we will separate the dyes that are found in this brand (whatever brand that may be) of washable markers.

- Pass around a cut strip of coffee filter to each camper.
- Have each camper pick out a washable marker color and draw a line across the piece of paper about ½ inch from the bottom. Black and brown usually work best.
- Pass around the cups/beakers with water – one per camper.
- Have the campers stick their filter paper into the beaker making sure that the marker line does not go under the water line. Hold this in the water for a few seconds, until it is noticeable that the dyes are separating out, then put the strip of filter paper on the table to dry. What colors do they see?
- Allow the campers to do this experiment again, with a different color this time. What colors do they see the second time?



Collect the cups/beakers to use in the next activity.

- As a demo, draw a line using a permanent marker on a piece of coffee filter using the same method as above. Wait a few seconds for the line to dry completely.
- Show the campers what happens when you hold this in a beaker with water. The coffee filter should soak up the water, but because the permanent marker is not water soluble (does not dissolve in water), the dyes will not separate.
- Now prepare another strip using the permanent marker. This time, dip the strip into a beaker with rubbing alcohol, again making sure that the marker line does not go into the liquid. What do the campers think will happen?
- Allow the strip to sit in the rubbing alcohol for a few minutes while the campers start their next activity. A few minutes later, pull out the strip and show the campers the strip of paper. What colors do they see? Permanent marker is soluble in rubbing alcohol.

Make Chromatography Art (20 mins)

Materials:

- Flat coffee filters – 1 per camper
- Cups or beakers – 1 class set
- Pipettes – 1 class set
- Wax paper – one 6"x6" piece per camper
- Washable markers in various colors – 1 class set
- Ballpoint pens – 1 class set
- Water
- Plastic sandwich baggies – 1 per camper (optional)

Prep:

- None.

Procedure:

- Pass out a coffee filter to each camper. Explain that they will experiment with chromatography on this. Once it has dried, they can use this as a secret compartment pocket.
- First, have the campers write their names on their coffee filter using a ballpoint pen. This will not bleed when we drop water on it.
- Next, have the campers decorate their coffee filter with the washable markers. Dots and dark blobs of color work best for chromatography.
- Once they are finished decorating, each camper should place their filter on a piece of wax paper.
- Pass out the pipettes and the cups/beakers with water from the last experiment.
- Have the campers squirt small amounts of water onto their coffee filter using pipettes; this will make the colors begin to run. Do only one drop at a time; don't completely soak the filter.
- Put these aside to dry (hanging from a string with clothespins works well for large groups of kids).

Snack Break (10 mins)

Mystery of the Day (5 mins)

Materials:

- Crime scene tape or rope
- Borax – at least 3 cups. (This a laundry booster found at Walmart and many grocery stores.)
- Small plastic baggies – class set
- Index cards – class set

Prep:

- Set up an area in the room to look like a crime scene with crime scene tape or a rope. Make sure that the crime scene tape or rope is high enough for the campers to be able to stoop underneath.
- Strategically place the mystery powder (borax) in a few piles in the crime scene area. Make footprints in the borax.
- If you didn't do so on day 1, print out and laminate pictures of at least four different suspects. These can be different teachers or adult helpers at your facility, different cartoon characters that the campers are familiar with, or similar.
- Print out today's clues that describe each suspect. See attached printable.