Station #1: **Microscopy and Surface Analysis**

1. Start your work at this station by looking around at the tools and materials here. What do you recognize? Which of these have you worked with before, in other Science classes or outside of school? What do you remember about how to use these microscopes and other tools correctly?

2. Thinking about how you've learned to use these tools in the past, read over the two articles. Re-familiarize yourself with the parts of a microscope, how to use it and take care of it, and how to work with microscope slides. As you read, record notes in whatever way works best for you. Make sure you have a good sense of how these different types of microscopes can be used to analyze and better understand evidence left behind by crimes and other unknown circumstances.
    - "**Microscopy, surface analysis, and their tools**" (introduces types and uses of different microscopes)
    - "**Appendix B: Using a Microscope**" (reviews parts of a microscope and how to use it correctly)

3. To learn more about SEM and how it works, watch this short video and view some images taken by scientists.
    - Watch this brief video explanation: **Scanning Electron Microscopy** by the Wellcome Collection
    - Check out some SEM images in this online gallery: **SEM Image Gallery** by ThermoFisher Scientific (Look beyond the first page; continue on to view other images on the later pages.)
    - Try to match up the printed SEM images and their descriptions

"Appendix B" also explains how to make a slide to view in a compound microscope. Slides, however, aren't necessary for some other types of microscopes. Use the materials here at this station to make a slide of your own and then view it and other items under the different microscopes we'll be using in our class:

4. Prepare the hand lenses and the microscopes for use by wiping them with a clean tissue. Gently wipe each surface involved in your viewing, including the mirror, stage, each lens, and the eyepiece. (Dispose of the tissue in a trash can.)

5. Use the handheld magnifying lenses and both the compound microscope and the stereomicroscope to view a few of the prepared slides and items at this station. Choose one of these slides to record in your notes. Record the name of the specimen and then sketch out what it looks like with (a) no magnification, (b) magnification using the hand lens, and (c, d, e) magnification using each of the microscope's lenses. (You should have 5 small sketches.) Make a note of what was different looking at the slides and objects through the stereomicroscope versus the compound microscope.

6. Create a slide of a hair from one of your group members, following the instructions on the "Appendix B" guide:
    - Since we'll be re-using microscope slides from past classes, start by carefully cleaning a glass slide with soap and water. Dry it completely, and then wipe it again with a clean tissue. (Make sure extra water from the sink gets cleaned up and used paper towels and tissues are disposed of in a trash can.)
    - Look closely at your clothing – there is likely a loose hair on your shoulder or back. Find a hair sample from one of your group members and mount it to be viewed under the microscope. Use a clean, glass microscope slide, a clean cover slip, and clear fingernail polish as the mounting fluid. (Using nail polish instead of water will make the mount permanent.)
    - Use a permanent marker to label the slide with its contents (what is the specimen and where did it come from) and your group members' name.

7. View your self-made slide under the compound microscope's highest magnification and sketch out what you see in your notes.

8. Use the camera app on you or a group member's phone to take two photos of each specimen you mounted: one picture of the slide you've prepared lying on the classroom counter with no magnification, and one picture using the microscope to show the specimen under maximum magnification. Take this second photo by placing the camera lens against the eyepiece of the microscope; use the phone's screen to focus and crop the image appropriately. Submit these two photos of your slide to **our class shared folder**; include your group members' names in the file's title.

9. **Please re-set the station** so that all of the materials are clear, organized, and ready for the next group.

Station #2:

Chromatography Analysis

1. Start by reading the background article about chromatography analysis and how it works to help identify unknown substances. As you read, record notes in whatever way works best for you. Make sure you have a good sense of how this technique can be used to analyze and better understand evidence left behind by crimes and other unknown circumstances.
    - "**Chromatography: A unique chemical signature for every substance**" (basic explanation of how chromatography works and how it is used)
2. To learn more about how chromatography works, watch these helpful videos and read through this webpage:
    - Watch this brief video explanation: **Basics of chromatography** by Khan Academy (You should only watch the first half – up to about 4:00.)
    - Check out these step-by-step instructions for how to set up and perform a basic chromatography analysis (including some very helpful diagrams): **How to Do Simple Chromatography** by wikiHow
    - Here's a short video about how the newest chromatography techniques can be used to help analyze crime scene evidence: **Catching Criminals with Lipstick Stains** by the American Chemical Society
3. Follow the step-by-step lab procedure (**Paper chromatography analysis of dye-based substance**) to correctly conduct two paper chromatography analyses: one comparing ink samples and another comparing lipstick samples. Using the same step-by-step procedure twice, you will compare the sample taken from the crime scene (labeled "evidence") to one of the known samples to determine whether or not they match. A chromatography strip has already been prepared for you with the evidence sample. You will prepare chromatography strips for the known samples and develop chromatograms for all samples using the procedure provided. Record all of your data in your notes.
4. Before you can finish your analysis of your work at this station, you will have to allow your chromatograms to completely dry. Set them aside to dry in a safe place and clean the area and prepare the station for the next lab group. Make sure that all equipment and supplies are returned to their proper places and that the counter area is clean and neat before moving on. Leave room in your notes to come back and finish your analysis of your work with paper chromatography.

(Leave the station for now, neat and ready for the next group, and return after your chromatograms have completely dried. Then, when you've come back to finish your analysis, continue below…)

5. After your chromatograms have completely dried, calculate R_f values for each sample, including the evidence from the crime scene. Record all of your data in your notes.
6. Analyze your data by answering the following questions in your notes:
    - What are the similarities and differences you can see in the chromatograms produced by your analysis? What can you infer from this?
    - Which samples have the most similar R_f values? What can you infer from this?
    - What is the identity of the lipstick found at the crime scene?
7. **Please re-set the station** so that all of the materials are clear, organized, and ready for the next group.

Station #3:

Density Determination and Analysis

1. Start your work at this station by looking around at the tools and materials here. What do you recognize? Which of these have you worked with before, in other Science classes or outside of school? What do you remember about how to use these tools correctly?
2. Thinking about how you've learned to use these tools in the past, read over the short article. As you read, record notes in whatever way works best for you. Make sure you have a good sense of how densities can be used to analyze and better understand evidence left behind by crimes and other unknown circumstances.
    - "**Density – the simplest analysis 'hack' around**" (outlines how density can be used to analyze evidence)
    - "**Three strategies for determining the density of a small, unknown specimen**" (detailed step-by-step procedures for determining density of unknown samples)

"Three strategies…" provides detailed instructions for how to determine the density of different unknown objects based on their characteristics. You'll follow each of the three methods to determine the density of three separate, unknown objects:

3. This station includes a rectangular metal prism. [Since the density of any pure substance is consistent from sample to sample, no matter its size, if we measure the density of a sample, we can then compare that value to known density data and determine its identity.] Determine the density of this metal and then (using online data) try to determine what type of metal it is made of. What are the possible source of error in this method? Record all of your data in your notes.
4. This station also includes a marble sphere. Determine the density of this sample using method 2. What are the possible sources of error in this method? Record all of your data in your notes.
5. There are two small samples of plastic available at this station – one that is clear and another that is red. Determine the density of these two samples using method 3. Is it likely that these two samples are made of the same type of plastic? How do you know? What are the possible sources of error in this method? Record all of your data in your notes.
6. If all of your data is properly recorded and your work is documented in your notes, clean the area and prepare the station for the next lab group. Make sure that all equipment and supplies are returned to their proper places and that the counter area is clean and neat before moving on. **Please re-set the station** so that all of the materials are clear, organized, and ready for the next group.

Station #4:

Techniques for Revealing and Preserving Invisible Prints and Markings

When invisible fingerprints and others markings are left behind at a crime scene, they are referred to as "latent prints;" this means that they are invisible to the naked human eye but can be revealed and preserved using some basic techniques. These techniques include dusting, lifting, or fuming.

1. Start by checking out these two resources that give us some helpful background information and examples of how latent prints might be left, where we are likely to find them, and how we can reveal them:
    - **A Simplified Guide to Fingerprint Analysis** (introduces how revealing works)
    - **Developing Fingerprint with Super Glue** (demonstrates a more complex method)

2. Now it's your turn: Using the materials at this station, create a few prints on the glassware and surfaces nearby, and then try to collect and preserve these using dusting and lifting, according to the instructions below. **Warning: The black dusting powder you will use very easily and very quickly can make a big mess. Be careful not to get the dust on your clothing and wash your hands immediately after you use the materials. Never leave the black powder container open when you are not using it. Keep the lid on the powder and use as little as possible – It goes everywhere!**
    - Use a paper towel to wipe away any markings or leftover prints on the table surface in front of you and the large beaker.
    - Taking the clean beaker, firmly press a finger onto the outside surface to create a new, clear latent print.
    - Next, carefully open the black dusting powder and use a brush to gather a little bit of the powder. Use a twisting motion to add a small amount of black powder to the brush and then to lightly brush it over the surface of the beaker where you created the new, fresh fingerprint. Quickly, you should see the powder adhering to the print, revealing it and its details.
    - **Replace the lid of the black powder and put the brush away carefully as soon as you are done using them. Keep the area as clean as possible to avoid extra dust making a bigger mess than is necessary.**
    - Cut a small section of clear tape and carefully lay the tape flat over the surface where your newly revealed print is located. Press firmly to make sure the tape completely attaches to the print and its original surface. Carefully pull the tape off of the original surface, hopefully carrying the revealed print with it. Place this neatly in the center of a clean, blank index card for preservation. Label the card with the date, time, location, and the original source where the print was found. You should also add whose finger was used and which finger they used to make the original print. Write your group members' names on the back of the card.
    - Use the handheld magnifying lenses to more closely observe the characteristics (called "*minutae*") of the lifted print.

3. Try to carefully make one or two other small prints and lift them using smaller pieces of tape. Tape these lifted prints into your notes and record any observations.

4. If all of your data is properly recorded and your work is documented in your notes, clean the area and prepare the station for the next lab group. **Wipe down the glassware and the table with a wet wipe and a paper towel to make sure there is no residual black powder left on the table for unsuspecting students approaching the station after you.** Make sure that all equipment and supplies are returned to their proper places and that the counter area is clean and neat before moving on. **Please re-set the station** so that all of the materials are clear, organized, and ready for the next group.

Station #5: **Casting 3-Dimensional Impressions and Markings**

When three-dimensional markings or dents are found in a crime scene, these are referred to as "impressions." Investigators will photograph these markings, and then try to preserve them by collecting the entire materials in which they were found (like a large chunk of soil, or a section of a wall). However, that is often impractical, and can even damage the evidence in some cases, so creating a "cast" is the next best method to preserve these impressions for further analysis. A cast is a three-dimensional replica of the surface of the original object that created the impression found in the scene; it is the opposite of the impression.

1. Start your work at this station by considering the short statement above that introduces "casting" as a method of preserving evidence for analysis. In your notes, define the terms "impression" and "cast," and then explain in your own words the relationship (similarities and differences) between the original object, the impression left behind as evidence, and the cast used to preserve the evidence. What are the possible sources of error in this process?

2. For an example of the process you'll be completing, watch this short "how to" video:
    - **Shoe Print Casts** by Scitech WA

3. Follow the step-by-step directions below to create a small, simple cast of markings you'll create here at this station:
    - Start by preparing your work area and container: Make sure the work area is clear of extra dust or water. Write your name on the side of a small disposable paper cup. This cup is where you will make your 3D impression and your cast.
    - Next, create the impression that you'll preserve with your cast: Get a small amount (about the amount that will fit in the palm of your hand) of modeling clay and roll it into a ball using your hands. Squish this small ball of clay into the bottom half of the paper cup with your name. Use the tools and materials here at the station to make noticeable markings and impressions into the top surface of the clay. Do not leave any physical objects embedded in the clay – this will damage your final cast and inhibit the casting process.
    - Now that you've created the impression that you want to preserve using casting, you need to mix a very small amount of plaster. **Please be careful as you work with these materials because they very easily make a large mess, and can too much commotion can cause clouds of dust that activate allergies and sinus irritation. Do not breathe in the dust.** Use this recipe to make your plaster mixture: In a clean plastic container, mix together ½ small paper cup of plaster mixture with ½ small paper cup of tap water using a clean popsicle stick. Stir the mixture until it is smooth and free of clumps. **Take care not to get any of this plaster mixture on your clothing. If any gets on your skin, immediately wash it off at a sink.**
    - Return to your original paper cup that contains the modeling clay and your 3D impression. Pour just enough of the plaster into the original cup so that it completely covers the top of the modeling clay. You should not need fill up the original cup completely, just enough to cover the clay and the impression you are trying to preserve.
    - Leave your labeled cup with wet plaster in a safe place to dry (probably more than 1 hour). When you return, and the wet plaster has dried, you'll be able to tear away the paper cup and reveal your original clay mold and new preserved cast of the 3D impression you created.

(Leave the station for now, neat and ready for the next group, and return after your plaster has completely dried. Then, when you've come back to finish your analysis, continue below…)

4. After your plaster has completely dried, reveal your cast by tearing away the paper cup. Careful pull apart the original clay mold and your dried plastic cast, and observe the similarities and differences. Record your observations in your notes.

5. Take a photo that shows your cast and the original impression that you and your group members created. Submit your photo to our **class shared folder**; include your group members' names in the file's title.

6. **Please re-set the station** so that all of the materials are clear, organized, and ready for the next group.

Station #6:

Spectral Analysis

Spectral Analysis is a whole category of laboratory techniques that most often include large, complex technologies to determine the composition (chemical make up) of unknown substances and other materials; it is especially common when working with illicit or controlled substances, like medicines and drugs. There are several different types of spectral analysis, depending on the equipment you have access to and the kind of information you want about the unknown substance you are trying to identify. [Note: Since the term "spectral" refers to light, most versions of spectral analysis involve a machine that sends light through the substance you are working with in an effort to measure its composition or concentration.] At this station, you'll look at three of the most common forms of spectral analysis – Mass Spectrometry, Spectrophotometry, and Infrared Spectroscopy:

1. Watch the following video clips that introduce basic ideas behind each of these analysis methods. As you watch, record notes in whatever way works best for you. Make sure you have a good sense of how these techniques can be used to analyze and better understand evidence left behind by crimes and other unknown circumstances.
    - **Mass Spectrometry** (explains basic theory and process and shows what the final data looks like)
    - **Spectrophotometry introduction** from Khan Academy (introduces the theory that allows spectrophotometry to work)
    - **How To Use A Spectrophotometer** from Professor Lui (shows how the actual machinery works)

2. Skim over this website that introduces a third type of spectral analysis – infrared spectroscopy. This is commonly used in the study, manufacture, and analysis of organic substances like medicine or drug molecules. As you watch, record notes in whatever way works best for you:
    - **Infrared Spectroscopy** from Michigan State University
        - As you skim through this webpage, notice the complex diagrams that show lots of lines and peaks at different number values. These peaks each represent a different part of the original substance that has been broken apart and analyzed. When a trained scientist sees this data, they know which peaks – their shapes, sizes, and number values – represent which chemical structures and are able to predict the most likely overall chemical composition of the substance they are trying to identify. You'll also notice a chart of the most common peaks and number values and which chemical structures they most likely represent. Using all of this data, the unknown substance can be identified.

3. Look at the printed examples of different spectral analyses of two commonly examined substances – aspirin and cocaine. These represent the mass spectrum (from mass spectrometry) and the infrared spectrum (from infrared spectroscopy). Compare how these different graphs might provide detailed data to help scientists identify unknown substances.

4. Answer the following questions in your notes:
    - Based on what you've read and learned about these different strategies, what is meant by the term "spectral analysis" and what is basic goal of this type of laboratory technique?
    - What is the major difference between mass spectrometry and spectrophotometry, in terms of what kind of data they offer a scientist?
    - Based on what you saw in the different print outs of mass spectra and infrared spectra, what are the key differences in the kind of data these different methods offer a scientist?
    - Imagine a crime-related scenario where one of these techniques would be valuable. Describe the crime and how spectral analysis techniques might help investigators better understand what happened.