

**truTV**

# ***Forensics in the Classroom***

Developed as part of a continuing educational partnership with the **American Academy of Forensic Sciences** and developed in collaboration with the **National Science Teachers Association**.

[www.trutv.com/forensics\\_curriculum](http://www.trutv.com/forensics_curriculum)



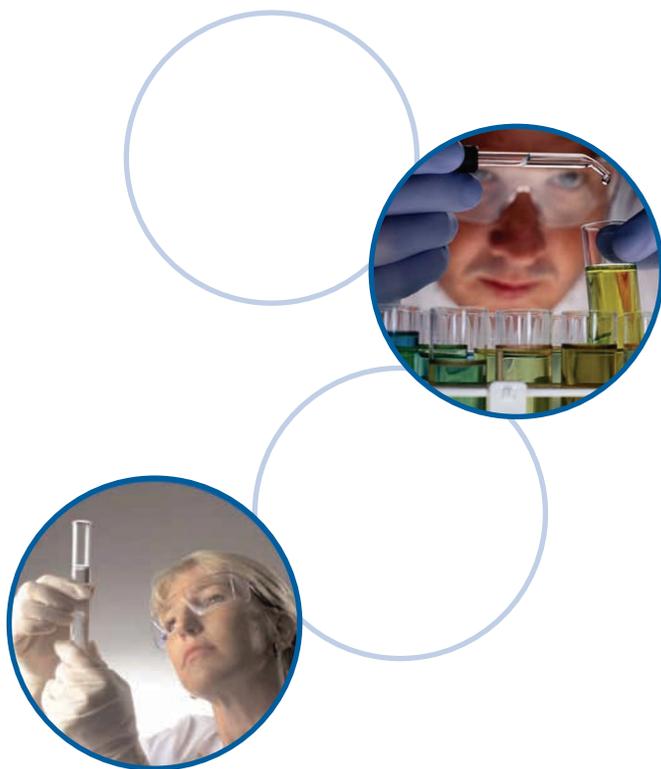
## WARNING and SAFETY PRECAUTIONS

Working with your students on these projects gives you an excellent opportunity to instill in them good work practices, in particular the practice of dealing safely and efficiently with chemicals and other materials that may be potentially hazardous and/or expensive. It is important to comply with the warnings and safety instructions concerning the use of your materials, as well as any laws regarding the disposal of the materials. For safety and for avoiding waste, you should inform your students of these warnings, instructions and laws, and the reasons behind them. The goal is to educate the students without implanting or enhancing any unreasonable fears.

Safety is an important part of any laboratory exercise. Plastic safety products, as illustrated below, can help protect your students as they conduct chemistry experiments such as those in the FIC units. To find out more about plastics log on to the American Plastics Council at <http://www.americanplasticscouncil.org>.

### Plastic safety devices, if used properly, can help save kids from injuries.

- Safety eye goggles
- Splatter-proof face shields
- Plastic apron to keep dangerous spills away
- Heat-resistant plastic gloves, chemical-resistant vinyl gloves
- Shatter-resistant plastic containers for acids
- Child-resistant plastic safety caps for storing dangerous substances
- Plastic film for spill-resistant laboratory beaker sealing
- Plastic tubs immune to harsh solvents for appropriate disposal
- Emergency plastic face mask and eyewash bowl
- Flame retardant countertops made with plastic composite



# MS Unit 1 Teacher Overview: It's Magic!

## UNIT DESCRIPTION:

This unit is designed to combine an introduction to forensic science with four investigative lab activities. A dognapping mystery is presented to the class, and student investigators are in charge of helping Detective Woodward solve it. After learning terminology and facts about forensics, students will examine clues from the story using pH analysis, paper chromatography of ink samples, Questioned Document (QD) analysis, and hair sample comparisons. The results of the lessons will lead students to conclude who committed the crime. Each lesson contains a teacher guide with background information, preparation instructions, and lesson steps, as well as reproducibles for the students. When the four labs are completed, students will compose an Investigative Report. After completing their reports, students will be provided with the story Epilogue to confirm their findings.

## IN ADDITION TO THIS TEACHER OVERVIEW, MS UNIT 1 INCLUDES:

### Lesson 1: Introduction to Forensics and the Mystery

- Forensics Terms and FAQ Sheet handout
- Mystery Synopsis handout
- Determining the pH of an Unknown Substance

### Lesson 2 Part I: Paper Chromatography

- Paper Chromatography Analysis Sheet
- Mystery InterludeLesson 2 Part II: A Closer Look at the Partial Ransom Note
- A Closer Look at the Partial Ransom Note Activity Sheet
- Handwriting Samples and copy of the partial ransom note (To be created by the teacher)

### Lesson 3: Hair Analysis and Conclusion

- Hair Analysis and Comparison Activity Sheet
- Hair Analysis Information Sheet
- Investigative Report

### Unit Epilogue

**DESIRED OUTCOMES:**

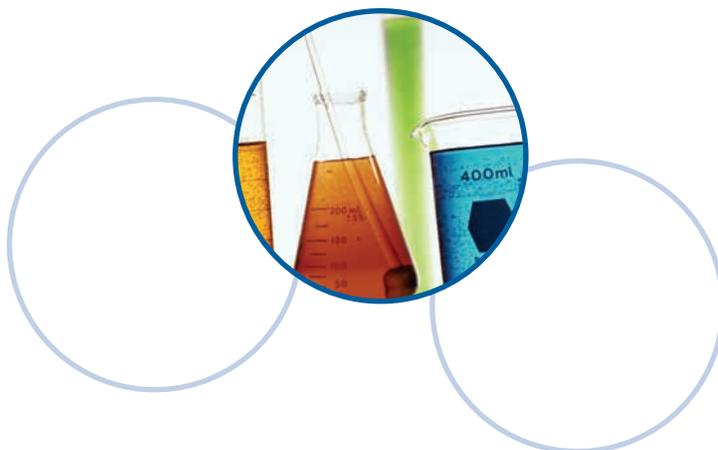
After completing the unit, students should:

- Develop basic skills in observation, data collection and data analysis
- Understand and perform scientific inquiry
- Analyze and synthesize several pieces of data to draw a conclusion
- Recognize and explain the limited role hair analysis and QD examination can play in a forensics investigation
- Understand and describe the importance of safety and following directions in lab procedures

**NATIONAL STANDARDS ADDRESSED:**

After completing this unit, students should develop:

- Abilities necessary to do scientific inquiry
- An understanding of properties and changes of properties in matter
- An understanding of structure and function in living systems
- An understanding of science and technology in society



**IMPORTANT TERMS:**

**Acid**– A corrosive substance that has a sour taste. (Students SHOULD NOT taste any acids in the lab!) When mixed with water, an acid yields  $H^+$  ions.

**Base**– A slippery substance that has a bitter taste. When mixed with water, a base yields  $OH^-$  ions.

**Chromatogram**– The recording of the results of a chromatography procedure.

**Chromatography**– The process of separating a chemical mixture — e.g., ink — into its individual substances.

**Diacritics**– Marks such as an accent or a tilde that indicate the correct pronunciation of a letter or combination of letters which, without the mark, would be pronounced differently.

**Microscopic Hair Analysis**– Investigative procedure of examining hair shafts for identifiable characteristics.

**Indicator**– A chemical used to determine the presence of an acid or a base.

**pH**– "power of Hydrogen" – a measure of the concentration of  $H^+$  ions found in a solution; the lower the pH, the higher the concentration.

**Questioned Document (QD) Analysis**– Procedure of examining handwriting, watermarks, inks, paper type, and other qualities of documents that may indicate a document's origin and author.

**QD Examiner**– One who analyzes documents professionally, often for investigative purposes.

**Solute**– A dissolved substance.

**Solvent**– A liquid substance capable of dissolving or dispersing one or more substances.

**Standard**– In handwriting analysis, material whose source and origin are known and used for comparative purposes.

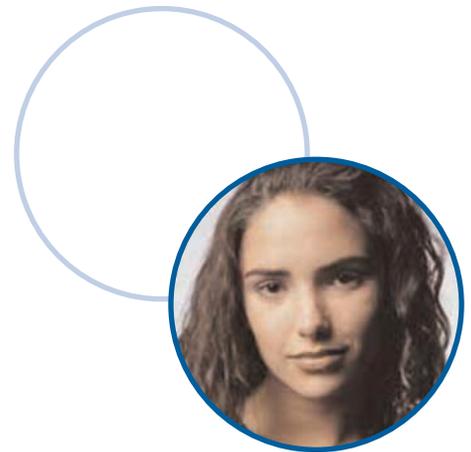


**MYSTERY SYNOPSIS:**

Liz is a neighborhood teenager hired by the Jeffersons to watch their dog, Magic, while they go away on vacation. Normally, the Jeffersons take their dog with them, but because Magic is sick, they decide they must leave him at home. The Jeffersons give Liz strict instructions to check on Magic at least four times a day, monitor his diet, and contact the veterinarian immediately if there are any problems. One afternoon Liz checks on Magic a little earlier than she usually does, and she is surprised to find the spare key in the door. She wonders if she accidentally left it there earlier that day. She is also concerned when she enters the house and sees a small, cloudy-looking puddle on the kitchen floor. Liz assumes that Magic must have had an accident. A noise upstairs startles her, but when she calls to him, Magic comes downstairs and seems fine. Liz decides against calling the vet, but because Magic's illness is related to his kidneys, she collects some of the liquid in case the vet needs to analyze it. As she cleans up, Liz also notices a piece of paper in the otherwise empty trash can. The paper has the words "I have taken" written on it. After calling her father to take a quick look through the house, Liz is careful to lock up on her way out. But when she returns to check on Magic later that afternoon, he is gone. A typed ransom note left on the kitchen table reveals that Magic has been dognapped and that the perpetrators demand money for the safe return of the dog. Liz notifies the Jeffersons and the officials. Students will launch an investigation to determine who took Magic. Students must consider various characters who provide clues or who could be persons of interest. They will examine the physical evidence left at the scene to determine if the dognapper can be identified.

**MATERIALS NEEDED:****Reproducibles**

1. Forensics Terms and FAQ Sheet
2. Mystery Synopsis
3. Determining the pH of an Unknown Substance
4. Paper Chromatography
5. A Closer Look at the Partial Ransom Note
6. Handwriting Samples (To be prepared by teacher)
7. Copy of the Partial Ransom Note (To be prepared by the teacher)
8. Hair Analysis and Comparison
9. Hair Analysis Information Sheet
10. Investigative Report
11. Unit Epilogue



**Lab Materials**

Determining the pH of a Substance – Lesson 1:

- gloves and safety goggles
- unknown liquid sample
- small beakers or plastic cups
- standard litmus paper
- pH indicator paper with color comparison chart

Paper Chromatography – Lesson 2 Part I:

- 3 chromatography chambers
- 3 types of sample pens
- filter paper
- water and rubbing alcohol
- labeling tape
- paper clips or tape
- stirring rod
- safety goggles

A Closer Look at the Ransom Note – Lesson 2 Part II:

- hand lenses (magnifying glass)

Hair Analysis and Conclusion – Lesson 3:

- human and dog hair samples
- microscopes, slides, and coverslips
- dropper
- Permout or other mounting solution
- forceps
- colored pencils
- hand lenses (magnifying glass)

**Note:** Any time you use chemicals in your classroom or lab, be sure to read and follow the safety instructions for use and disposal that are provided in the MSDS information that came with your lab materials.

**ORDER OF ACTIVITIES:**

1. Introduction to Forensics and the Mystery (Lesson 1)
2. Determining the pH of an Unknown Substance (Lesson 1)
3. Paper Chromatography (Lesson 2 Part I)
4. A Closer Look at the Partial Ransom Note (Lesson 2 Part II)
5. Hair Analysis and Comparison (Lesson 3)
6. Investigative Report and Epilogue

Present students with the story's Epilogue when all activities are successfully completed, or hold a classroom discussion to share various theories and the mystery conclusion.

**ADDITIONAL RESOURCES FOR TEACHERS:**

<http://www.crimelibrary.com>

truTV's online crime library with overviews of some forensics techniques and cases that have been solved using them. (Note: This site is for teacher reference. Some topics discussed here may not be appropriate for classroom use.)

<http://www.swafde.org/faq.html>

Official site with information about QD analysis.

[http://www.aafs.org/The\\_Resource/](http://www.aafs.org/The_Resource/)

Forensics section provides additional links to forensics information.

<http://www.cheminst.ca/ncw/experiments/echromatography.html>

Directions and background information pertaining to paper chromatography.

<http://www.trutv.com/forensics/lab/>

truTV's online virtual forensics lab where students can learn about forensic techniques and watch videos of experts at their stations.

<http://www.msdssearch.com/>

A search site containing a national repository of Material and Safety Data Sheets.



## LESSON 1: INTRODUCTION TO FORENSICS AND THE MYSTERY

### OBJECTIVE:

Students will review the Forensics Terms and FAQ sheet. After being introduced to the mystery, they will brainstorm in groups to compile a list of suspects and possible evidence. In addition, they will analyze an unknown liquid to determine its possible source.

### MATERIALS NEEDED:

#### Reproducibles

- Forensics Terms and FAQ Sheet
- Mystery Synopsis
- Determining the pH of an Unknown Substance

#### Equipment and Chemicals

- unknown Liquid Sample – diluted bleach prepared by the teacher
- 2 small beakers or cups per lab group
- rubber gloves and safety goggles
- standard litmus paper AND/OR
- pH indicator paper with color comparison chart

**Note:** Any time you use chemicals in your classroom or lab, be sure to read and follow the safety instructions for use and disposal that are provided in the MSDS information that came with your lab materials.

### TIME REQUIRED:

- Teacher Prep Time: 30 minutes
- Class Time: 60 – 90 minutes, depending on the amount of discussion about forensics

If time permits, spend 30-40 minutes discussing forensics and going over important vocabulary terms (see Forensic Terms) (Lesson Steps 1–3). Spend another 30 minutes discussing the mystery and possible steps to take in analyzing the evidence (Lesson Steps 4–5). If the lab is already set up (solutions poured, testing paper cut, etc.), the pH analysis itself will take less than 10 minutes. The analysis and conclusion questions on the student handout can be assigned for homework following the lab (Lesson Steps 6–7).

### LESSON DESCRIPTION:

In this lesson, students will be introduced to forensic science. The class will discuss basic forensics questions and learn new forensics vocabulary. Students will then read the mystery and make lists of suspects and possible pieces of evidence. As a group, the class will decide how to proceed with the evidence. One piece of evidence—an unknown liquid found at the crime scene—will be analyzed.

**TEACHER BACKGROUND INFORMATION:**

Before beginning this lesson, familiarize yourself with the history of forensics and how different scientific tests can be used to help solve crimes. Review the forensics vocabulary provided in the unit (see Forensic Terms). Students will have many questions about forensics and want to give you several examples of crime-solving they have seen in the movies and on television. Although it is important at this point to clear up some of their misconceptions, use their energy and enthusiasm for the subject as an opportunity to teach scientific inquiry.

Review key vocabulary terms in boldface on the student handout. Define these words as you proceed with the lab. Also review basic properties of acids, bases, and indicators. As your students complete the lab, encourage them to make quick and accurate readings of the litmus paper test and the pH indicator test before the bleach solution starts to bleach the paper.

**LESSON STEPS:****Teacher Preparation for "Determining the pH of an Unknown Substance"**

1. Standard litmus paper and pH indicator paper can be ordered from any scientific supply company. (If time allows, use both types of test paper. Doing so will give students a chance to perform two different controlled experiments. If time is tight, however, using EITHER test paper is fine for this experiment.) Usually the paper comes on a roll that is several mm thick. Before your students arrive, cut pieces of both test papers for each group of students. Lengths of 6–8 cm will be plenty. Stack the paper by type for the student groups to pick up.
2. Mix and pour all solutions ahead of time. For the "unknown liquid" use diluted bleach (10 ml bleach/40 ml of water). Each student group will need only 3–5 ml of the solution. Use small beakers or plastic bathroom cups to hold the liquid.
3. Have a waste beaker available where students can pour their liquid waste when they are finished with the lab. **Be sure to follow the local, state, and federal regulations for correct and safe disposal of all liquids.**

**Lab Execution**

1. Write the term FORENSICS on the board. Ask students to brainstorm phrases or ideas that come to mind when they hear the term. They should write down these ideas in their notebook.
2. Ask students to share their ideas about forensics with the class. As they contribute, point out the difference between "true" lab-based science and the sometimes exaggerated use of science seen in movies and on television.
3. Have students visit truTV's online Virtual Forensics Lab to research different forensic techniques and watch them being performed. (<http://www.trutv.com>)

4. Distribute the Mystery Synopsis to the students. If possible, try to have a police officer or school resource officer come in to introduce the crime. Read the mystery together as a class. Discuss the scenario to ensure that all students understand the story. Break the class into small groups (3–4 students) to reexamine the mystery, this time listing all suspects, pieces of evidence, and possible ways to analyze it. These groups will be the investigative teams and will work together throughout the unit. Students should also start a running list of questions that need to be answered. Instruct students to keep all of their notes and data relating to the mystery in their notebooks.
5. Each group should report back to the class their ideas for analyzing the case, as well as questions that they feel need answers. In reviewing the clues and evidence with students, you may need to ask students some guiding questions to help them recognize some of the clues that are contained in the mystery. It's not vital that students pick up on all of the clues. However, here are many of the clues that students should try to identify (some are more obvious than others):
  - It is likely that Liz interrupted the perpetrator(s) when she arrived at 12:15. The key in the door, the noise upstairs, and the note in the trash can, which appeared to be the beginnings of a ransom note, are all indications of this.
  - It is likely that the perpetrator(s) had a key or knew where Liz hid her key since there was no sign of forced entry. (There is the possibility that the perpetrator(s) entered in the morning if Liz did in fact leave a key in the door, and then hid until Liz and her father left.)
  - It is possible that the perpetrator(s) knew what Liz's schedule was — and thus was caught off guard when she arrived 45 minutes earlier than she normally did.
  - Magic likely knew the perpetrator(s) since he wasn't barking when Liz interrupted the perpetrator(s) earlier in the morning. Additionally, the final ransom note referred to Magic as "he," and since the note was prepared ahead of time, it is likely that the perpetrator(s) knew that Magic was a male dog.
  - Magic may not have had an accident since he went to the bathroom as soon as Liz let him out. Students should consider that the puddle may have come from another source.
  - The perpetrator(s) may be one person because the beginning of a ransom note says, "I have taken."
  - Otis Nixon is likely a person of interest because he lived next door (on the side of the house with the anthills) and could have been aware of Liz's schedule as well as the key's hiding place. He also said some things that implied that he knew more than he should have (e.g., asking where Magic was, asking about the ransom note before it was mentioned, knowing that there had not been a forced entry). He also reported a suspicious van without a license plate that no one else saw. However, he doesn't appear to have any obvious motives for taking Magic.

- Hal Jefferson is also a likely person of interest because his whereabouts at the time of the dognapping could not be verified. Although he said he was playing golf, he could have driven home and back to the vacation spot during that time. He obviously had a key to get into the house. His motive might have been wanting to avoid having to pay for Magic's expensive operation, something that his wife would surely want the dog to have.
- Melinda Johnson could be a person of interest because she lived next door and could have been aware of Liz's schedule as well as the key's hiding place. Liz believed that Melinda was envious of Liz's status in the neighborhood; she also suspected Melinda of spreading a false rumor about her. Melinda's motive might have been to destroy Liz's reputation for being responsible, so people would turn to her instead.

Finally, through teacher-directed questioning, the class should decide on a series of steps to take to analyze the evidence and ultimately solve the crime:

- pH analysis of unknown liquid
  - Questioned Document (QD) analysis (including paper chromatography and handwriting comparisons)
  - hair analysis
6. Distribute the reproducible Determining the pH of an Unknown Liquid. Go over the instructions and remind students to be careful when working with potential acids and bases. Give students the materials they will need to complete the lab (see materials section). Students will work together in groups to determine the pH of the unknown liquid. The lab will show that the liquid is a base, and that urine is acidic, so it is likely that the puddle on the floor was not a result of Magic having an accident.
7. After students have completed the activity and the corresponding analysis and conclusion questions, discuss as a class the results and what they mean to the investigation.

### **ACADEMIC EXTENSIONS/MODIFICATIONS:**

1. If time is short, assign students to research forensics using the Forensics Terms and FAQ Sheet, as well as the truTV Online Laboratory ([www.trutv.com](http://www.trutv.com)) before the class period in which you introduce the mystery. In addition, you can decide to discuss the evidence and list possible questions as a class, rather than breaking up into small groups. As mentioned in the Lesson Steps above, the analysis and conclusion sections of the lab can be completed as homework if time is short.
2. If the lesson is to be divided into several days, there is a natural break between steps 3 and 4 and between steps 5 and 6.
3. As an extension, pH probes can be used to determine the pH of the unknown liquid. You may also want to order a prepared "urine" sample from a supply company to test for comparison.

**STUDENT HANDOUT****FORENSICS FAQ SHEET****Q: What is forensic science, and how can it aid in criminal investigations?**

A: Forensic science is not limited to just criminal investigations. It is essentially the application of science to law in events subject to criminal or civil litigation. More commonly, though, it is applied to the investigation of criminal activity. The term "forensic science" includes many different technical fields, including (but not limited to) physics, chemistry, biology, engineering, psychology, and medicine. Forensic scientists might study a Questioned Document (QD), DNA evidence found at a crime scene, or the mental and emotional state of a suspect. Investigators turn to forensic scientists to discover additional evidence that requires specialized training to analyze and interpret.

**Q: How long have investigators been using forensic science?**

A: Forensic science has been around for nearly 900 years. The first recorded application of medical knowledge to the solution of a crime was in the year 1248. The first known use of a forensic chemical analysis was in 1836 when James Marsh, a Scottish chemist, detected arsenic poisoning in connection with a criminal investigation. Techniques involving blood typing have been used since 1900, when Karl Landsteiner discovered human blood types. Developed only within the past 20 years, DNA tests are now commonplace, and are revolutionizing the field.

**Q: What are some types of evidence that investigators look for?**

A: Investigators look for clues such as:

- fingerprints, palm prints, and footprints
- shoeprints
- fibers from clothes
- handwriting on a ransom note
- presence of chemicals•blood spatters
- DNA samples (Samples can be obtained from hair, skin cells, blood, semen, and saliva)
- residue from accelerants (e.g., compounds used to speed up fires set by arson)
- gunshot residue on hands and clothing
- bullet casings
- tool marks (e.g., marks left on a bullet by a gun when fired)
- insect and mold growth in a body as well as body temperature (to determine time of death)
- bullet residues around bullet holes
- pattern of gunshot residue spray (This can help determine the distance the shooter was from the victim)
- gunpowder burns

**STUDENT HANDOUT****Q: Why are fingerprints important?**

A: If you look at the palm side of your hands and feet, you will see a maze of lines in your skin curving, breaking apart, and joining back together. The places where skin ridges break apart and join together are unique for every person. This unique pattern allows forensic investigators to trace a print found at the scene of the crime back to a specific person. Even identical twins will have slightly different fingerprints!

Though one of the older forms of investigative techniques, fingerprint identification is not without some controversy. One recent court ruling declared that fingerprint examination and identification did not qualify as a "science," in part because an examiner subjectively decides if a set of prints match. There is no uniform set of requirements used by all analysts to determine a positive match, so critics argue that fingerprint identification should not be considered scientific evidence. More importantly, there have been no studies published of the rate of false matches ("false positives") obtained with partial prints of the type found at a crime scene. It is important to note, however that other court challenges to the science of fingerprint identification have been rejected.

**Q: How long after a crime can DNA evidence be collected?**

A: DNA is a wonderfully stable molecule. Researchers have been able to recover usable DNA from Egyptian mummies thousands of years old. Each individual strand of DNA is made of strong, unreactive bonds. The strands of DNA twist around each other to form the well-known double helix, concealing weaker hydrogen bonds in the middle of the molecule. There are so many billions of hydrogen bonds that even though one is not strong by itself, the cumulative effect is strong enough to keep DNA intact.

**Q: Are some forensic tests, by their nature, NOT conclusive?**

A: Yes, not all tests performed by forensic investigators are conclusive. Some tests, such as morphological hair analysis (microscopic comparison between the appearance of two or more hairs for points of similarity) are presumptive, meaning they do not provide absolute proof for what the investigator is testing. When investigators use presumptive tests, which are often quick, easy, and sensitive ways to initially screen evidence from a crime scene, they must then follow up with conclusive tests of the issue of interest.

**Q: What is microscopic hair analysis, and how is it useful in a criminal investigation?**

A: When a crime is committed, physical evidence in the form of hair is often left behind by the perpetrator and/or the victim. Police collect these hair samples and forensic scientists examine the structure (morphology) of the individual hairs microscopically in an attempt to identify potential suspects or victims. Microscopic hair analysis is useful because it can narrow the field of suspects. It can also determine whether or not the evidence is human or animal hair.

**Q: Can microscopic hair analysis provide a positive identification of a suspect?**

A: A positive ID based on hair morphology alone is rare. Hair samples are used, however, to obtain DNA samples from suspects and victims. DNA evidence is more conclusive in nature.

**STUDENT HANDOUT**

**Q: What is the difference between a "suspect" and a "person of interest"?**

**A:** Sometimes investigators designate people as "suspects," and sometimes they refer to them as "persons of interest"; however, no published definition distinguishes the difference between the two. Generally speaking, investigators consider someone a suspect once he/she becomes an official focus of an investigation as the result of initial evidence or circumstances having made it likely that the person in question was a perpetrator of the crime under investigation. Once someone is deemed a suspect, police must follow certain rules for interrogation. For example, police must advise a suspect of his/her Miranda rights, and if a suspect requests a lawyer, the police must stop their questioning until a lawyer is present. If someone is simply a person of interest, however, police can do some initial probing for information without such restrictions in place. If the investigation is to probe more deeply into someone's background and possible connection to a crime, the judicial system then insists that the police treat that person as a suspect.

**Q: What changes are occurring in the field of forensic science?**

**A:** Experts believe forensic science will continue to evolve so as to provide faster and more accurate tests and techniques for the solution of crimes. One current focus of the field is to scrutinize closely its many analytic techniques in order to strengthen their use in investigations, mainly by eliminating as many potential errors as possible. For example, by comparing cases from all over the world that involve similar uses of handwriting analysis or ballistics tests, investigators can establish improved practices. Many in the community of forensic science hope to improve on the techniques already in place by establishing standards and using careful error analysis.



**STUDENT HANDOUT****FORENSICS TERMS**

The following are just a few of the many terms related to the field of forensic science.

**Acid:** a corrosive substance that has a sour taste. (Students SHOULD NOT taste any acids in the lab!) When mixed with water, an acid yields H<sup>+</sup> ions.

**Autopsy:** the internal and external examination of a body after death. An autopsy (the literal meaning can be expressed as "see for oneself") is performed to confirm or determine the cause of death and establish other pre-death conditions, such as the type of food last consumed and the time it was consumed.

**Ballistics:** the study of the motion of bullets and their examination for distinctive characteristics after being fired. Examiners can use this evidence to match bullets or bullet fragments to specific weapons.

**Base:** a slippery substance that has a bitter taste. (DO NOT TASTE) When mixed with water, a base yields OH<sup>-</sup> ions.

**Bloodstain (or Blood Spatter) Interpretation:** the interpretation of size, shape, orientation, and distribution of blood pooled or spattered on various surfaces at a crime scene. Information about the event can be derived from the proper interpretation of the stains.

**Bullet Track:** the path of a bullet as it passes through matter, such as a body or a wall.

**Catalyst:** a substance that accelerates a chemical reaction but is not itself permanently changed by the reaction.

**Chromatogram:** the recording of the results of a chromatography procedure.

**Chromatography:** the process of separating a chemical mixture — e.g., ink — into its individual substances.

**Composite Drawing:** a sketch of a suspect produced from one or more eyewitnesses.

**Criminology:** the study of criminal activity and how it is dealt with by the law.

**Diacritics:** marks such as an accent or a tilde that indicate the correct pronunciation of a letter or combination of letters which, without the mark, would be pronounced differently.

**DNA:** deoxyribonucleic acid. Occurring in the form of double-helix strands, DNA contains genetic code. In each individual, identical DNA occurs in the nucleus of every cell and serves to define that individual's characteristics. In addition to the portions of the DNA that encode the proteins making up all the individuals of a species, there are portions of "junk" DNA unique to each individual within the species. Often an individual's DNA appears in the blood and other bodily fluids. This provides a powerful technique for uniquely identifying the person or animal that left traces of such fluids at a crime scene. Indeed, this is the best method presently known for such identification.

## STUDENT HANDOUT

**DNA Profiling:** the process of testing to identify DNA patterns or types. In forensic science this testing is used to indicate parentage or to exclude or include individuals as possible sources of bodily fluid stains (e.g., blood, saliva, or semen) and other biological evidence (e.g., bones, hair, or teeth).

**Evidence:** anything that has been used, left, removed, altered, or contaminated during the commission of a crime or other event under investigation.

**Fingerprint:** the unique patterns created by skin ridges found on the palm sides of fingers and thumbs.

**Forensic Science:** the application of science to technical questions relating to events that may lead to civil litigation or criminal prosecution.

**Gene:** a unit of inheritance consisting of a sequence of DNA. Individually or collectively, genes determine a particular characteristic in that organism.

**Indicator:** a chemical used to determine the presence of an acid or a base.

**Latent Fingerprint:** a full or partial fingerprint made by deposits of oils and/or perspiration, not usually visible to the human eye. Various technologies, including lasers, can be used to visualize latent prints so that they can be recorded (usually by photography) for comparison with previously recorded fingerprints.

**Lie Detector:** also known as a "Polygraph." A machine that charts how respiration and other bodily functions change as questions are asked of the person being tested. An attempt to knowingly provide false answers can cause changes in bodily functions. Lie detector tests are usually not admissible in court. Essentially all scientists not directly engaged in the use of polygraphs consider polygraph results to be unreliable.

**Luminol:** a chemical that is capable of presumptively detecting bloodstains diluted up to 10,000 times. Luminol is used to identify blood that has been removed from a given area. It is an invaluable tool for investigators at altered crime scenes. It is luminous (gives off light) and thus in a darkened scene highlights the distribution of what may be blood.

**Microscopic Hair Analysis:** investigative procedure of examining hair shafts for identifiable characteristics.

**Morphology:** The branch of biology that deals with the form and structure of organisms without consideration of function.

**pH:** "power of Hydrogen" – a measure of the concentration of H<sup>+</sup> ions found in a solution; the lower the pH, the higher the concentration.

**STUDENT HANDOUT**

**Physical Evidence:** any object, as distinguished from witness statements, that can help explain an event under investigation. For example, physical evidence can establish that a crime has been committed, and sometimes it can provide a link between a crime and its victim or between a crime and its perpetrator.

**Point-by-Point Analysis:** when comparing a known object to one that needs to be identified, analysts will break down photos of each into small portions, and compare the respective similarities within those portions.

**Questioned Document (QD) Analysis:** the procedure of examining handwriting, watermarks, and other qualities of a document that may indicate the document's origin and author.

**QD Examiner:** one who analyzes documents professionally, often for investigative purposes.

**Ridge Characteristics:** ridge endings, bifurcations, enclosures, and other ridge details, which, if present in both of two fingerprints being compared, must match in the two fingerprints for their common origin to be established.

**Serology:** the science dealing with properties and actions of serums in blood; also known as "blood analysis."

**Solute:** a dissolved substance.

**Solvent:** a liquid substance capable of dissolving or dispersing one or more substances.

**Standard:** in handwriting analysis, material whose source and origin are known and used for comparative purposes.

**Super Glue Fuming:** a technique used to visualize latent fingerprints on nonporous surfaces. A chemical in the glue reacts with and adheres to the finger oils, producing a visible substitute for the underlying prints.

**Toxicology:** the study of poisons and drugs and their effects on human and animal populations.

**Trace Evidence:** material deposited at a crime or accident scene that can only be detected through a deliberate-processing procedure. An individual entering any environment will deposit traces of his or her presence, and this material can be used as evidence. Common types of trace evidence are hairs and clothing fibers.

**Trajectory:** the path of an object as it moves through space, usually referring in the forensic context to a bullet or other projectile.

## STUDENT HANDOUT

**MS Unit 1 Mystery Synopsis: It's Magic!**

Liz couldn't believe it. How could she have let this happen?!

For some reason, she could not get the song, "How Much is that Doggie in the Window?" out of her head. How could a song from her first piano recital when she was seven — half a lifetime ago — be lodged in her head? Liz could even hear her piano teacher saying, "D-G-D-B-G-E-D-C-D-A" as she played it. True, she had a great memory, but why did it have to be of that particular song?



Actually, it was no great mystery. Liz had been hired by her neighbors, the Jeffersons, to take care of their dog Magic while they were on vacation. She didn't know how much Magic cost, but she knew he was very expensive. Magic was a purebred Afghan — one of those big dogs, with really long blond hair. He was like a child to the Jeffersons.

In fact, the only reason the Jeffersons didn't take Magic with them on vacation was because he had been sick. They almost canceled their vacation, but Liz had proven herself to be very responsible. She had taken care of many people's pets in the neighborhood. She babysat. She "house-sat." Whenever a family needed help, they hired Liz Lincoln.

"How much is that dog—" Thankfully, Liz's singing was interrupted; but it was only because she was startled. She was at the Jeffersons' back door, and the spare key she had been using to get in was still in the lock. She wondered how in the world she could have left it in the door when she was there earlier that day. She could picture herself putting the key back in its hiding place, but was that earlier that morning? Or yesterday? She had been going to the Jeffersons' four times a day for almost four days, so it all kind of ran together.

At least Liz had come a little earlier than she normally did — so she knew that the key had been in the doorknob for just a short time. Usually, she did an afternoon check on Magic around 1:00 p.m. each day, but she was planning on meeting her friend Maria at one, so today's afternoon Magic check was about 45 minutes early.

When Liz opened the back door into the kitchen, her concerns about the key briefly vanished. As soon as she stepped inside, she stepped in a very small puddle. Oh, no! Magic must have had a little accident! He had been sick because of problems with his kidneys — problems that meant he would most likely need some expensive surgery in the near future. Had he stood at the back door wanting to go out and just couldn't hold it any longer? Liz felt awful.

Liz carefully entered, walking on her heel. "Magic! Magic! Are you okay, boy?" Before she could say anything else, Liz heard a thud sound upstairs, like something had been knocked over. She was starting to feel a little nervous. "Magic? Is that you? C'mere boy!"

**STUDENT HANDOUT**

Liz stopped holding her breath when Magic came down the stairs. She pet him even more energetically than she normally did. "You feel all right?" He seemed fine. Liz debated calling the Jeffersons but decided to hold off. She was still a little concerned about the noise she had heard though, so she called her father. Magic barked at anybody he didn't know, and since he hadn't been barking, she was pretty sure that Magic must have made the noise. Still, she didn't want to take any chances.

While she waited for her dad to come over, Liz took Magic outside. She wanted to let him do his thing, so she could clean her shoe as quickly as possible. Surprisingly, Magic went to the bathroom immediately. Liz laughed, thinking, "Boy, dogs must go 100 times a day!" She also kept a close eye on him to make sure that he stayed away from the part of the yard on the other side of the house. The Jeffersons had been having problems with fire ants, and according to Mr. Jefferson, the best way to get rid of ants was with bleach water. (One of Liz's other jobs for the Jeffersons was to pour bleach water — a lot of it — on any anthills she found. She was a little worried that she was doing more than just killing the ants. But she performed that duty each day when she checked on Magic in the morning.)

Liz's father came over while she and Magic were still outside. She described everything that had happened. He was glad she called him over to check things out upstairs. Liz left him to do that while she cleaned up her shoe and the little puddle on the kitchen floor. She was surprised how dirty/cloudy it was. Had she brought that much dirt in with her? Since it was so cloudy and since Magic was having kidney problems, Liz realized that Magic's vet might want to see a sample of the "accident." Liz collected a little of it using a paper towel and put that towel in a plastic zip-top bag. She wiped up the rest to put in the trash.

As she was about to throw away the dirty paper towels, Liz noticed a single piece of paper in the trash can. Before they left, the Jeffersons took out the trash, and Liz knew for sure that she hadn't thrown anything away. She pulled the piece of paper out and tossed in the paper towels. The paper was "from the desk of Sally Jefferson." It had the words "I have taken" written on it. Puzzled, Liz assumed that Mr. or Mrs. Jefferson must have started to write a note after they had already emptied the trash. She put the note in her pocket to take home to be recycled.

As Liz thought about what a weird day it had been, her father came downstairs, announcing that the noise was a plant being knocked over. Nothing else seemed to be out of place. And since it was almost one o'clock, Liz and her father left, making sure that the key was back in its hiding place. Normally, Liz brushed Magic when she checked on him at one, but that would have to wait until she came back around five.

"Magic! Magic! C'mere, boy! Let's go outside!" Liz hadn't wanted to leave the mall so early, but she had to get back home by five to walk Magic. And with all of the strange stuff that happened earlier, she wasn't about to risk the possibility of more accidents. "Magic! Time to eat!" For Magic, the word 'eat' was even more exciting than 'outside.'

"Magic?!"

**STUDENT HANDOUT**

Suddenly, Liz was scared. She continued to call out his name while she walked around the house. She went upstairs. Nothing. He wasn't on his bed. He wasn't anywhere. But Liz didn't totally panic. There had to be an explanation.

And there was. A note she hadn't noticed at first was on the kitchen table. Typed in a large font, the note said:

**"We have taken your dog. We will keep him unless you pay us ransom money. If you except our conditions and pay the money, he will be fine."**

Magic had been dognapped?! Liz couldn't believe it. How could she have let this happen?! Dognapped and by a bad speller to boot. (Liz was an excellent student and saw immediately that the dognapper wrote "except" when it should have been "accept.")

The first thing Liz did was call her parents. While she waited for them to arrive, she replayed in her mind the events that had happened earlier. As she remembered the key in the door and the noise in the house, it started to come together for her. Maybe even the little puddle was connected. Had she startled the dognappers earlier that day?

Liz's parents immediately offered to call the Jeffersons and then the police. "No. I need to be the one to do it. The Jeffersons put me in charge of Magic," she said calmly.



"My Magic!?" Sally Jefferson was stunned. Liz had to explain it twice before she finally reacted. The reality of the situation began to set in. "We'll pay whatever they want!" Then, Mrs. Jefferson remembered how "frugal" her husband was. "Well, I mean, I'll need to talk to Hal first." She continued as if she were thinking out loud. "First the news of the expensive operation, now a ransom payment. He's not going to be happy about having to spend more money on 'that mutt,' as he sometimes calls my precious Magic." Then Sally snapped back to the matter at hand. "But you don't need to worry about that. Hal's playing golf right now, but, uh, I can't reach him. He turns off his cell phone, so no one can disturb him."

Liz got the sense that Mrs. Jefferson was a little embarrassed by the fact that she was unable to immediately get in touch with her husband. Was she worried he wouldn't pay the ransom? "Um, Mrs. Jefferson, do you want us to go ahead and call the police?"

"Please." And with that, Sally Jefferson began to bawl. "As soon as Hal gets back, we'll come home," she said between sobs. Liz didn't know how long Mr. Jefferson would be on the golf course, but she knew that it would take them almost three hours to drive home.

**STUDENT HANDOUT**

Liz and her parents were surprised at how quickly the police arrived. Bernie Woodward was in charge of the investigation. It was obvious from the way he acted that he was taking this very seriously. While another officer looked around inside the house, Detective Woodward stayed outside with Liz and her parents. "Liz, I need you to tell me everything that happened." She appreciated that Detective Woodward spoke to her as if she were an adult.

"Four days ago, I started looking after Magic ..." Liz impressed Detective Woodward with her very detailed description. As she was describing the noise and the knocked over plant, however, she got a little distracted. She saw Otis Nixon coming across the yard from his house next door. The way he is, Liz thought, he'll probably step right on an anthill and not even realize it.

Liz didn't really like Otis. For the first time, she realized that the Jeffersons had people on both sides of their house she didn't care for that much. Melinda Johnson was their other neighbor. She was Liz's age, and Liz suspected that Melinda was jealous of her status in the neighborhood (and the money that came with it!). People always hired Liz, never Melinda. Liz could never prove it, but she suspected Melinda was the one spreading a rumor around last year that Liz had gotten caught at school cheating on a big science test. Of course Liz and her parents knew it wasn't true, but the rumor had always bothered her. Liz had to stop thinking about Melinda, though, because Otis had made his way over to them.

"What's going on?" Otis asked everybody. "Where's Magic? I mean, Liz, you're usually out here with him and all." Liz could tell that Detective Woodward was as annoyed as she was at the interruption.

Detective Woodward said, "Interesting that you should ask. It appears that he's been stolen. Do you know anything about that?"

"Me? Uh, no, of course not." Otis answered. "But I'm a private eye, so I might be able to help out with the investigation. Otis Nixon's my name." Liz almost laughed out loud. Was he serious? Private eye? Otis was something like 25 years old and living with his parents, and she didn't think he'd ever had a job for more than a few months. And now he was calling himself a private eye? "Magic's a very valuable dog. Did she tell you that?" Otis pointed to Liz. "Any clues inside? What's the ransom note say — I assume the perp took the dog to get the Jeffersons to pay a ransom." Otis talked very quickly. Liz could only shake her head as she imagined Otis on the case using words like "perp" to try to impress people.



Detective Woodward tried to get Otis to slow down a little. "Mr. Nixon, have you noticed anything suspicious or out of the ordinary over the last few days?"

"Why, I'm glad you asked." This should be interesting, Liz thought. "As a matter of fact, there was a white van — you know, one of those without any windows in the back. One of those rental vans." Then Otis paused, scratching his nose. "It just seemed a little out of place. I've got ESP for those things. That's why I'm such a good PI. That's short for private eye, you know." Liz smiled politely but sarcastically thought, "Oh, really?" "And when they don't leave any clues from breaking in, that's when you've gotta have a ..."

**STUDENT HANDOUT**

"Sixth sense?" Detective Woodward didn't seem to question Otis' special abilities. Otis nodded. The detective, though, was ready to move on, wondering, "I don't suppose you got a plate number or anything?"

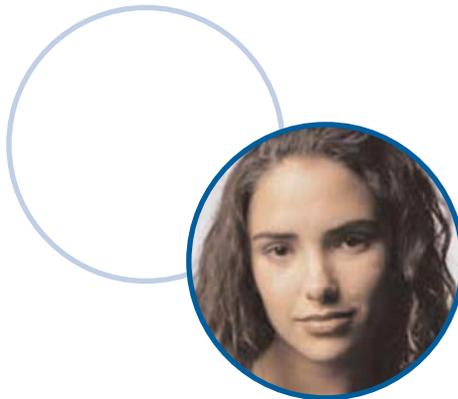
"Oh, I was ready to memorize it, but it didn't have a plate on it."

"Memorize? What a bonehead," thought Liz as she again fought back the urge to laugh out loud. How would Detective Woodward ever get to the bottom of Magic's disappearance without Otis there to "help"? If Liz hadn't felt so confident in the detective's ability to get Magic back, she might not have found Otis so funny and ridiculous — just ridiculous.

By the time the Jeffersons returned home, Detective Woodward had canvassed the neighborhood for any possible eyewitnesses. Other than Otis, no one reported seeing anything suspicious. There was no sign of forced entry, and Liz had touched the key most recently, so her prints were on it.

But had it not been for Liz, the police would have had very little physical evidence. There were the wet paper towels that she was saving for Magic's vet. She had assumed the mess came from Magic, but now they weren't so sure. She also had the beginnings of that note in her pocket. Maybe that was something?

To solve the case, investigators had to think about who would have had access to the hidden key or another key, and at the same time, who would have had a motive for taking Magic. Investigators couldn't wait on the dognappers to make their next ransom demand, so they had to start testing the physical evidence immediately.



**STUDENT HANDOUT**

# Determining the pH of an Unknown Substance

## INTRODUCTION:

One way to classify an unknown substance is to determine whether it is an acid or a base. Acids are corrosive substances that have a sour taste. Note: **DO NOT TASTE THE LIQUID!** While a sour taste is one of the most basic properties of an acid (such as citric acids in lemons), these liquids should not be tasted **UNDER ANY CIRCUMSTANCES**. When mixed with water, an acid yields H<sup>+</sup> ions. A base is a slippery substance that has a bitter taste. (**DO NOT TASTE BASES EITHER!**) When mixed with water, a base yields OH<sup>-</sup> ions. The acidity of a solution is determined by the number of H<sup>+</sup> ions present and is measured using a pH scale\*. The table below shows the pH of several common substances.

pH scale	Common Substances
0	Battery acid
1	Hydrochloric acid in the stomach
2	Lemon juice, vinegar
3	Soda, orange juice
4	Tomato juice
5	Black coffee
6	Urine, milk
7	Pure water, human blood
8	Sea water, eggs
9	Baking soda
10	Milk of magnesia
11	Ammonia
12	Soap, household bleach
13	Oven cleaner, household lye
14	Liquid drain cleaner

\*pH stands for "power of Hydrogen" – the number of H<sup>+</sup> ions found in the solution.

## STUDENT HANDOUT

An **indicator** is a chemical used to determine the presence of an acid or a base. Scientists use several different indicators when determining the pH of an unknown substance. Some techniques give very general results, whereas others give very specific data. The following are just a few examples of common indicators:

- Standard litmus paper turns red in the presence of an acid ( $\text{pH} < 7$ ) and blue in the presence of a base ( $\text{pH} > 7$ ).
- pH indicator paper turns various colors, depending on the acidity of the solution. A numerical pH value can be determined by comparing the test strip to a pH indicator color chart.
- pH probes give a specific numerical value for pH.

Liz collected an unknown liquid sample, presumed to be from Magic, from the kitchen floor in the Jeffersons' home. Note that urine is slightly acidic ( $\text{pH}=6$ ). You will now test the unknown liquid sample using standard litmus paper and pH indicator paper to verify that the liquid is indeed acidic.

### PROCEDURE:

1. Obtain materials from your teacher. Each group should have the following: 2 samples of the unknown liquid in small beakers or cups, standard litmus paper, pH indicator paper, gloves, and safety goggles.  
**Safety Note: Caution: You should always wear safety goggles and gloves when working with potential acids and bases. Depending on their strength, acids and bases may be poisonous or burn the skin. DO NOT TASTE THE LIQUID!**
2. Review the table and other information found in the beginning of this handout. Also review the color chart provided with your pH indicator paper kit. What do you predict the results will be for each test? Record your predictions in the chart below.

### PREDICTIONS TABLE

Substance	Standard Litmus Paper Test (What color will the paper turn?)	pH Indicator Paper Test (What color will the paper turn?)
Unknown liquid sample taken from the kitchen of Magic's home.		

3. Wearing your gloves and safety goggles, carefully dip the standard litmus paper into one sample of the unknown solution. Record your observations in the Observations chart provided on page 19.

## STUDENT HANDOUT

4. Wearing your gloves and safety goggles, carefully dip the pH indicator paper into the other sample of the unknown solution. Record your observations in the Observations chart provided below.
5. Compare the color of the test paper with the color chart provided to determine the pH of the unknown sample. Record the pH in the Observations chart provided below.
6. Do not pour liquids down the sink. Dispose of all materials as instructed by your teacher. As you dispose of them, be careful not to touch the liquids.

## OBSERVATIONS/RESULTS TABLE

	Standard Litmus Paper Test	pH Indicator Paper Test	pH
Unknown Liquid Sample			

### ANALYSIS:

1. According to the standard litmus paper test, is the unknown liquid an acid or a base?
2. According to the pH indicator paper test, is the unknown liquid an acid or a base?
3. What is the pH of the unknown liquid?
4. Study the known pH values of common substances listed in the table. Which substances can be eliminated as potential sources? Which substance could be the source of the unknown liquid?

**STUDENT HANDOUT****CONCLUSION:**

Write a paragraph summarizing the results of this lab as they relate to the investigation. In your paragraph, revisit your predictions and indicate whether or not the evidence supports your predictions. You will refer to these notes later in the investigation.



## LESSON 2 PART I: PAPER CHROMATOGRAPHY

### OBJECTIVE:

In this activity, students will perform paper chromatography on ink samples collected from three different pens and the partial ransom note that Liz found in the trash can. Students will analyze the chromatograms to determine which type of pen could have been used to write the note.

### MATERIALS NEEDED:

#### Reproducibles

- Paper Chromatography
- Mystery Interlude

#### Equipment and Chemicals

- partial ransom note (Each student group will need a piece of the original note large enough to cut into three sections.)
- 2 chromatography chambers (plastic cups with lids) per lab group
- 3 sample pens labeled A, B, and C per lab group
- filter paper
- water
- rubbing alcohol
- pencil
- labeling tape
- paper clips or tape
- stirring rod (or other blotting tool)
- safety goggles

**Note:** Any time you use chemicals in your classroom or lab, be sure to read and follow the safety instructions for use and disposal that are provided in the MSDS information that came with your lab materials.

### TIME REQUIRED:

- Teacher Prep Time: 30 minutes
- Class Time: 45-60 minutes

### LESSON DESCRIPTION:

At the beginning of this lesson, students will review the information that they have gathered up to this point. They will revisit their possible suspect lists and make any necessary changes or additions. They will spend time learning about paper chromatography and how it might be useful in this particular investigation. Students will then perform paper chromatography of ink samples collected from various pens and the ransom note; analyze the chromatograms; and relate their findings to the investigation.

At the end of the lesson, the teacher will provide the students with additional information (evidence) – Mrs. Jefferson has reported that a calligraphy pen was missing from her desk and, further, that a pen matching its description was found in Otis Nixon’s truck.

### **BACKGROUND INFORMATION:**

For this lesson, you will need to create the partial ransom note that was found in the trash can. A sample partial note is included for your reference; however, you must make your own note so that students can identify the matching handwriting in the next lesson. Make copies of the partial ransom note you create before cutting it into pieces. You will need these copies for the handwriting analysis in the next lesson.

Before this lesson, you will want to review the steps of paper chromatography as well as the vocabulary terms in boldface on the student handout.

### **LESSON STEPS:**

#### **Teacher Preparation**

1. You will need to find 3 types of pens to use as sample pens for the experiment. Use black, felt-tip pens – one permanent (not soluble in water but soluble in alcohol) and two water-soluble. Each group needs to have all three pen types. One of the pens should be a calligraphy pen to coordinate with the mystery. This pen should also be the one with which you write the partial ransom note sample.
2. Write a portion of the ransom note as described in the mystery with the words: “I have taken.” You should write the phrase in large letters, because all of your student groups need a portion of it. Write the note in cursive—this will be helpful when designing your handwriting analysis sheet. If you are doing the lab with several different classes, write several different copies of the same partial ransom note.
3. Cut filter paper into pieces approximately 3-4 cm wide and 10 cm long. You can use chromatography paper from a supply company, or thick coffee filters. Each group will need 12 pieces of filter paper.
4. Become familiar with the expected band patterns that result from the experiment by practicing the experiment yourself prior to the lab. You may want to try several different pen types and then pick 3 that work well.
5. Decide ahead of time how students will dispose of the liquid solvents after use. Alcohol is flammable. You can set up waste beakers where students can pour the leftover liquid. Rubbing alcohol can be poured down the sink. Always follow your local, state, and federal laws for proper waste disposal. Refer to the MSD Sheets for additional safety and disposal information.

6. At the conclusion of this lab, give students additional information about the crime: Mrs. Jefferson has stated that a calligraphy pen was missing from her desk, and a pen matching its description was found in Otis Nixon's truck.

### Lab Execution

1. Review information gathered in the investigation up to this point. Take a few minutes to answer questions and discuss what steps need to be taken next.
2. Distribute the Paper Chromatography handout to students. Read the introduction together and discuss the set-up of the experiment. Remind each group to label all chromatography chambers and pieces of filter paper before beginning.
3. Instruct students to complete the paper chromatography experiment. Following the lab, discuss the results and what impact they might have on the investigation.
4. Provide students with the Mystery Interlude handout. This will fill students in on new developments in the case. (If you had a school resource officer or local police officer announce the crime, consider having the same person return to 'deliver' the interlude.) It is important NOT to introduce this new information until students have completed their chromatography analysis. A calligraphy pen is reportedly missing from Sally Jefferson's desk, and one matching its description has been found in the truck belonging to a person of interest. Have students write a journal article for homework explaining how this piece of evidence changes the investigation. Brainstorm as a class the next logical step to take to find Magic's abductor.

### ACADEMIC EXTENSIONS/MODIFICATIONS:

- If time or materials are limited, you can assign each student group a different ink sample to analyze. Then they can report their findings to the rest of the class.
- If your students are more advanced, your analysis of the chromatograms can be much more detailed. You can teach them to calculate the R<sub>f</sub> values for each ink. (R<sub>f</sub>=distance band travels/distance solvent travels) For information on this procedure, refer to this section of the Santa Fe Community College (Gainesville, Florida) web site: <http://chemscape.santafe.cc.fl.us/chemscape/catofp/chromato/tlc/tlcq.htm>

## STUDENT HANDOUT

# PAPER CHROMATOGRAPHY

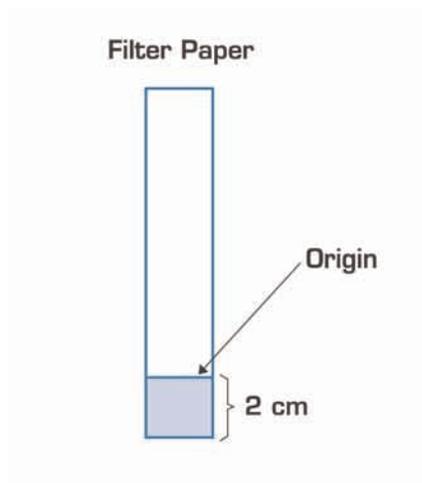
### INTRODUCTION:

Have you ever spilled water on your homework and watched the ink run and smear all of your hard work? If so, you have witnessed the most basic form of **paper chromatography**. Paper chromatography is a technique used to separate a mixture of pigments. The mixture to be separated, or **solute**, is blotted onto a piece of filter paper and placed in a solvent such as water or alcohol. The solvent moves up the filter paper, resembling a paper towel soaking up liquid. As this occurs, the solute pigments separate, and a pattern of bands forms. This pattern of bands — called a **chromatogram** — is unique and determined by several factors: attraction of pigment to the paper, size of the pigment, and attraction of the pigment to the solvent. Botanists use this method to analyze pigments found in the leaves of plants. You will use this method to determine what type of pen could have been used to write the partial note found in the trash can.

### PROCEDURE:

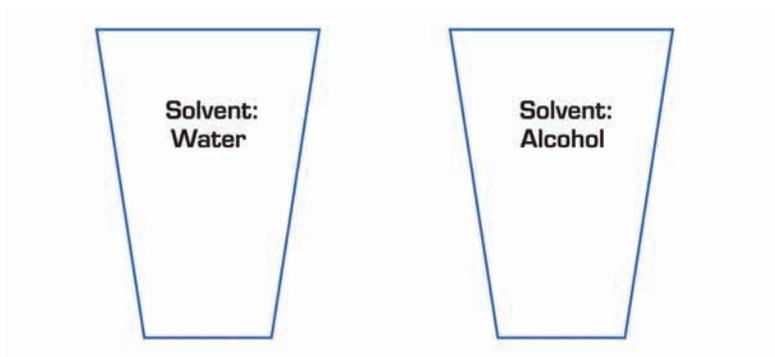
**Caution:** During this lab you will be working with flammable liquids. Follow all safety instructions given by your teacher. Always wear your safety goggles!

1. Obtain a piece of the partial ransom note from your teacher. Cut your piece of the note into three sections, each containing a sample of the ink. Label the back of each piece Sample D.
2. Obtain chromatography materials from your teacher including: three sample pens labeled A, B, and C, filter paper, three chromatography chambers, a stirring rod, labeling tape, water, and rubbing alcohol. You will also need a pencil and a ruler.
3. On each piece of your filter paper, draw a line in pencil 2 cm from the bottom of the paper. This represents your point of origin. You will blot your ink samples on this line. See diagram below.

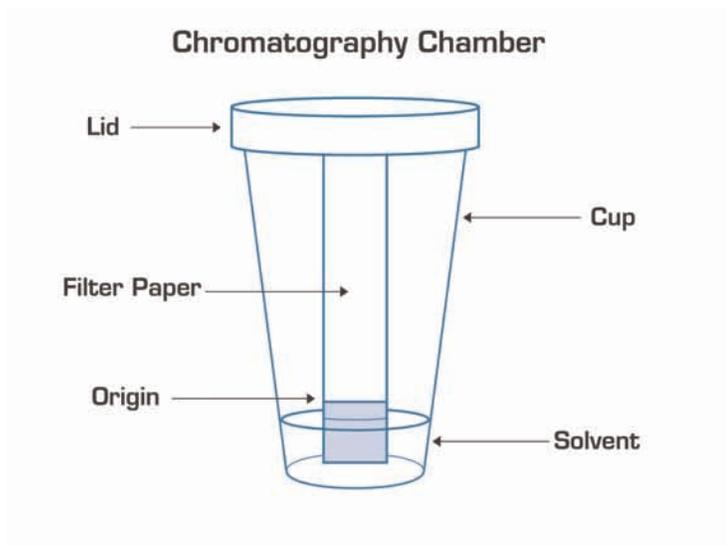


**STUDENT HANDOUT**

4. Use your pencil to label the back of each piece of filter paper with the letter of the sample pen ink you will be testing on that paper. Also indicate which solvent you will be testing. For example: Sample A/water or Sample B/alcohol. Note: All sample inks (A-C) will be tested in all solvents.
5. Label all of your chromatography chambers with a solvent. See example below.



6. Pour a small amount of each solvent in the appropriate chamber. You need only enough solvent to cover the bottom of the containers you are using.
7. Wet a small area of the ransom note (Sample D) with the first solvent and use the stirring rod to blot the ink on the origin of the filter paper. Place the end of the filter paper strip in the solvent chamber. Make sure the line of origin is above the solvent. You can either use a paper clip or tape to hold the paper in place. Place the lid on the chamber. See diagram below.



**STUDENT HANDOUT**

8. Watch as the solvent travels up the paper. The solvent front, or the edge of the wetness, will travel up the paper. Remove the paper from the chamber before the solvent front runs off of the top edge (2–3 cm from the top). Place the chromatogram on a paper towel to dry.
9. Repeat steps 6–8 until all sample inks have been tested in all solvents. When testing ink from sample pens, you may place the ink directly on the origin line, or indirectly using the blotting technique.
10. Record your observations in the table provided. Observations might include answers to the following questions: How many bands appeared in the chromatogram? Are any of the bands colored? How far did the bands travel?
11. Clean up your lab area as instructed by your teacher. Be sure to follow the proper rules for disposal of your materials.

**CHROMATOGRAM OBSERVATIONS TABLE**

Solvent	Sample A	Sample B	
Water			
Rubbing Alcohol			

**ANALYSIS:**

1. What factors determined the band pattern when separating a mixture?
2. Are all of the chromatograms for Sample A the same? For Sample B? For Sample C? Why or why not?
3. Check for similarity between the different chromatograms. Can you eliminate any of the pen types as the source of the note? Can you identify the type of pen that could have been used to write the note?

**STUDENT HANDOUT****CONCLUSION:**

Write a paragraph relating the results of this laboratory to the investigation. Is this chromatography data conclusive? Why or why not?



**STUDENT HANDOUT****MYSTERY INTERLUDE**

Detective Woodward found it odd that the partial ransom note appeared to have been written with a calligraphy pen. Who still writes with calligraphy pens? More often than not it's women and girls, thought the detective. He turned his thoughts to Melinda Johnson, who was one of the Jeffersons' neighbors. She had an alibi, but in Detective Woodward's opinion, it was a little sketchy. A friend of Melinda's backed up her story that she and Melinda had been at an amusement park all day. But Melinda had very fair skin, and it didn't appear as though she had been out in the sun all day. Detective Woodward made a note to himself that they should probably question her again to see if they could poke any holes in her alibi. It was just one of a number of things they still had to do in the investigation.

Although they were making progress, Detective Woodward and his investigative team still weren't one hundred percent sure why there was a puddle on the floor with such a high pH. Because there still had been no contact from the perpetrator or perpetrators, they had to proceed with other tests of evidence, namely Questioned Document analysis.

With their ink analysis results in mind, the detective and another investigator returned to the Jefferson home to collect some writing samples. In any kidnapping — and that goes for dognapping too — involving a ransom note, it's important to get writing samples from everyone within the home. When Detective Woodward asked Sally Jefferson if her husband ever wrote with a calligraphy pen, she laughed. "He's got the worst handwriting in the world. I'm the calligrapher." Sally Jefferson's expression quickly changed. "And it's so weird that you say that. I was working on some 'Have You Seen Me?' posters for Magic last night, and I wanted to use my favorite calligraphy pen — a purple, hand-painted one my father gave me a long time ago. But I couldn't find it anywhere." Then Sally smiled, but she had tears in her eyes. "They took my prized dog and my prized pen." She tried hard to laugh at her joke. Detective Woodward smiled politely.



The detective still had Sally Jefferson's half-hearted laugh in his mind as he stood outside peering into a truck next door. "Hey, what are you guys doing?" Otis Nixon nervously asked, coming out of his house. "I mean, is there, uh, something that I can help you with? To, you know, crack the case on Magic?"



"Well, you can start by helping us find the person who owns this truck, so we can tell 'em to move it," answered Detective Woodward rather curtly, knowing full well the truck belonged to Otis. "It's blocking the sidewalk." Otis had parked his truck in his driveway in such a way that its front end was completely blocking the sidewalk. He always parked like that — he'd back into his driveway, and the front of it would hang over the sidewalk, usually all of it. "And since this truck is parked illegally, we were looking inside it to see if we could identify its owner," said Woodward.

**STUDENT HANDOUT**

"Well, it's mine. I've got the registration right in my glove compartment," Otis volunteered. As Otis opened his glove compartment, Detective Woodward watched as a purple pen that looked like a calligraphy pen fell out even before Otis could retrieve the registration.

"May I see that pen?" Otis handed the pen and the registration to the detective. At this point, Detective Woodward didn't really care that much about the registration. "Is this your pen, Otis?"

"Uh, no. No, it's not my pen. Purple's not really my color." Otis laughed uncomfortably. "I found it out here on the sidewalk and just threw it in my truck." Then, as if he were feeling more sure of himself, he added, "Maybe my ESP guided me to pick it up."

"Yeah. Maybe so, Otis. Maybe so." Detective Woodward sat down in the passenger seat of the truck. "May I?" he asked as he returned the registration to its home in the glove compartment. The detective carefully inspected the cab, hoping to spot anything else that could be evidence. Seeing nothing else suspicious, he got out of the truck ready to tell Otis to move it immediately. He changed his mind, however, as soon as he stood up and noticed that his charcoal gray pants had what looked like blond hairs all over them. "Otis, have you had any animals in this truck lately?" he asked.

"Animals?! No way. I'm a PI — who has time for animals?" Otis couldn't help notice that the detective was pulling some hairs off of his trousers. Otis slowly smiled. "I've always got time for the ladies, though! Blondes are my favorite. Just something about being a PI that drives 'em wild. Know what I mean?"

Detective Woodward tried to imagine throngs of women around Otis. Somehow he managed not to laugh out loud at the thought. Instead, the detective coolly instructed Otis "Ladies' Man" Nixon to move his truck off of the sidewalk. As Otis complied with the request, Detective Woodward put the purple pen and the hair samples from his pants into small containers used to hold evidence.



## LESSON 2 PART II: A CLOSER LOOK AT THE PARTIAL RANSOM NOTE

### OBJECTIVE:

Students will study the partial ransom note found in the trash can from the perspective of a QD examiner. They will first learn about QD analysis and then apply their knowledge in an attempt to identify the author of the ransom note.

### MATERIALS NEEDED:

#### Reproducibles

- A Closer Look at the Partial Ransom Note
- Handwriting samples (to be created by the teacher)
- Copy of the partial ransom note (to be created by the teacher)

#### Equipment and Chemicals

- 1 hand lens (magnifying glass) for each student

**Note:** Any time you use chemicals in your classroom or lab, be sure to read and follow the safety instructions for use and disposal that are provided in the MSDS information that came with your lab materials.

### TIME REQUIRED:

- Teacher Prep Time: 1 hour
- Class Time: 30 minutes

### LESSON DESCRIPTION:

At the beginning of this lesson, students will review the information gathered so far and they will update their notes as necessary. Most of the class period will be spent learning about QD analysis. The class will first discuss the techniques used by scientists to compare handwriting of a known and unknown source. Then they will discuss the validity of handwriting analysis. Students will examine the partial ransom note found in the trash and handwriting samples. Then, they will be asked to compare them in hopes of identifying the author of the note. Following the activity, the class should discuss the implications of their findings and should decide on one last test to run before confirming the suspect.

### BACKGROUND INFORMATION:

Before beginning this activity, you should become familiar with handwriting analysis and its place in forensic science. After a little research, it will become clear that QD analysis, as it is now called, is very different than graphology, or the study of handwriting as it relates to personality. The following web sites have valuable information on handwriting analysis and QD analysis:

Michigan State University School of Criminal Justice:

<http://www.cj.msu.edu/~people/quesdoc.html>

Southwestern Association of Forensic Document Examiners:

<http://www.swafde.org/faq.html>

truTV's Crime Library:

<http://www.crimelibrary.com>

In addition, review vocabulary terms in boldface on the student handout.

## LESSON STEPS:

### Teacher Preparation

1. You must make copies of the partial ransom note for all student groups. (It's best if this is done before cutting up the ransom note used in Part I.)
2. For this lesson, you will need to make several handwriting comparison samples. These samples will represent persons of interest, such as Otis Nixon, Melinda Johnson, and Hal Jefferson. They should not be labeled with names, but rather with letters or numbers. (Students may tend to examine them less objectively if they know ahead of time who wrote the sample.) The sample belonging to Otis should most closely match the partial ransom note handwriting. Depending on the ability of your students and the time you have allowed for this part of the investigation, you may want to make your samples similar or very different from one another. (The more similar they are to one another, the more challenging it is to identify the author of the ransom note.) It is important to remember when collecting handwriting samples that one of the samples must have the same author as the ransom note. When preparing your handwriting samples, remember to use words or letter combinations that are used in the ransom note.

Suggestions for making the analysis easier...

- misspelling a word in the ransom note and then again in one of the samples
- using the exact phrase in the samples as you did in the note

Suggestions for making the analysis more difficult...

- spelling all words correctly
- not including exact phrasing from the ransom note, instead using similar letter combinations (e.g., "I have taken" and "I love talking")

**Lab Execution**

1. Introduce the lesson by reviewing all of the information you have gathered to this point. Ask the students to share their thoughts from their journal entries (homework from Part I of Lesson 2).
2. Distribute the handout, A Closer Look at the Partial Ransom Note. Read over the Introduction and Background sections together, ensuring that students understand the basic characteristics of handwriting.
3. If possible, break students into their investigative groups, and have them compare their own writing style with that of their group members. To do this, write a sentence on the board and have each student copy it onto their paper. Using the characteristics of handwriting, students can examine their own samples. Discuss as a class the different handwriting styles within the class.
4. Distribute the copies of the partial ransom note and the handwriting samples you have prepared. Instruct the students to complete the activity on their handout. After students have identified the sample they think matches the note, provide the corresponding name that goes with each handwriting sample.
5. Following the analysis, discuss the validity of handwriting analysis in criminal investigations. Ask students if they feel they have enough evidence to accuse any of the suspects. Lead the students to ask for one more piece of evidence... analysis of the hair found in Otis' truck.

**ACADEMIC EXTENSIONS/MODIFICATIONS:**

- If time is a factor, students can skip Lesson Step #3 (although they will enjoy analyzing their own handwriting).
- You can make the analysis easy or difficult based on your handwriting samples. See the hints in the Teacher Preparation section of this lesson.

## A CLOSER LOOK AT THE PARTIAL RANSOM NOTE

### INTRODUCTION:

Have you ever received a letter in the mail and instantly identified the sender by looking at the handwriting? Your handwriting is as unique to you as your personality. Scientists believe that no two individuals have the exact same handwriting, although some people's style may have general characteristics in common.

Detectives often call on handwriting experts known as QD examiners to analyze handwriting samples of suspects in crimes where a ransom note or other pieces of handwriting are left behind as evidence. These examiners are also experts on paper types and typewritten documents. They can appear in court to testify about QD with unknown authors.

In this lesson, you will use handwriting analysis to see if the handwriting of any of the persons of interest matches that found on the partial ransom note. Study the background information provided below, and then begin your analysis.

### BACKGROUND:

Through the years, as people write, their handwriting becomes unique. It is often possible to identify an author of an unknown document by comparing the handwriting with a known source. For the most accurate comparisons, the known document, or the standard, needs to contain similar words or letter combinations to that of the evidence. QD examiners use "identifiable features" such as slant, spacing, and letter formations to make their comparisons.

Listed below are six different handwriting samples along with seven characteristics of handwriting that QD examiners use for comparison. As you read through the examples provided, answer the question in the space provided.

- |   |   |
|---|---|
| 1. <u><i>I love forensic science!</i></u> | 4. <u><i>I love forensic science!</i></u> |
| 2. <u><b>I love forensic science!</b></u> | 2. <u><i>I love forensic science!</i></u> |
| 3. <u><i>I love forensic science!</i></u> | 3. <u><b>I love forensic science!</b></u> |

### Identifiable Characteristics of Handwriting

1. Spacing or margins between letters and words: In sample #1, there is little space between the words. In sample #4, there is more space between letters compared to the other samples.

Q: How does the spacing in #2 compare to the spacing in #3?

**STUDENT HANDOUT**

2. **Size of the letters, especially the height compared to the width:** In sample #2, the letters are tall relative to their width. In sample #6, the letters are not as tall relative to width.

Q: Which of the samples above have letters that are short compared to width?

3 **The strokes connecting capital letters to lower case letters and lower case letters together:** In sample #1, some letter combinations are connected ("ov" in love, "ens" in forensics). In sample #4, the letters are not connected.

Q: How do the connections in #5 and #6 compare with one another?

4. **Unusual letter formations such as loops and curls or a hybrid of printing and cursive:** Compare the l's and the f's in the samples above. Notice how they vary among the handwriting styles.

Q: Which 2 samples have similar f's? Which two samples have unique l's?

5. **Slant of the letters to the right or left and the angle of the slant:** Notice the samples that slant and those that don't. Even those that slant vary in the angle of slant.

Q: Which samples slant to the right? To the left?

6. **Writing above, on, or beneath the baseline:** Some individuals have a tendency to write portions of some characters below the baseline.

Q: How do #2, #3, and #4 compare with one another for this characteristic?

7. **Crossing of t's and dotting of i's (diacritics:** Individuals tend to dot their i's and cross their t's in unique fashions).

Q: Study the samples on the previous page carefully using a hand lens to contrast the dots and crosses.

**STUDENT HANDOUT****PROCEDURE:**

1. Study your copy of the partial ransom note with a hand lens (magnifying glass). Focus on the characteristics of handwriting discussed in the background section of this handout. Write down any observations in your notebook.
2. Study the handwriting samples provided by your teacher. Focus on the characteristics of handwriting discussed in the Background section of this handout. Write down any observations in your notebook.
3. Compare the handwriting on the partial ransom note with that on the handwriting samples. You may use a hand lens to get a closer look at each sample. Using the identifiable characteristics of handwriting, choose the handwriting sample that most closely matches the writing on the partial ransom note.

**ANALYSIS:**

1. Which handwriting sample most closely matches the writing on the partial ransom note?
2. What characteristics did you examine to make this conclusion?
3. Is QD analysis conclusive proof? Why? Why not?
4. Describe a situation in which a person's handwriting could be distorted.

**CONCLUSION:**

Write a paragraph explaining how the handwriting analysis relates to the current investigation. Is the QD analysis enough to convict the suspect? You will need to refer to this conclusion later in the investigation.

## LESSON 3: HAIR ANALYSIS AND CONCLUSION

### OBJECTIVE:

Students will learn about hair morphology (also called microscopic hair analysis). They will then prepare, view, and sketch wet mount slides of hair samples. They will also view and sketch permanent slides of the same samples. After gathering and reviewing all evidence, students will conclude their investigation by filling out the final Investigative Report.

### MATERIALS NEEDED:

#### Reproducibles

- Hair Analysis and Comparison
- Hair Analysis Information Sheet
- Investigative Report
- Epilogue: Unit Conclusion

#### Equipment and Chemicals

- hair samples A (human hair), B (Magic's hair/any blond dog hair), and C (evidence hair, same as B) taped to 3x5 cards. Enough samples for each group to have one of each.
- microscope slides and coverslips
- water and droppers for preparing slides (if students will perform own slide preparation)
- microscopes
- colored pencils for drawings
- forceps
- Permout (available at <http://www.carolina.com>), or other permanent mounting solution
- hand lenses (available at <http://www.carolina.com>)

**Note:** Any time you use chemicals in your classroom or lab, be sure to read and follow the safety instructions for use and disposal that are provided in the MSDS information that came with your lab materials.

### TIME REQUIRED:

- Teacher Prep Time: 1 hour, but allow 24 hours for permanent slides to dry
- Class Time: 45–75 minutes, depending on the amount of instruction required for microscope use and slide preparation

### LESSON DESCRIPTION:

In this lesson, students will conclude their investigation by analyzing and comparing hair samples to determine if Magic could have been in Otis Nixon's truck. Students will learn about hair morphology and use this knowledge to make detailed sketches of the prepared hair sample slides, as well as make their own wet mount slides of the samples. (If time is tight, prepare slides ahead of time using

Permout for the students to use.) In conclusion, students will review all of the evidence and prepare an Investigative Report. When the reports have been successfully completed, present your students with the Unit Epilogue, or hold a classroom discussion to share various theories and the mystery conclusion.

### **BACKGROUND INFORMATION:**

Before beginning this lesson, you should review hair morphology and hair anatomical terms. You will also need to make permanent hair sample slides using Permout. These slides must be prepared 24 hours in advance. Permout can be purchased from Carolina Biological Supply Company (<http://www.carolina.com/>). Other permanent mounting solutions are available through different supply companies.

### **LESSON STEPS:**

#### **Teacher Preparation for Hair Analysis and Comparison Lab**

1. Prepare permanent slides for Samples A, B, and C. These slides are prepared as wet mount slides, using a drop of Permout in place of the drop of water. (They must dry overnight!) Each student group will need a set of these slides:

Sample A = human hair sample

Sample B = Magic's hair sample (choose any blond dog hair)

Sample C = Unknown hair sample (same as Sample B)

You may want to choose human and dog hair samples that are similar in color. You don't want the students to be able to tell them apart without looking under the microscope. On the other hand, choose samples that will appear different enough under the microscope so that students can draw a conclusion. **View the samples under the microscope yourself before preparing the permanent slides.**

2. Prepare microscope stations for each of your investigative groups with hair samples, slides, coverslips, droppers, and water.

#### **Lab Execution**

1. As a class, review the information you have gathered up to this point. Ask students what else they need to know to establish enough evidence to arrest Otis. Did he ever have Magic in his car? If so, how could we prove it?
2. Inform students that hairs have been collected from Otis' truck. It is unknown whether or not these are human hairs or dog hairs. Otis contends that he never even had a dog in his truck. Tell students that they will be learning about hair morphology and hair analysis to determine the type of hair samples that have been collected from the truck.

3. Distribute the Hair Analysis Information Sheet and the Hair Analysis and Comparison Lab Worksheet. Read the information sheet together to make sure that everyone understands the terminology used in hair anatomy. Remind students to keep the information sheet with them as they make their observations so they can use the correct vocabulary when describing the hair samples.
4. Instruct students to perform the lab as outlined in the student handout. Depending on the ability of your class, you may need to review microscope procedures as well as the technique you want them to use when making wet mount slides. (You may skip this step of having students prepare their own wet mount slides if time doesn't allow it.)
5. Go over the results of the hair comparison. Does the hair analysis alone provide conclusive evidence that a crime has been committed? As a class, explore different scenarios when hair analysis would be valid and other situations in which it would not.
6. As a conclusion to the lab activity, distribute an Investigative Report to each student. Instruct students to complete their reports based on all the evidence that has been gathered in each lesson. You can adjust the length and specificity of the report based on your students' abilities and/or the amount of time you have to devote to it.
7. Upon completion of the unit, present students with the Epilogue, or hold a classroom discussion to share various theories and the mystery conclusion.

### **ACADEMIC EXTENSIONS/MODIFICATIONS:**

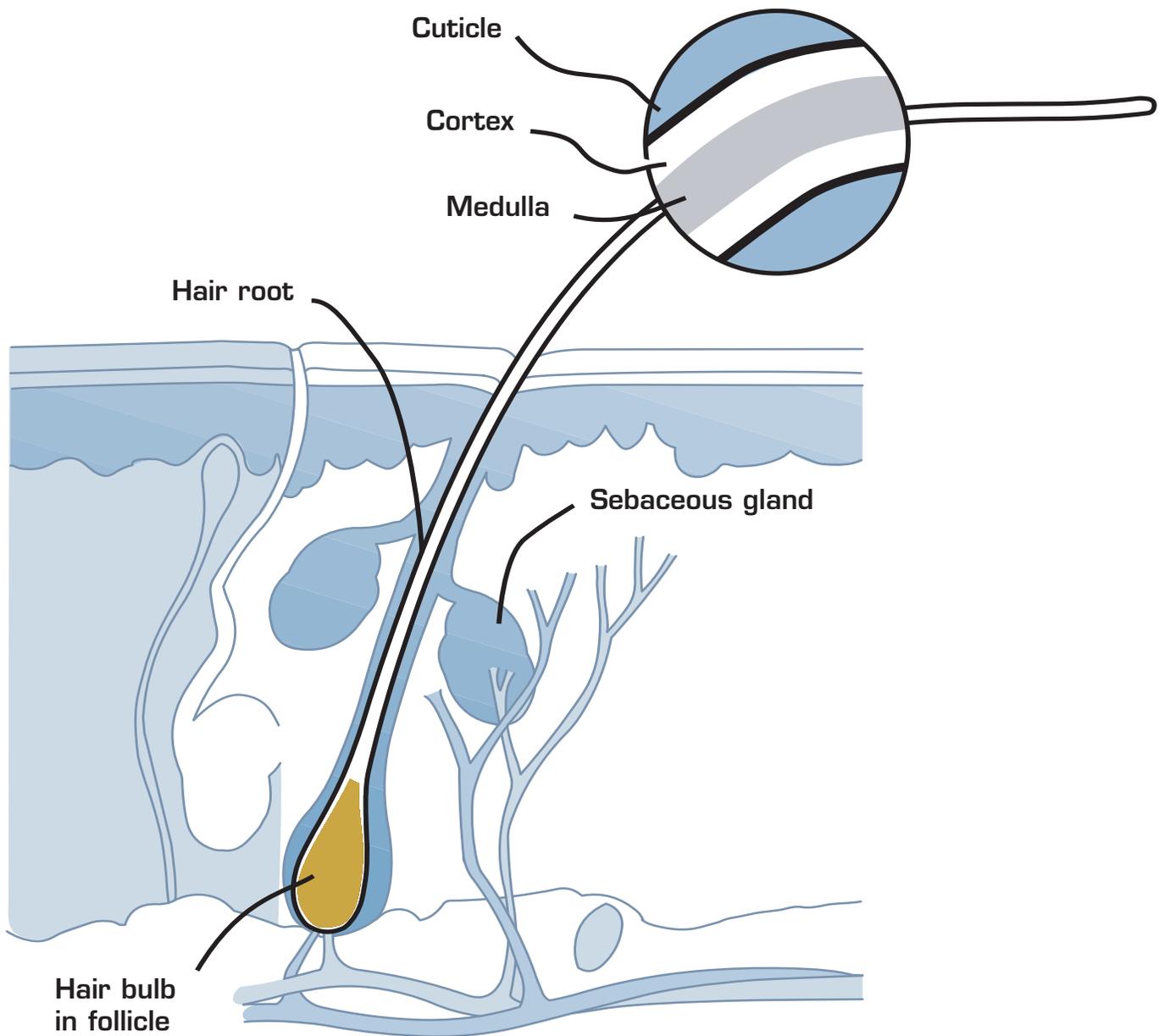
- If time is a factor, assign the Hair Analysis Information Sheet to read for homework before you begin the hair analysis. Then, open the class with a review of what students read for homework. The Investigative Report could also be a homework assignment to be completed after the hair analysis lab.
- If students are not familiar with the microscope, you should spend 30-45 minutes reviewing the parts of the microscope and wet mount slide preparation before the students attempt to prepare the wet mount slides themselves.
- If you worry about your students' ability to prepare wet mount slides, you can simply use the permanent slides by themselves.
- As an extension activity, have students research the current use of hair analysis in forensics and prepare a short report with their findings. They will most likely discover that hair analysis is rarely conclusive and that hair samples are collected in hope of obtaining DNA samples rather than morphological comparison. However, several historical cases have used hair evidence.

**STUDENT HANDOUT**

**HAIR ANALYSIS INFORMATION SHEET**

**Hair Morphology:**

When performing hair analysis, it is important that you become familiar with the structure of the hair and its characteristics. Study the following diagram and the terms that follow before beginning your hair analysis.



**STUDENT HANDOUT**

**Cuticle:** The cuticle is the outermost protective covering of the hair. It is usually thicker in animal hair and often contains overlapping scales that are unique to the species. These scales overlap and point upwards toward the tip of the hair.

**Cortex:** The cortex is located beneath the cuticle of the hair. This part of the hair contains pigment granules. These granules differ in their size, color, and pattern. The cortex of the hair is viewed most clearly using slides with a permanent mounting fluid.

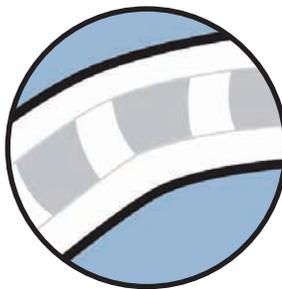
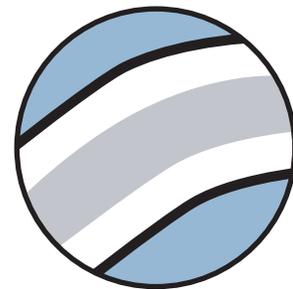
**Medulla:** The medulla is a canal located inside the cortex. Although it is the most visible structure of animal hair, it is usually very thin or absent in human hair.

**Root:** The root is the part of the hair in the follicle that is below the surface of the skin. The condition of the root is sometimes examined in forensics to determine whether or not the hair was pulled out in a struggle.

**Follicle:** The hair follicle is a pocket located beneath the surface of the skin from which the hair grows.

**Shaft:** The shaft is the part of the hair that is visible above the skin's surface.

**Medullary Pattern:** The pattern of the medulla varies among species and can be used to distinguish animal hair from human hair. The following diagrams show different medulla patterns.

**Fragmented****Interrupted****Continuous**

**Medullary Index:** The medullary index is the diameter of the medulla relative to the diameter of the hair. This index is often less than  $1/3$  in humans and may be over  $1/2$  in animals.

**STUDENT HANDOUT**

**HAIR ANALYSIS AND COMPARISON LAB WORKSHEET**

**INTRODUCTION:**

Hair analysis is often used in crime scene investigations to narrow the field of suspects, or to place a person or an animal at the scene of a crime. Morphological analysis of a hair includes structure, color, length, and texture. Despite popular opinion, morphological analysis alone cannot provide a positive identification among humans. Today, forensic scientists use hair gathered at a crime scene as a source of DNA, which can provide a positive identification.

As far as the current investigation goes, you now have a collection of evidence pointing to a suspect in the neighborhood. List these pieces of evidence in the space provided below:

- 1.
- 2.
- 3.

Although the evidence is strong, more proof is needed to place Magic with the suspect. To conclude the investigation, you need to analyze hair samples found in the suspect's truck to determine if they belong to an animal or a human. You will compare the unknown sample from the suspect's truck with a human hair sample and a sample from Magic's bed by making slides of all three.

**PROCEDURE:**

1. Read the information provided on the Hair Analysis Information Sheet.
2. Examine each hair sample with the naked eye or with a hand lens provided by your teacher. Record observations in the Macroscopic Observations table.

**MACROSCOPIC OBSERVATIONS**

	Sample A (Human hair)	Sample B (Magic's hair)	Sample C (Evidence hair)
<b>Length</b>			
<b>Color</b>			
<b>Texture, Structure, (wavy, curly, straight)</b>			

**STUDENT HANDOUT**

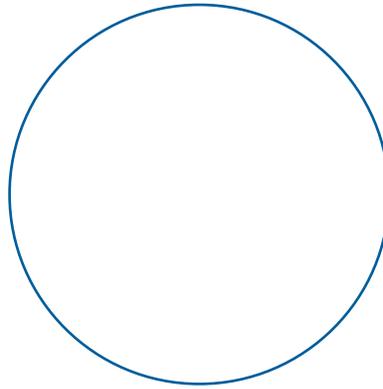
3. Prepare wet mount slides of each hair sample.
4. Study the wet mount slides under the microscope on high power. Make sketches of each slide in the Observations section of this handout. Under each "field of view," record the magnification in the space provided. To the side of each drawing, indicate which hair sample is shown. In addition, you should label the major hair structures including the cuticle, cortex, follicle, medulla, and shaft. Only label those structures that you actually see. Use colored pencils when necessary.
5. Next, sketch the permanent slides of the hair samples prepared by your teacher. These slides are used to show the cortex layer more clearly. Under each "field of view," record the magnification in the space provided. To the side of each drawing, indicate which hair sample is shown. Concentrate on the arrangement of pigment granules and air spaces in your drawings. Label these structures on your drawings.
6. After completing your sketches, fill in your observations and data in the Microscope Observations table. Refer to the Hair Analysis Information Sheet and use the correct terms when recording your data. For example, the medulla pattern could be continuous, interrupted, fragmented, or absent.

**MICROSCOPIC OBSERVATIONS**

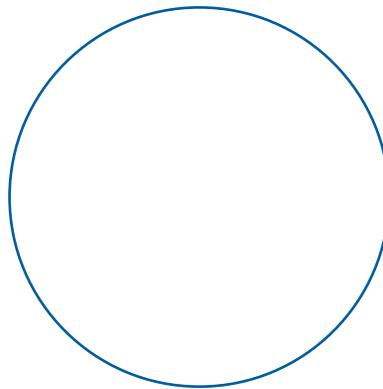
	Sample A (Human hair)	Sample B (Magic's hair)	Sample C (Evidence hair)
<b>Medulla pattern</b>			
<b>Size of medulla compared to size of hair</b>			
<b>Condition of hair tip</b>			
<b>Condition of root tip</b>			

**STUDENT HANDOUT**

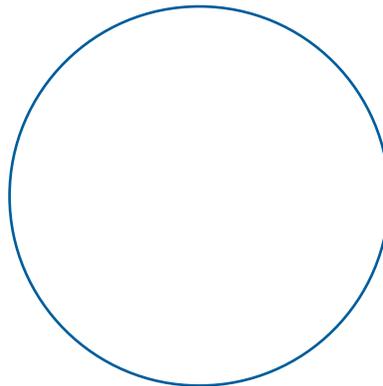
**Observations/Drawings: Wet Mount Slides**



Magnification\_\_



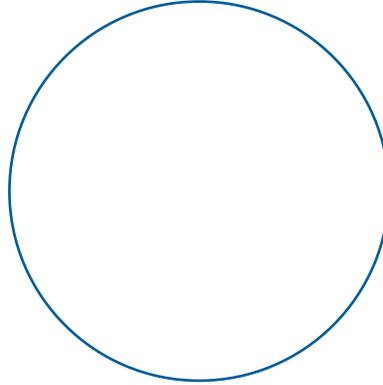
Magnification\_\_



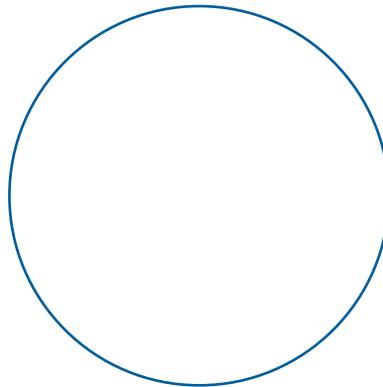
Magnification\_\_

**STUDENT HANDOUT**

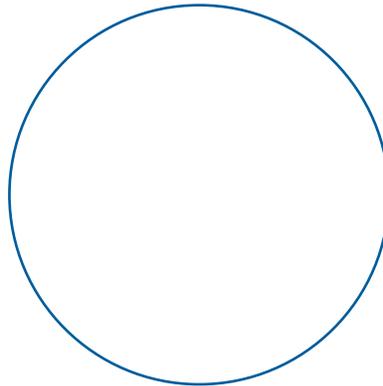
**Observations/Drawings: Permanent Slides**



Magnification\_\_



Magnification\_\_



Magnification\_\_

**STUDENT HANDOUT****ANALYSIS:**

1. What features of hair do forensic scientists examine to make comparisons?
2. Describe in as much detail as possible the difference between the human hair and Magic's hair.
3. Are all human hairs identical? Are all dog hairs identical? How do hairs of organisms within the same species differ?
4. Is hair sample C an animal hair or a human hair? How can you tell?

**CONCLUSION:**

Write a paragraph summarizing the results of this lab as they relate to the investigation. Why is hair analysis not conclusive evidence in forensic science? How can hairs be used to help form a positive identification?

**STUDENT HANDOUT**

**INVESTIGATIVE REPORT**

To conclude your investigation, you need to summarize all of your results in an Investigative Report. A report such as this is intended to take all of the evidence you have — the results of the pH test, along with the ink, handwriting, and hair analyses — to conclude the identity of the guilty party. The Investigative Report is used by the district attorney’s office during the prosecution of the criminal, so it needs to be as thorough as possible. You may also cite information provided by witnesses; however, your conclusions should rely strongly on the results of the scientific tests and physical evidence. Refer to your notes in the conclusion section of each unit activity for details.

Questions that should be answered by this report include the following: What is the most plausible explanation for the puddle of water on the Jeffersons’ floor based on its pH rating? Who most likely wrote the partial note that Liz found in the trash can? What other evidence corroborates this? Were the hairs found in the truck animal hairs or human hairs? How does this information compare to statements made by the suspect?

**DATE:** \_\_\_\_\_

**INVESTIGATOR NAME:** \_\_\_\_\_

**LOG OF EVIDENCE RECEIVED:** \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**CONCLUSIONS:** \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**CONFIDENTIAL:** This is an official report and is to be issued in connection with an official criminal investigation. Do not make public or reveal the contents thereof to any unauthorized person. The form for this report is found to be in compliance with NCGS 000001 and is hereby approved by the Attorney General.

**STUDENT HANDOUT****EPILOGUE: UNIT CONCLUSION**

Sufficient evidence pointed to Otis as the perpetrator, so Detective Woodward had him arrested and brought down to the station. That same evidence also indicated to the detective that the likely perpetrator was less than smart. He relished the opportunity to interrogate Otis and try to get him to make a full confession.

"Otis, you're a bright guy. You've got ESP. You know you wouldn't be here unless something was wrong. Unless we had some evidence that points to you. In fact, it turns out that we've got a lot of evidence that points in your direction." Detective Woodward paused to watch Otis squirm. "I think you'll need to call your lawyer right now. 'Cause this is going to get very ugly. You need someone who's smart and tough."

"I don't need to do that." The detective thought that Otis had fallen for his bait — that Otis figured he was smart and tough enough to handle it. But Otis surprised him. Otis wanted to confess right there.

"I don't need a lawyer because I did it. I admit it. I took Magic."

"Is that so?" Otis looked to the ground and nodded.

"Is the dog all right?"

Otis nodded again. Detective Woodward wanted more than nods, though.

"So you're saying that the dog is completely unharmed?"

"Yes. Yes, he's fine! Okay? I haven't done anything to him. I wasn't going to do anything to him. I promise!" Otis looked Detective Woodward right in the eye when he said, "I promise." It probably was the first time that Otis had looked at him that directly.

"Otis, I think you should still get a lawyer right now," the detective said, dropping some of his tough interrogation attitude. "Prosecutors can charge you with a whole host of things from grand theft to blackmail to animal endangerment. You need to help us get the Jeffersons' dog back. You need to cooperate in any way you can."

Otis again nodded with his head down. "One thing I have not been able to figure out, though," continued Detective Woodward, "is why you did it? Both Mr. and Mrs. Jefferson told us that they never had problems with you, nor could they think of anything that they did that would have upset you. So help me out here."



**STUDENT HANDOUT**

Otis had one more surprise left. "This whole scheme was going to be my big break. I was going to be the one that solved the case. I was going to have my name in the papers for finding and returning Magic to the Jeffersons. I'd be the hottest PI in town. I just had to wait a little longer until you guys ran out of leads, and then put that part of my plan into action. You didn't follow my plan, though."

After hearing his story, Detective Woodward almost felt sorry for Otis. How could he have expected that they would not figure out he was the perpetrator — that they would have followed his "plan" and run out of leads? For that matter, how could Otis have even entertained the idea of being a private eye?

Detective Woodward remembered Liz's snicker when Otis had first introduced himself and mentioned his "profession." Liz's reaction was very slight, but the detective had noticed it. He wondered if the thought of Otis as a detective had been simply too ridiculous for Liz to take as well. Thinking of Liz reminded Detective Woodward that he needed to thank her again for all of her help. But that would have to wait until he made sure that Magic was back safely.



Within an hour, the detective had Magic home to the Jeffersons, where he was happy to be back and shedding his blond hairs all over the couch. The detective returned Sally's prized calligraphy pen to her as well. Sally Jefferson couldn't have been more relieved; even Hal seemed to be genuinely pleased to see Magic. On his way out of the neighborhood, the detective made a quick stop at Liz's house to update her on the outcome of the case.

