THE MYSTERY OF LYLE AND LOUISE

SMALL CLASS EDITION

A COMPLETE FORENSIC LABORATORY SUITE

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A COMPLETE FORENSIC LABORATORY SUITE

NATIONAL SCIENCE EDUCATION STANDARDS:

UNIFYING CONCEPTS AND PROCESSES
Evidence, models, and explanation
Change, constancy, and measurement

SCIENCE AS INQUIRY
Abilities necessary to do scientific inquiry
Understanding about scientific inquiry

PHYSICAL SCIENCE
Motions and Forces

SCIENCE AND TECHNOLOGY
Understanding about science and technology

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES
Science and technology in local, national, and global challenges

HISTORY AND NATURE OF SCIENCE
Science as a human endeavor
Nature of scientific knowledge

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INTRODUCTION TO SMALL CLASS EDITION

WELCOME to The Mystery of Lyle and Louise: Small Class Edition, a Complete Forensic Laboratory Suite. A brutal murder case is unfolding in a small Appalachian town. Already the case spans two crime scenes and five people are dead. In this laboratory suite, your students must analyze the evidence left behind during the murder of two people in a remote fishing cabin, evidence collected from a vehicle crash site where three unidentified victims were found dead, and evidence collected from an abandoned vehicle several states away. This evidence will allow them to determine how the crime unfolded and who was responsible for the horrific events.

In this lab, students will learn various forensic techniques performed on evidence collected at crime scenes. These include: Blood Spatter Analysis

- Forensic Entomology
- Footprint Analysis
- Blood Detection and Evidence Processing
- Questioned Documents Analysis
- Fingerprint Analysis
- Bite Marks Analysis
- Glass Fragment Identification
- Drug Testing and Analysis

After learning about and practicing each of these techniques, students will then apply what they have learned in the processing of evidence collected from the scene of the crime.

Teacher's notes can be found at the beginning of the laboratory modules, and copies may be freely made of all materials for your students.

THE INVESTIGATION

NINE days ago, during the night of a sudden summer thunderstorm, the Mondelo family car went over the side of Backbone Mountain and caught fire on impact. Three bodies were found in the wreckage; an adult woman, a teenage male, and a female child. All were burned beyond recognition. The three victims were identified as Louise Mondelo and her children, Wally and Jan, by personal effects that survived the fire.

Pictures of the scene were recorded but, due to the rainstorm, the crash was initially believed to be simply a tragic accident and was not treated as a crime scene. When Lyle Mondelo could not be reached and was found to be missing, he became a possible suspect, and the wreckage was thoroughly processed. The scene was substantially disturbed and some evidence was undoubtedly lost however, upon retracing the path of the vehicle, investigators found several pieces of broken glass lying in the roadway. Becoming increasingly more suspicious of foul-play, the broken glass fragments were packaged and retained. In addition, investigators cut and removed a section of charred carpet from the vehicle for further laboratory analysis. The bodies, as part of an ongoing criminal investigation, were kept in the county morgue.

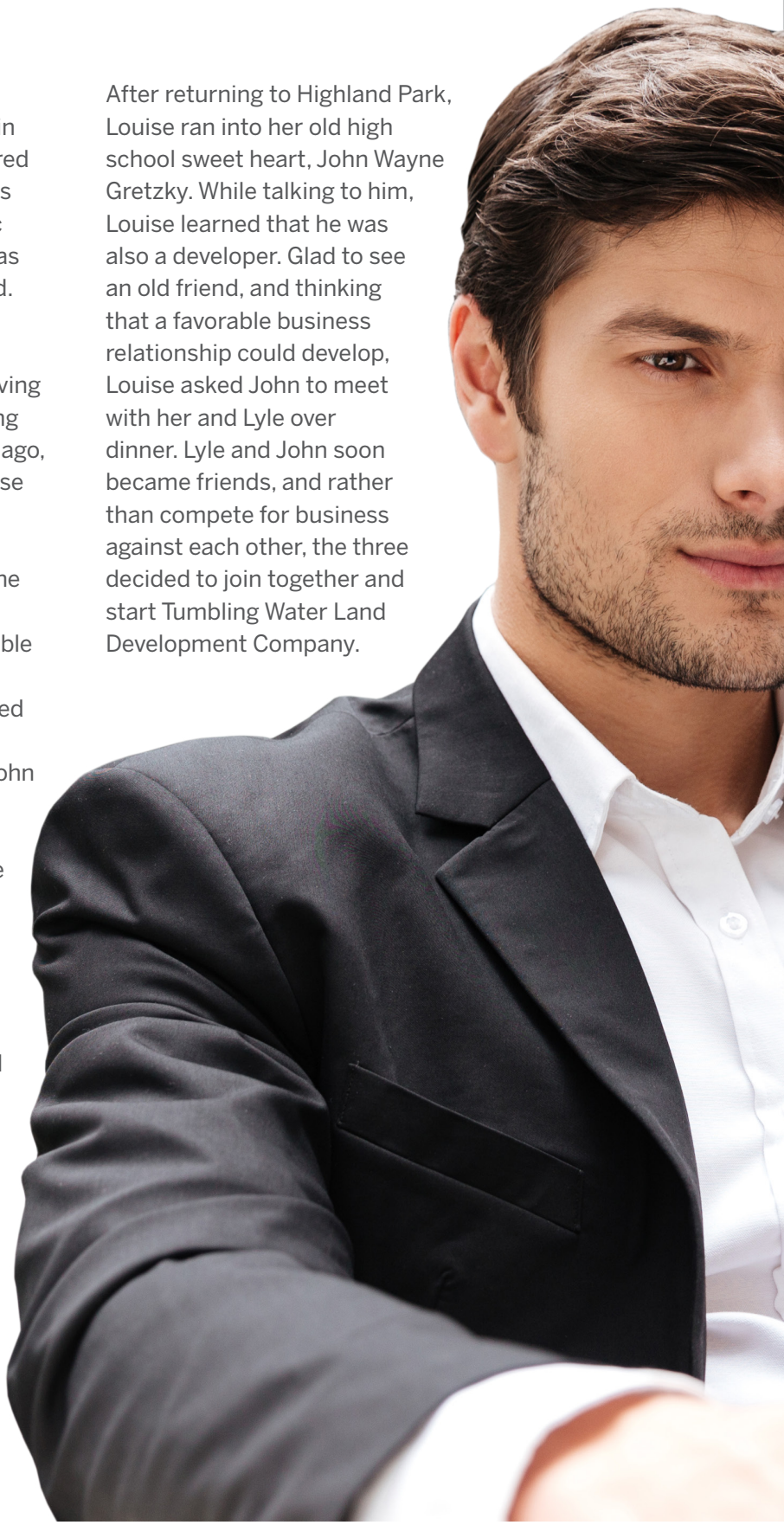
The small town of Highland Park was shocked, since nothing this terrible had ever happened in the area. Tips from neighbors and friends poured into the police department, but none of the tips were eyewitness accounts or provided specific information regarding the car accident. Lyle was the likely suspect but was nowhere to be found. An all-points bulletin was issued for everyone to be on the lookout for Lyle Mondelo. He was presumed armed and dangerous and to be driving a missing, blue, 1993 Ford Ranger with Tumbling Water Land Development Co. logos. Four days ago, Lyle Mondelo's credit card was used to purchase gasoline and food at a gas station in Texas.

When contacted, business associate John Wayne Gretzky told investigators that Lyle had been slipping into a deep depression because of trouble at their jointly owned business, Tumbling Water Land Development Company. Gretzky also hinted that there had been problems in the Mondelo family. At this time, investigators noticed that John had a large bite mark on his upper arm. When asked about the wound, Gretzky claimed to have been bit during a bar fight the night before and allowed the bite to be photographed. He was not held or charged with any crime.

BACKGROUND INVESTIGATION

With no additional leads, policed launched a full investigation into the Mondelos. Louise Wilson and Lyle Mondelo had met at college while receiving Business Degrees in Management. They married in college and moved to Highland Park, Louise's hometown, after graduation. The town was still ailing at the time, suffering from the shut down of the mines a little over a decade ago. Although at first Lyle thought their business prospects in the small town were poor, he soon discovered that money could be made developing land for the private lodges and ski resorts that employed most of the residents.

After returning to Highland Park, Louise ran into her old high school sweet heart, John Wayne Gretzky. While talking to him, Louise learned that he was also a developer. Glad to see an old friend, and thinking that a favorable business relationship could develop, Louise asked John to meet with her and Lyle over dinner. Lyle and John soon became friends, and rather than compete for business against each other, the three decided to join together and start Tumbling Water Land Development Company.



A year after Tumbling Water was founded, Louise conceived her first child, Wally. Friends of the Mondelos said that Lyle suspected Louise and John of having an affair at the time, and the two nearly divorced. The couple worked out their relationship with the help of a marriage counselor.

Tumbling Water became prosperous and was able to buy several hundred acres of land adjacent to Blackrock River, a prime recreational waterway. Soon thereafter, Louise had another child, Jan, and took leave from the office to work from home while she raised the two children. Friends say that Louise never really went back to Tumbling Water, even after the children were older and in school. Their friends also suggested that Lyle and Louise's relationship was healthier with them not working together.

Tumbling Waters' lawyer told investigators that she began preparing bankruptcy papers for the company about a year ago; the ski resort was dragging out negotiations for a property purchase, and the company's other business deals weren't making enough profit to keep the business afloat. Soon after being asked to begin the bankruptcy filing, though, she said an unexpected deal was made to build a number of fishing cabins on the Blackrock River land. That was enough to keep the business going, and after that, Tumbling Water began making deals at a steady rate.

A potentially related case recently touched on the Mondelos' lives. Three weeks ago, a crystal methamphetamine lab was discovered in an abandoned camper on Tumbling Water land. Louise's nephew, Mitch Wilson, and John Wayne's brother, Larry Gretzky, were found in the lab and indicted for possession with intent to sell the 6 kilograms of meth found in the lab. Two days later they were both released on bond, posted by Lyle Mondelo and John Gretzky. Mitch and Larry gave no names of possible suppliers or dealers.

Two weeks before the crash, Louise Mondelo filed for divorce. Friends say she told them that she suspected Lyle of being involved with drugs, but that the friends believed she was involved with John Wayne Gretzky again. Two days later after filing for divorce, Louise requested a restraining order against Lyle, stating that Lyle had harassed her and the children. Louise also told police that she was afraid that Lyle might try to take the children away.

When attempting to contact Mitch Wilson and Larry Gretzky for questioning about the car accident, police discovered that they had both skipped town along with Larry's girlfriend, Mary Bradey. Authorities believed that their disappearance could be related to the accident, and they were described as possibly armed and dangerous in the warrant posted for their arrest.

Two days ago, an abandoned blue Ford Ranger with out-of-state plates was found on a strip of New Mexico highway. The pickup was dirty and a headlight was broken, but investigators noticed a Tumbling Water Land Development Co. sign on the back tailgate. Forced entry was apparent. Upon access to the truck, investigators discovered several pieces of trace evidence and sent it to Highland Park for analysis.

AT THE SCENE

This morning the bodies of two deceased victims were discovered in a remote fishing cabin on property owned by Tumbling Water Land Development Company. The cabin, isolated from view of the main road and deeply buried in the thick woods, lies along the bank of the Blackrock River and is accessible only by a gravel road cutting into the forest. Soon after the bodies were discovered, the small cabin was surrounded by police tape and investigators combing the scene in search of evidence.

Detective Murray, the lead investigator in the case, explained, "A Girl Scout on a hiking trip found the

victims about an hour and a half ago. There are two bodies inside, both in advanced stages of decomp; PMI undetermined. The female vic was identified as Louise Mondelo, the same woman identified in the car that ran off Backbone Mountain and caught fire during the storm last weekend. The bodies are in bad shape, but hopefully we'll get a positive ID when DNA analysis comes back."

Inside the cabin the smell of advanced human decay was overwhelming. The overturned chairs and tables led investigators to conclude that a violent struggle had taken place. The smaller body, dressed in a blouse and jeans, was found near the phone in the kitchen. The larger corpse was dressed in a man's polo shirt and slacks lying in the corner to the left of the door, and blood covered the walls and floor around him. Investigators collected maggots from the corpses to help establish a time of death and collected DNA samples from both victims. While processing the scene, flesh was discovered scraped across the stone of the fireplace, and blood and skin were found on a piece of firewood lying near the woman's body. Samples of both were collected for analysis. The wounds upon the head of the female victim appeared consistent with the firewood, but a definitive determination was difficult to make due to the state of decay. Outside of the cabin, a set of tire tracks were found deeply rutted in the mud and grass. As none of the investigators had driven near that area, dental stone molds were cast of the tracks and pictures were taken to preserve evidence.

PERSONS OF INTEREST

THE MONDELOS

Louise Ann Mondelo, the 38 year old wife of Lyle Mondelo and mother of Wally and Jan, is also one of the owners of Tumbling Water Land Development Company. Friends say that Louise was in an unhappy marriage and had recently filed for divorce.

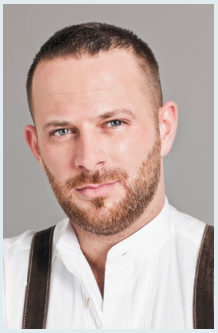
Lyle Christopher Mondelo, the 40 year old husband of Louise Mondelo and father of Wally and Jan, is a part owner of Tumbling Water Land Development Company along with his wife.

JOHN WAYNE GRETZKY

John Wayne Gretzky is 41 years old. He is a friend and business partner of the Mondelo's in the Tumbling Water Land Development Company. According to rumors, John Wayne and Louise had a brief affair when Lyle and Louise first moved to Highland Park. He is known around town to be a greedy businessman, and has been suspected of shady deals in the past.

LARRY GRETZKY AND MITCH WILSON

Larry Gretzky and Mitch Wilson were recently indicted on charges related to their apparent operation of a methamphetamine laboratory. Larry was bailed out by his brother, John Wayne, and Mitch was bailed out by his uncle, Lyle Mondelo. Larry and Mitch failed to appear in court and are currently missing. Police are interested in locating them for questioning.



TEACHER'S NOTES
BLOOD SPATTER

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Blood Spatter Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 16 and 23, respectively.

SUPPLIES

- Cardboard Blood Drop Angle Support (1)
- 11×17" Paper (10 sheets)
- Synthetic Blood, 1 oz. bottle (1)
- Pasteur Pipettes (2)
- Pasteur Pipette Bulb, 1 mL (2)
- Cardboard Cabin Model (1)
- Crime Scene Blood Spatter Images (1 set of 4)
- String, 18" (1 bundle)
- Push Pins (1 box)
- Tape Measure (1)
- Protractor (1)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Clear Tape
- Lab Gloves
- Computer with MS Excel

ASSEMBLIES

An assembly sheet for the Blood Drop Angle Support and the Cabin Model is included. To save class time, you may wish to assemble these prior to the lab session. When assembling the cabin model, do not attach the blood spatter images until directed in Lab Procedure 3.

SAFETY PRECAUTIONS

- Imitation blood will stain clothing.
- Exercise caution with push pins, as they will stick through the cardboard mock-ups.
- While dropping blood from the highest height, do not stand on unstable supports.

SPREADSHEETS

This lab requires that you download the Excel spreadsheet from www.LyleAndLouise.com. Visit the "Downloads" page, create/login to an account, and register your product to download the supplemental material for this module.

EQUATIONS

By analyzing their data, students should come up with equations similar to the ones shown below.

- Angle vs. Arc Sin is y = 55.743x 4.9547
- Height vs. Width is y = 610x 410

Note that students' equations will vary, but if a group is having trouble with Lab 2, the equations above will allow them to complete Lab 3.

DROPPING BLOOD

The blood dropping procedure must be performed consistently between individuals to obtain the best data.

- Instruct students to always hold pipette vertically.
- Before dropping blood, shake the bottle vigorously. Recap and shake often during the lab.
- While dropping blood, hold constant pressure on the pipette and make 4-5 separate blood drops in succession. The first drop is unlikely to be useful as it will frequently contain air. The remaining drops should be measured and used for data analysis.
- Measure drops only after they have dried.
- Do not allow the paper to be tilted while drying as this will produce faulty results.

BACKGROUND INFORMATION
BLOOD SPATTER

In crime scene investigation, fingerprint comparison and DNA analysis can often identify who committed a crime, but how that crime occurred is often harder to determine. In most cases, the only individuals with firsthand knowledge of an event are the perpetrator and victim. One way to help determine how a violent crime occurred is to analyze the bloodstains present at the scene, as this analysis may shed light upon the events that produced the stains.

Blood Stain Pattern Analysis (BSPA) is a systematic approach to evaluating the origin and mechanics involved in the creation of a bloodstain. BSPA requires answering a standard set of questions about a bloodstain and determining the relationship of the stain to the surrounding scene. BSPA includes determining the type of impact, the direction the blood traveled after impact, the minimum number of blows required to produce the bloodstain, the stain's area of origin, the distance between target surface and origin, the position of the victim or an associated object, and any movement of the victim or object after bloodshed.

Typically, the point where the violence started will be close to the location where the least amount of blood is observed at the scene. Bleeding generally increases as greater damage and breach of the

circulatory system occurs, and victims are less likely to be able to flee as an attack progresses.

Once a scene has been examined and a general assessment of events is determined, blood patterns are placed into general stain groupings. Stains can be first grouped into passive stains (created by droplets in freefall, under only the force of gravity), projected stains (created by the transfer of some external energy to the blood droplets), or transfer stains (created when a wet, bloody surface contacts a clean surface).

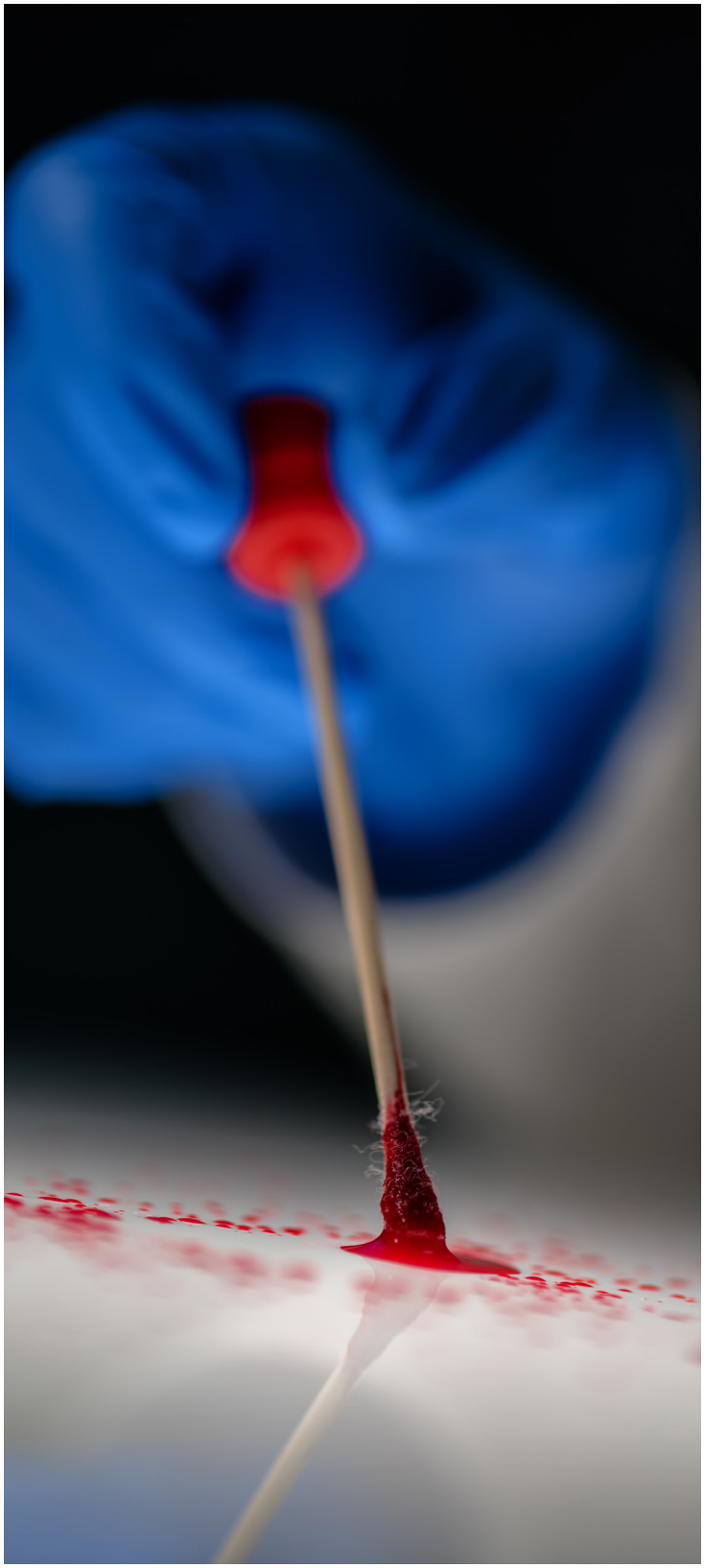
Bloodstains are then further defined utilizing an understanding of the physical and biological characteristics of blood that affect pattern characteristics. Surface character plays a fundamental role in altering the surface tension that holds a droplet of blood together during impact. Droplets hitting smooth target surfaces will remain relatively intact, while those hitting rough surfaces will tend to fragment.

In studying patterns formed on flat target surfaces, two main stain shapes are observed; round and elliptical. Round stains indicate the droplet impacted the surface at a 90° angle, either falling straight down onto horizontal surfaces or traveling in a perpendicular direction when striking vertical surfaces. Elliptical stains are formed when a droplet strikes the surface at an angle; generally, longer stains indicate more acute angles of impact. "Scalloped", or wave-like, edges may also occur in a stain. These edges point away from the origin. Impacts occurring at sharp angles often create smaller droplets, called satellite spatter, which can originate from the parent stain with a fine, straight line connecting the two.

The most basic of BSPA determinations is direction of travel. As a droplet impacts a surface, the inertia of the droplet keeps the mass of blood moving along the same path it was traveling prior to impact. The major (or long) axis of the circle/ ellipse begins to define a droplet's direction of travel. To further define which direction the droplet is traveling in reference to its long axis, satellite spatter, scallops, or spines (pointed edges of a stain that radiate out from the spatter) are used.

At an impact angle of 90°, satellite spatter and spines may be evident around the entire stain. As the impact angle decreases, stains become more elliptical and travel forward along the leading edge of the droplet. Stains formed at these acute angles are also likely to create a smaller number of satellite droplets. Using these general characteristics, the direction of travel of a droplet can be identified by drawing a line down the long axis of the parent stain and aligning it with the tail, scallops, or satellite droplet.

Projected spatter stains are categorized based on the volume of blood in the flying droplet, a factor directly related to the amount of force that generated the droplets from the blood source. Projected stains are split into three categories: low, medium, and high-velocity spatter. Low-velocity spatter results from low energy at the point of origin, such as blood dripping or being splashed onto a flat surface. Medium-velocity spatter results from an impact that was sufficient to overcome the surface tension of blood. To generate this type of stain, an object must strike the blood source at a velocity of 5-25 feet per second. A common example of this is bluntforce trauma, and during such an event blood is frequently deposited on the perpetrator's clothing. High-velocity spatter is caused by the aerosolization of blood and requires an impact of greater than 100 feet per second. These stains are most frequently caused by gunshot wounds, but may also be associated with explosions or machinery wounds. Normally blood in this form does not travel a significant distance; therefore, highvelocity stains occur in close proximity to the point of origin and often occur in combination with medium-velocity spatter due to insufficient force necessary to aerosolize the entire volume of blood.



At crime scenes, stains often fall into multiple classification categories. In order to adequately and systematically characterize these stains with multiple velocity characteristics, analysts use a technique called preponderant stain sizing. In this analysis the number of droplet stains are counted and placed into the three spatter velocity categories based upon size. The highest percentage of droplets in a particular category then dictates the overall classification.

Other characteristic patterns occurring as a result of bloodshed are cast-off, pattern transfers, and stain ghosting, or voiding. Cast-off stains involve the projection of blood from an object and occur by one of two actions, both associated with centrifugal force. When a blood covered object is swung in an arc, blood is flung off of the object during the swing, or by inertia at the end of the swing. These patterns are linked in groups of straight lines and are easily recognizable. Cast-off stains travel away from the victim, or point of origin, and the nature of the arc, the width of the item, and the volume of blood all play a part in cast-off pattern formation. Analysis of these patterns is very important in the identification of the minimum number of blows to the blood source required to produce the stain. Investigators count the arcs and add one to the number counted, as the first blow rarely deposits enough blood onto the weapon to result in the production of a cast-off pattern.

Blood stain patterns can also be used to orient an attacker during the attack. Droplets striking adjacent walls and the ceiling directly above the point of origin hit at 90°. Correlating the 90° impacts from

both walls and ceiling allows the identification of the general pivot point during the event.

After evaluating a stain and identifying the direction of a projected stain's creation, the point or area of origin must be established. To do so, the common converging point of several spatters should be determined in one of three ways:

1. Using an overhead view which identifies a point of convergence
2. Using a combination of overhead and side views which defines both convergence and height
3. Using software or stringing techniques

While the overhead viewing technique is generally the easiest way to determine the convergence/origin, this technique is limited to determining a two dimensional convergence point and no information on height is available to form a true point of origin in three dimensional space. In each instance in which a stain's path can be defined, a line is drawn in the opposite direction. By mapping the path of multiple droplets, an intersection point can be determined. The intersection point of droplets caused by the same impact should be close to the origin of the blow. Additionally, multiple blows can be established by determining clusters of intersection points from multiple droplets.

To establish a specific location above the point of convergence, an investigator must use a side-view approach, requiring the determination of a droplet's impact angle. Because droplets in flight are spherical, when the droplet impacts the target, its dimensions can be used to define the angle of impact. The inverse of this sine relationship provides an estimate of impact angle accurate to within 5°7°. These techniques require the ability to

define a well formed stain, where length and width of the stain can be clearly and precisely measured. Satellite spatter and spines must also be excluded, so only the elliptical part of the stain is measured.

Building on these theoretical bases for determining points of origin, two three-dimensional techniques have been developed to aid analysts in evaluating bloodstains at a crime scene. Stringing a crime scene is simply a physical extension of the side and overhead approaches described above. To perform this technique a protractor is placed along the stain and a string is placed at the determined impact angle in the direction opposite the trailing spatter defining the potential flight of the droplet. Repeating this exercise using multiple stains creates a series of strings that converge to determine the point of origin.

These procedures construct a three dimensional model of the incident. Collectively, these data should be used to refute or confirm statements made by those involved in the crime scenario.

PRE-LAB QUESTIONS
BLOOD SPATTER

BACKGROUND

1. What is the first step in characterizing a bloodstain pattern?

2. What does a medium-velocity blood stain look like?

3. What type of objects might cause wounds with low, medium, and high impact patterns?

4. If you were studying a bloodstain on a flat surface, what are the shapes of droplets you will observe? What do they indicate?

PROCEDURE

5. At what angles and heights will you drop blood? How many sheets of drops will you have at the end?

6. When measuring the width and length of blood droplet, which will be longer?

7. When stringing a crime scene or crime scene model, what does the string's intersection indicate?

8. Why is it, or is it not, important to know the scale of the crime scene photos?

PRE-LAB SOLUTIONS
BLOOD SPATTER

BACKGROUND

1. **What is the first step in characterizing a bloodstain pattern?**
   The investigator must take a macroscopic look at everything in the scene.

2. **What does a medium-velocity blood stain look like?**
   Medium velocity stains are characterized by small, but still easily identifiable, droplets.

3. **What type of objects might cause wounds with low, medium, and high impact patterns?**
   Answers will vary. Low: knife stab, garrote, a foot splashing in a blood pool. Medium: knife slash, baseball bat, punch. High: gunshot wound, machinery.

4. **If you were studying a bloodstain on a flat surface, what are the shapes of droplets you will observe? What do they indicate?**
   Circle and ellipse. Circle indicates that the blood impacted perpendicular to the surface; an ellipse indicates an impact at some angle other than 90 °.

PROCEDURE

5. **At what angles and heights will you drop blood? How many sheets of drops will you have at the end?**
   Angles: 90 °, 80 °, 60 °, and 40°. Heights: 30 cm, 60 cm, 120 cm, and 150 cm. 8 sheets.

6. **When measuring the width and length of blood droplet, which will be longer?**
   The length will always be longer.

7. **When stringing a crime scene or crime scene model, what does the string's intersection indicate?**
   The strings will intersect at or around the origin of the blood spray.

8. **Why is it, or is it not, important to know the scale of the crime scene photos?**
   When constructing the model, the scale of the photos is needed to know where to position the crime scene photos. When measuring the width/length ratio of blood drops, the scale is unimportant because you are interested in a ratio and not an absolute measure.

THE EVIDENCE
BLOOD SPATTER

Inside the fishing cabin investigators discovered the bulk of the blood spatter in the corner near the male corpse. Spatter covered the two corner walls and a number of spatter-centers were evident.

While processing the crime scene investigators also found a small amount of blood on a piece of firewood found near the female victim, pooled blood around the female victim that appeared consistent with a knife wound at her throat, and low-velocity spatter near her body.

Additionally, a trail of blood droplets was found connecting the male and female victims, and another similar trail was found connecting the female victim's body to a spot near the door, where the trail ended. A trail of what appeared to be bloody footprints also led from the female victim to the door. Each of these bloodstains was documented and photographed by crime scene investigators for further analysis.

LAB PROCEDURE 1
BLOOD SPATTER

ASSEMBLING THE ANGLE SUPPORT

1. Fold the wings of the cardboard angle support assembly up and turn the tabs so that they stand along the back.
2. Fold the back of the assembly up and over the tabs and tuck it into the holes at the base.
3. Fold the support tabs down and into the assembly. They will hold the rectangular piece of cardboard that supports your paper.

CREATING BLOOD DROPS

Each piece of paper is used for two tests, one test on each half. It is best to put different heights on the same page and keep the angle constant. This results in two sheets being used for each of the four angles.

STUDENT NOTE

The angle you write on your sheet is the angle of impact the blood drop will have with the page. For a sheet laying flat, the drop impacts at 90°, and a sheet that's nearly vertical will have an impact near 0°.

1. Choose a piece of paper. Draw a line down the center.
2. Label one half of the sheet as "30 cm, 90 °" and the other as "60 cm, 90 °".
3. Place the sheet into the support so that it rests flat against the bottom.
4. NOTE: Before every measurement, cap the blood bottle and shake vigorously. Repeat often during the experiment. Draw blood from the vial into your pipette.
5. Using your tape measure as a guide, hold the pipette above the half of the page at the height indicated on that half of the paper.
6. Drop 5 to 10 drops onto the appropriate half. Ensure the volume of blood dropped is consistent and that no bubbles are present at the tip.
7. On the other half of the page and repeat steps four through six.
8. Remove the sheet from the support, and set it aside to dry. If there are others in the lab group they may begin processing the blood drop sheets as per the directions in the next section, Measuring Blood Drops, as the drops dry.

9. Keeping the angle constant, repeat steps one through six for the additional heights of 120 cm and 150 cm.

10. Repeat this procedure for the remaining angles: 80 °, 60 °, and 40 °.

When finished, you should have 8 sheets of drops, with two angle-height combination on each.

MEASURING BLOOD DROPS

1. Choose a blood drop collection -half of one of the sheets.

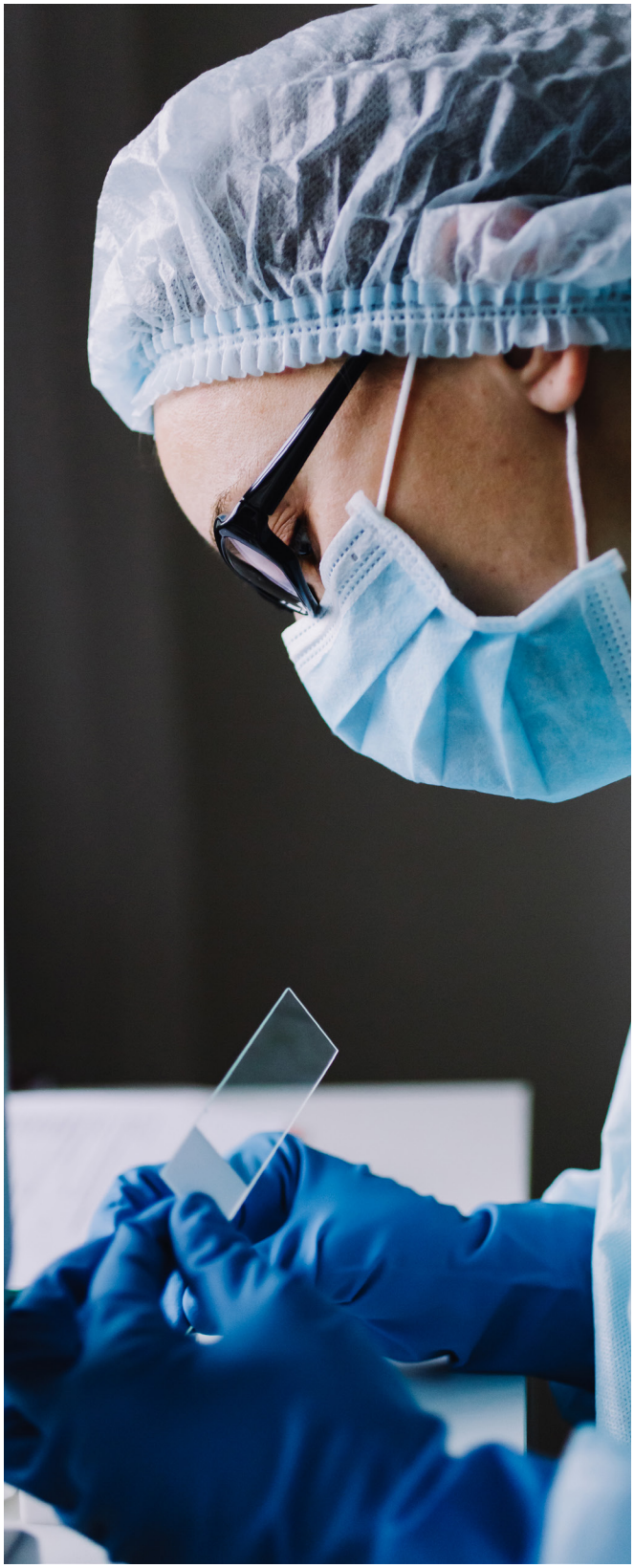
2. With your pencil, circle several well-formed drops on that half page.

3. Measure the width and length of these drops and record your measurements beside the drop measured. Be sure to measure according to the figure on page 11 (length will be the longest measurement).

4. Find the arithmetic mean (average) for both the widths and lengths of all drops measured on that half page. Record these means on the "Blood Spatter Data Collection" worksheet.

5. Repeat these steps for each of the 16 blood drop collections.

When all of the data has been measured and recorded, continue to Lab Procedure 2.



DATA COLLECTION
BLOOD SPATTER

	90°	80°	60°	40°
30 CM	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:
	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:
60 CM	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:
	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:
120 CM	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:
	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:
15 CM	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:	MEAN WIDTH:
	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:	MEAN LENGTH:

LAB PROCEDURE 2
BLOOD SPATTER

The remaining portions of the laboratory procedure require a computer with MS Excel, and the "blood_spatter.xls" sheet downloaded from www. LyleAndLouise.com. Alternatively, the sheet can be printed and data hand-written for later analysis.

GENERATING DATA PLOTS

1. Open the MS Excel sheet "blood_spatter.xls" provided by the instructor.

2. Transfer the width and height data from the "Blood Spatter Data Collection" sheet to the "Lab2 Data" worksheet within the workbook.

3. After entering all of the data, open the "Angle vs. Arcsin" chart within the workbook.

4. This chart is an X-Y scatter plot from all of the observations of Angle versus Arcsin. The plot will contain data points 'stacked' at each of the four angles, along with a linear trendline.

5. In the top right-hand corner of the chart is shown an equation and R^2 value. The closer the R^2 value is to 1, the more statistically relevant the data. If the R^2 is close to 1, then the angle of blood spatter is directly proportional to the arcsin of the width-length ratio, or put another way, the width-length ratio is directly proportional to the sin of the angle.

6. If the R^2 is far away from 1 (less than 0.7), then the data is suspect, and the procedure should be repeated.

7. Now open the "Height vs. Width" chart within the workbook.

8. This chart is an X-Y scatter plot from all of the observations of Height versus Width when the angle is 90°.

9. Look at the resulting R^2 value. If it is far away from 1 (less than 0.7), then the data is suspect, and the procedure should be repeated.

In Lab Procedure 3, the trendline equation of angle versus arcsin will be used to approximate the relationship between the width and length of a drop and its angle of impact. This is used when stringing the crime scene.

The trendline equation of height versus width will be used to determine the height from which a measured blood drop fell.

LAB PROCEDURE 3
BLOOD SPATTER

3A. DETERMINING AREA OF IMPACT

1. Open the "Lab3a Data" worksheet in the "blood_ spatter.xls" spreadsheet. Replace the formulas in column H with the equation derived in the "Angle vs. ArcSin" chart. Replace the "x" in the formula with the appropriate cell in column G. For example, in row 8, the formula in cell H8 should be "=[SLOPE]*G8 + [INTERCEPT]", where [SLOPE] and [INTERCEPT] are the values from your equation.

2. Choose up to 15 large, clear blood spots from blood spatter images A, B, and C, and measure their length and width. Note that the length will always be the longest part of the ellipse.

3. Circle and number each spot. Also note with a small arrow the direction of travel, as indicated in the figure below.

4. Enter the length and width data into the "Lab3a Data" worksheet in the gray shaded cells. NOTE: The cabin model is a 1/8 scale model. Measurements are corrected in the spreasheet automatically to accomodate this scale.

5. Assemble the cabin model of the interior corner of the cabin using blood spatter images A, B, and C. The sheets should be mounted 5 cm from the floor to aid in measuring. Note that the base of the model has the largest area.

6. Use a pushpin to secure an end of string to the center of each selected blood spot.

7. Hold a protractor to the model wall so that it is centered on the end of the string.

8. Using the protractor, pull the string out so that it runs in the direction of travel, and at the appropriate angle as generated by the "Lab3a Data" worksheet.

9. Attach the free end of the string to the base of the model with a piece of tape do not use the push pins to attach the string to the base.

10. Repeat steps 6-9 for each of the drops circled. If a drop is not able to be measured easily, or if the string is too short to mount to the base, choose a different blood drop.

11. After placing the strings, they should converge in one, two, or three areas. These areas are the locations of impact.

12. Measure to the center of each of the areas of impact, along the x, y, and z axes (as shown in the figure above). Record the measurements in the "Lab3a Data" worksheet.

3b. Determining Height of Drops

1. Open the "Lab3b Data" worksheet in the spreadsheet. Replace the formulas in column E with the equation derived in "Height vs. Width" chart. Replace the "x" in the formula with the appropriate cell in column B.

2. Examine blood spatter image D. This is a 1:1 scale image of the trail of drops from the male victim to the female victim, therefore the measurements do not need to be adjusted.

3. Measure the length and width of drops in the photo. Record these values in the gray shaded cells in the "Lab3b Data" worksheet.

4. The spreadsheet will have generated the estimated height from which the blood drops fell.

POST-LAB QUESTIONS
BLOOD SPATTER

MEASURING IMPACT PROPERTIES

1. Can the width/length ratio of a bloodstain ever exceed a value of 1? Explain.

2. What kind of relationship does the width/length ratio have to impact angle.

3. Describe the relationship between the height of the fall and the diameter of the drop.

4. During this procedure, what possible sources of human error could have occurred? What could you suggest or what kind of adaptations could correct this type of error?

ANALYZING EVIDENCE

5. What was the estimated height of the fall of the drops at the crime scene?

6. Can you say anything about the attacker?

7. How many points of convergence did you find?

8. Legally, what might a low point of convergence suggest that a high point of convergence does not?

9. What kind of weapon could have made the spatter seen at the crime scene? Explain.

POST-LAB SOLUTIONS
BLOOD SPATTER

MEASURING IMPACT PROPERTIES

1. **Can the width/length ratio of a bloodstain ever exceed a value of 1? Explain.**
   No, the length must always be greater than the width.

2. **What kind of relationship does the width/length ratio have to impact angle.**
   The sin of the impact angle is equal to the length/width ratio.

3. **Describe the relationship between the height of the fall and the diameter of the drop.**
   The diameter of a drop is logarithmically proportional to the height from which it fell.

4. **During this procedure, what possible sources of human error could have occurred? What could you suggest or what kind of adaptations could correct this type of error?**
   Answers will vary. Some examples include holding the pipette at a constant angle and dropping a constant volume of blood. Answers should also include possible solutions to these problems.

ANALYZING EVIDENCE

5. **What was the estimated height of the fall of the drops at the crime scene?**
   The drops at the crime scene were created from a height of approximately 3 ft (91 cm).

6. **Can you say anything about the attacker?**
   Answers will vary. Possible statements may involve the attacker's heigh or gait.

7. **How many points of convergence did you find?**
   There are two points of convergence. They are found at XYZ and XYZ.

8. **Legally, what might a low point of convergence suggest that a high point of convergence does not?**
   A low point of convergence might indicate that the attack continued even after the victim had fallen prone, neglecting any claims of self-defense.

9. **What kind of weapon could have made the spatter seen at the crime scene? Explain.**
   A knife made the spatter in the corner. Other types of weapons that might make multiple medium-velocity blood spatter stains are also possible.

TEACHER'S NOTES
ENTOMOLOGY

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Forensic Entomology. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 30 and 37, respectively.

SUPPLIES

- Species A Life Stages (1 set of 6 vials)
- Species B Life Stages (1 set of 6 vials)
- Evidence Collections (1 set of 2 vials)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Forceps
- Dissection microscopes or hand lenses
- Computer with MS Excel. See Notes in the next column for directions on downloading the spreadsheet.

RUNNING THE LAB

Each set of specimens contains six stages. The possible stages included are: egg, 1st instars, 2nd instars, 3rd instars feeding, 3rd instars migrating, pre-pupae, and pupae.

This exercise is divided into three sections. In the first part, students familiarize themselves with the morphology of each life stage of two species of fly. During this portion, students identify key characteristics and develop a system to separate the two species and six life stages. Make certain that students are coming up with objective identifying characters (distinguishing features or attributes). Students tend to devise relative characters, such as 'bigger than 1st instars' or 'darker than larvae'. Encourage the use of absolute characters so that identifications can be made without needing to have other life stages available, as they may be absent in a case.

In the second section of the lab, students use the system (or taxonomic key) they developed to identify samples of flies collected from the bodies of two victims. The lab procedure instructs students to add tick marks to a grid on the data collection sheet. Additionally, if working with

multiple students, this task may be divided among students. If the task is to be divided place the grid upon the board and allow students to fill in their data. In this case the grids from the Data Collection Sheet (page 35) should be utilized as templates.

In the final portion of the lab, students will analyze the data collected and determine an approximate time of death.

NOTES

- The Weather Service Data can be downloaded from www.LyleAndLouise.com. Visit the "Downloads" page, create/login to an account, and register your product to download the supplemental material for this module.
- This should be downloaded for student use ahead of class time.
- If you or your students have trouble with the Data Analysis for the Weather Service Data, there is a Powerpoint tutorial available on our website as supplemental material for this module.

BACKGROUND INFORMATION
ENTOMOLOGY

FORENSIC entomology is the application of the scientific study of insects to criminal and civil investigations. Forensic entomologists collect and prepare insects for identification, provide accurate identifications of insects, and make inferences on the age of larval stages based upon the size and stage of larvae in the sample collected from a crime scene.

Forensic entomology rarely links a particular suspect with a crime or location. Rather, it provides data used to estimate the time that elapsed between the actual death and when the body was first discovered. This period is referred to as the post mortem interval, or PMI.

Many organisms use "carrions", or carcasses, as a food source. Some fly species specialize in living on carrions. These carrion flies are the most important insects to the forensic entomologist. There are two families of carrion flies: the blowflies, in the family Calliphoridae, and the flesh flies, in the family Sarcophagidae. Adult calliphorid flies are easily identified by their iridescent blue, green, copper, or black bodies. Sarcophagid flies, on the other hand, are grayish, usually with three distinct longitudinal dark stripes on the dorsal thorax.

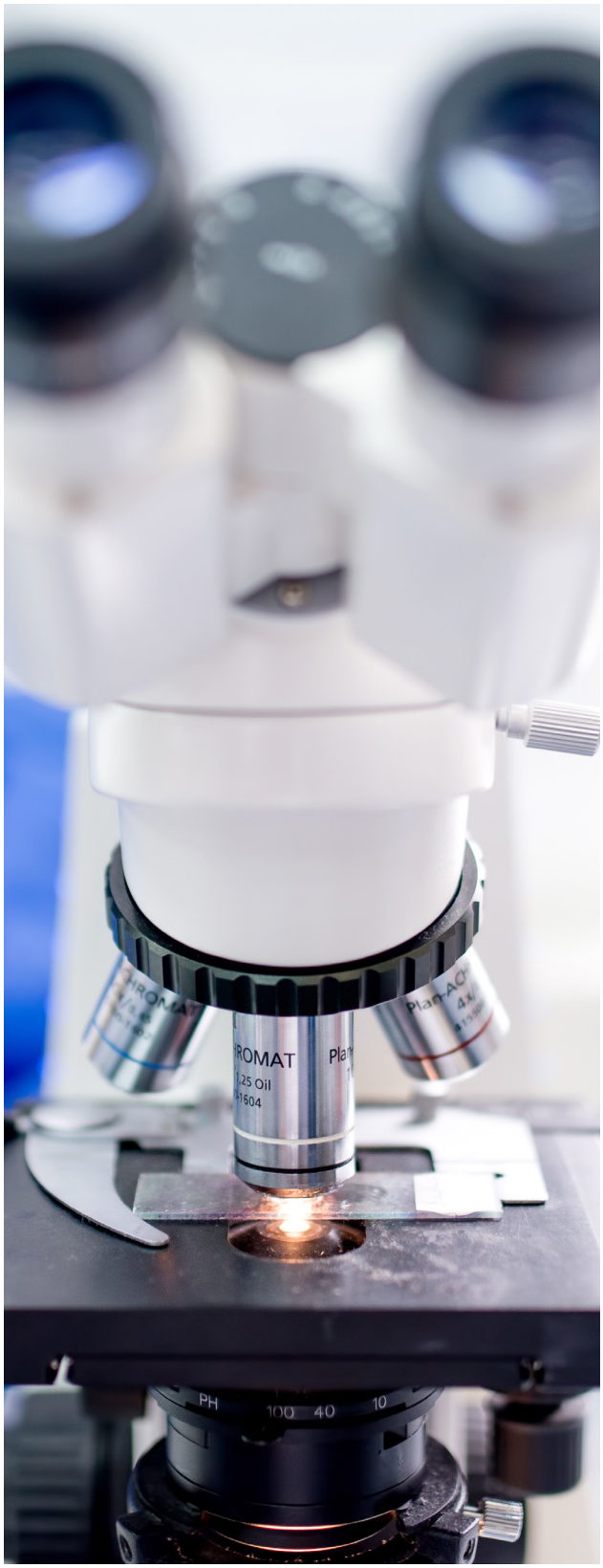
Carrion flies are attracted to dead bodies, often arriving within minutes of death. The flies lay eggs which develop into larvae in open, moist surfaces like eyes, mouths, and open wounds. Larvae become so numerous on the cadaver, they actually speed its rate of decomposition. This phenomenon is due to the fact that the large maggot mass has a high metabolic rate which can increase the temperature in the body above the ambient temperature. Entomologists measure the rate of carrion fly larvae growth and development; if a particular larval stage is present on a cadaver, and it takes three days for this stage to develop, then the cadaver must be a minimum of three days old.

Cadavers decompose in four stages: fresh, bloated, decay, and dry. The time the body spends in any individual stage will vary depending on environmental conditions; warm, wet weather speeds decay, while cold, dry weather slows it. Different insects are attracted to each of the four different stages of decomposition. The ordered series of insects attracted to the decomposing body is called a succession. The succession pattern is useful in estimating how long a cadaver has been exposed to the insects.

Forensic entomologists have developed succession databases for carrion insects found in different geographic regions. They perform experiments to determine the order in which various species of flies arrive at the cadaver and the times their larvae take to pass through the various stages through pupation. Then, when a crime scene is investigated, the forensic entomologist compares the insect species and their distribution of larval stages to the database to estimate the time of death. A key piece of data which must be experimentally determined is the time required for the different larval stages.

The adult female blowfly, for example, lays her fertilized eggs on the carcass in a single batch, but she may return to lay eggs several times during her reproductive life (two to three weeks). The eggs begin to hatch in 12 to 24 hours, producing small (approximately 2 mm) first stage larvae. Because the outer 'skin', or integument, of insect larvae cannot expand to accommodate growth, the larvae molt their outer covering to keep growing and developing. The first larval stage, or 'instars', become the larger second instars after they molt. The second instars feed and subsequently molt to become third instars. The feeding third instars are very active and grow rapidly to a length of 14 to 18 mm. They then develop into post-third stage larvae which stop feeding, migrate away from the cadaver, and burrow into the soil. They become inactive and the integument hardens into a pupa. After six to eight days the adult fly emerges from the pupa, crawls to the soil surface, the wings harden, and it flies away to begin the process anew. Flies survive over winter in the pupal stage and emerge in the following spring when temperature conditions become favorable. The process for fleshflies is similar, with the exception that eggs hatch within the body of the female, and she deposits live first instar larvae.

Insect species are attracted to lay their eggs on a corpse at different times. The regular pattern of development of the larvae or maggots on the corpse can be used to estimate the number of days since the eggs were laid for each species. Each new species replaces an earlier species in this succession since the cadaver is going through a process of decay and attracts new insects able to use it as a food resource. A sign that this is occurring is the presence of younger larvae of one species (often flesh flies) with older larvae of another species (often blow flies) that colonized the cadaver earlier. Cadavers decompose as bacteria and the body's own cellular enzymes join forces to break down tissues, a process assisted by insects and other scavengers. Taphonomy is the science which studies the natural process of plant and animal decay.



In addition to succession, these larval development rates help forensic entomologists estimate the PMI. This is challenging since insects are cold-blooded animals and their larval growth rate increases as the environmental temperature increases until they reach a lethal point. Researchers rear insects at a constant temperature and calculate the time it takes for an insect to develop from one life stage to another. By comparing growth rates at a variety of temperatures, entomologists have calculated Degree Hours required for the insect to develop from one stage to another. The number of hours to reach a stage is multiplied by the standard rearing temperature during that time period. The Degree Hours needed to complete an insect's development does not vary. If larvae take 40 hours at 25 degrees C to develop to the next live stage, this is 1000 degree hours. If the larvae are kept at 20 degrees, they will take 50 hours to reach the same stage. When investigators can get accurate weather reports for an area, they calculate Accumulated Degree Hours and estimate the hour when larvae hatched from the eggs. The temperatures for the days preceding the discovery of the body and the growth and development rate of the fly species in degree hours must be known. By adding the incubation time for the egg, the entomologist can estimate the time of initial oviposition, which is an estimate of the time of PMI. When two species colonize a cadaver at the same time, the pattern of development may differ from when each individual species was present on its own. Flies, generally, do not lay eggs at night, therefore a corpse exposed at night will not attract flies for several hours until light conditions become favorable for adult fly activity.

Adult flies are very mobile and their age cannot be easily determined, so they are not commonly collected from a corpse. Ideally, samples of larvae are collected from several different areas of the carcass, such as nasal and oral cavities, open wounds, and from the hair and/or skin. A

proper sample should contain 50 to 100 larvae. About half of the larvae should be processed immediately, on-site. This is best accomplished by dumping the larvae into a pan of boiling water for 15 to 20 seconds to kill bacteria in the intestinal tract, then quickly straightening out the larvae to allow for measurements to be taken later in the laboratory. The larvae are then transferred into a bottle of 70% ethanol for preservation. This bottle is labeled with the date, location and time of collection, and the name of the collector. Because adult flies are easier to taxonomically identify than larvae, the remaining larvae are left alive and reared in the lab. When they develop into adults, a positive identification is easily made.

In addition to the succession of insects on the decaying cadaver, there is a succession of species of insects throughout the year, especially in a temperate climate. Some fly species are active in the early spring, different species are active in the fall, and others are continuously active. In regions with cold winters, bodies are often discovered when the snow melts in the spring, and investigators are called upon to determine in which season the death occurred. If an insect larvae which is more abundant in the fall is discovered, this can indicate the body was undiscovered for many months, while if larvae are found from spring flies, this could indicate the cadaver is more recent, or that it was recently exposed to the newly emerged adult flies.

FLY LIFE CYCLE CHART
ENTOMOLOGY

1 EGGS

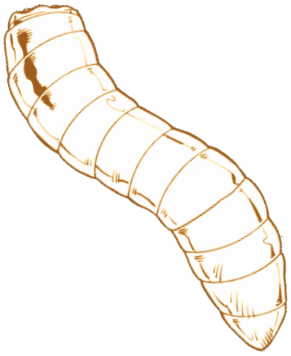
Off-white, translucent capsules, rarely more than 3 mm long.

2 1ST INSTAR LARVA

Worm-like creatures between 2 and 4 mm long. Posterior spiracles (openings for breathing) are set apart in a darker area. One spiracle slit is present.

3 2ND INSTAR LARVA

Intermediate in size between 1st and 3rd instar and approximately 4 to 8 mm. Posterior spiracle has 2 slits.



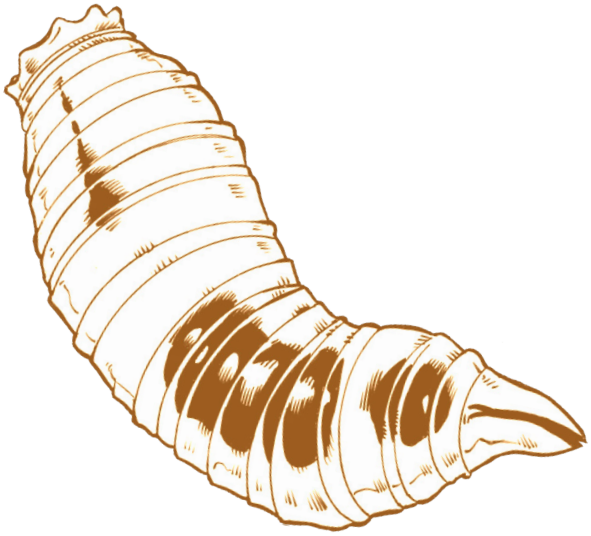
4 3RD INSTAR LARVA

Much larger than 2nd instar larvae, between 10 and 15 mm, and noticeably thicker. Undigested flesh is observable through the outer cuticle as a dark area toward the tapered anterior end.

MIGRATING 3RD INSTAR LARVA

5

Larvae have not changed in size, but flesh has been digested and is no longer observable through the cuticle. At this stage, larvae migrate to find a suitable site to pupate.



6

POSTERIOR SPIRACLES

To locate posterior spiracles, orient the larvae so that you can see the broad end through the microscope. Increase magnification and count the slits in one of the two dark areas.

PUPA

7

Hard, dark, capsule slightly smaller than 3rd instar larvae.

PRE-LAB QUESTIONS
ENTOMOLOGY

BACKGROUND

1. What is the role of a forensic entomologist in a homicide investigation?

2. Why are insects important when determining post mortem interval (PMI)?

3. What is an instar?

4. What are some factors that may delay fly oviposition?

5. Flies develop at predictable rates. What measure is used to make this prediction?

PROCEDURE

6. What should you record on your Species Separation sheet?

7. How many individuals from the sample collected from the decedent will you identify?

8. How will you determine the species and life stage of these individuals?

PRE-LAB SOLUTIONS
ENTOMOLOGY

BACKGROUND

1. **What is the role of a forensic entomologist in a homicide investigation?**
   The forensic entomologist can determine the time of death if the bodies have already cooled to the ambient temperature.

2. **Why are insects important when determining post mortem interval (PMI)?**
   If the body is exposed, the predictable growth rates of many insects can be used to determine the post mortem interval.

3. **What is an instar?**
   An instar is a larval growth stage characterized by the larvae shedding a smaller cuticle and forming a larger one.

4. **What are some factors that may delay fly oviposition?**
   If the decedent is located in an enclosed area inaccessible to flies, or if the decedent died during night-time or during a cold period, flies will not lay eggs immediately.

5. **Flies develop at predictable rates. What measure is used to make this prediction?**
   Degree-hours, degree-days, or another measure of temperature-time.

PROCEDURE

6. **What should you record on your Species Separation sheet?**
   Characters that are between two flies of different species but the same life stage.

7. **How many individuals from the sample collected from the decedent will you identify?**
   Ten

8. **How will you determine the species and life stage of these individuals?**
   You will use the characters identified and written on the Species Separation sheet, as well as those on the Fly Life stage chart.

THE EVIDENCE
ENTOMOLOGY

When the double homicide victims were discovered at the fishing cabin along Blackrock River, they were found to be in the advanced stages of decomposition.

In an attempt to determine the post-mortem interval and establish a time of death, maggots were collected from the face and wounds of both victims. These specimens were then placed into vials with 70% ethanol to preserve them for later identification.

SPECIES SEPARATION WORKSHEET
ENTOMOLOGY

Record observations on the two species of flies provided at each life stage. You will rely on these notes later when identifying samples collected from the victims. You may not have all of the stages presented below.

EGGS:

1ST INSTAR LARVAE:

2ND INSTAR LARVAE:

FEEDING 3RD INSTAR LARVAE:

MIGRATING 3RD INSTAR LARVAE:

PRE-PUPAE:

PUPAE:

ADULT:

The following charts show the time in hours individuals of each species spend in each life stage at a standard temperature, 21 °C. Notice the species development times are somewhat different. It requires 21 hours for the egg from Species A to reach first instar, while it takes 25 hours for Species B.

SPECIES A

TEMP °C	EGG	1ST INSTAR	2ND INSTAR	FEEDING 3RD INSTAR	MIGRATING 3RD INSTAR	PUPA
21	21	31	26	50	118	240

SPECIES B

TEMP °C	EGG	1ST INSTAR	2ND INSTAR	FEEDING 3RD INSTAR	MIGRATING 3RD INSTAR	PUPA
21	25	37	31	60	124	286

LAB PROCEDURE
ENTOMOLOGY

EXAMINATION OF TAXA

1. Look over your Fly Life Cycle Chart. Keep it nearby as you examine the life-cycle exemplars. Keep in mind not all the stages are shown on the chart.

2. Remove the earliest life stage vial from your exemplar collection. Place 1 or 2 specimens under your microscope.

3. Compare the sample under the microscope to the drawing in your Fly Life Cycle chart. Find the key identification features listed on the chart in the sample.

4. Place additional specimens under the microscope so that you have 3 or 4 samples. Note the amount of variation between individuals at the same life stage. Record your observations.

5. Return your samples to the vial.

6. Repeat this examination for each of the life stages for each of the species.

SEPARATION OF TAXA

1. Place 2 specimens of the same life stage from each species under the microscope.

2. Although species A and B have many characteristics in common, there are important characteristics that distinguish one from the other. Define one such characteristic.

3. Record this in your Species Separation Worksheet.

4. Return the specimens back to their respective vials, being careful not to mix up the samples.

5. Repeat this process with samples from each life stage.

6. You may not have two of the same life stage from each species. If this is the case, skip these stages.

7. Return all the vials to the exemplar collection.

ANALYSIS OF EVIDENCE

1. Randomly collect 10 specimens from the male collection evidence sample.
2. Place a specimen under your dissection scope.
3. Using your knowledge from examining different life stages and your Fly Life Cycle chart, determine the life stage of the individual.
4. Using your notes on species separation, determine whether the individual is of Species A or Species B.
5. Select a specimen of the species and life stage from the exemplar collection to which you believe your sample maggot belongs. Compare the two under the microscope to verify your analysis.
6. Record your results.
7. Repeat this process for each of the 10 individuals you removed from the collection vial.
8. Repeat steps 1-7 for the female collection evidence sample.
9. Using the charts at the beginning of this exercise, determine the minimum number of degree hours needed for the oldest life stage of each species to develop.
10. Choose the largest value for the minimum number of degree hours that the victim has been deceased.

LAB PROCEDURE/ DATA COLLECTION ENTOMOLOGY

DEGREE-HOUR DETERMINATION

1. Review the Weather Service Data provided on the Excel document downloaded from the website. The bodies were discovered at 1:00 PM on June 20 and the insects were collected at 3:00 PM.

2. Determine the number of degree hours for each day using the weather service data. To do this, multiply the average temperature by 24 hours for each day. This can be performed in a spreadsheet.

3. Determine the number of degree hours required for each life stage of both species. To do this, multiply the number of hours by the degrees Celsius given in the table.

4. By adding all the degree hours for each of the six life stages together, you calculate the cumulative degree hours required for an adult fly to develop at 21 °C. Next calculate the cumulative degree hours required to reach each of the other five stages. Do this for both species.

5. Calculate elapsed degree hours for each of the days in the climatological data provided. To do this, multiply the number of hours by the average temperature that day. For example on day 20, there are 15 hours (since the insects were collected at 3:00 PM) times 18.4 °C for a total of 276 degree hours. For Day 19, add the degree hours for that day to the degree hours from day 20. Perform this task for each of the 20 days in the month of June.

6. Examine the Species A life stages collected as evidence and identify the oldest species A life stage in the collection for the adult male. Determine how many cumulative degree hours that life stage took to develop at 21 °C. Which day in the climatological data comes closest to equaling this number? This is an estimate of the day the adult insect laid eggs on the cadaver.

7. Repeat step 6 for Species B for the adult male collection. Is the number of degree days required for this stage to develop longer or shorter than for species A? What fact about the biology of carrion flies could explain any differences you have observed?

8. Based on the data from both species, estimate the earliest and latest time that each insect began developing on the adult male cadaver.

9. Repeat these steps for the collection from the adult female. Determine the earliest and latest time that each insect began developing on the female cadaver.

DATA COLLECTION
ENTOMOLOGY

DATA ANALYSIS

For the male and female collection evidence sample, record the species and life stage in the tables below.

ADULT MALE IN CABIN

SAMPLE	SPECIES (A OR B)	LIFE STAGE
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

ADULT FEMALE IN CABIN

SAMPLE	SPECIES (A OR B)	LIFE STAGE
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

After examining the evidence samples, fill in the two tables below with the total counts of all individuals analyzed for both victims.

	SPECIES A	SPECIES B
EGGS		
1ST INSTAR		
2ND INSTAR		
3RD FEEDING		
3RD MIGRATING		
PRE-PUPAE		
PUPAE		
ADULT		

	SPECIES A	SPECIES B
EGGS		
1ST INSTAR		
2ND INSTAR		
3RD FEEDING		
3RD MIGRATING		
PRE-PUPAE		
PUPAE		
ADULT		

POST-LAB QUESTIONS
ENTOMOLOGY

SHORT ANSWER

1. What species was/were found on the male decedent? The female?

2. What was the latest life stage of which species found on the male decedent? The female?

3. For both victims, what were the minimum number of degree hours that passed between time of death and discovery?

4. What were the post-mortem intervals for the two victims?

5. What life stage did you find the most of on the male decedent? The female?

6. What reasons can you think of to explain why there were more of this life stage than any other life stage?

7. Review the climatological data. Which three categories of information do you believe will impact the development of insects the most and why?

8. What was the weather like on the day the PMI predicts the individuals died?

POST-LAB SOLUTIONS
ENTOMOLOGY

SHORT ANSWER

1. **What species was/were found on the male decedent? The female?**
   Both Species A and B were found on both victims.

2. **What was the latest life stage of which species found on the male decedent? The female?**
   Migrating third instars of Species A are the latest stages found on both victims. Second instar of Species B are found on both victims.

3. **For both victims, what were the minimum number of degree hours that passed between time of death and discovery?**
   2688 degree hours for migrating third instar life stage at 21 °C.

4. **What were the post-mortem intervals for the two victims?**
   Eight days and sixteen hours.

5. **What life stage did you find the most of on the male decedent? The female?**
   Second instars.

6. **What reasons can you think of to explain why there were more of this life stage than any other life stage?**
   Student reasoning will vary. A sample explanation is given: When the victims died, a few flies found the bodies immediately. For a few days the number of flies that found the body steadily grew as the body began to decompose and smell. After a few days the number of suitable places to lay eggs decreased, so the number of eggs layed decreased. This gives a bellshaped curve of both egg laying and life stages.

7. **Review the climatological data. Which three categories of information do you believe will impact the development of insects the most and why?**
   Weather conditions include temperature, humidity, and wind.

8. **What was the weather like on the day the PMI predicts the individuals died?**
   There was a storm nine days earlier when the car with the unidentified woman and children ran off of the road. The PMI predicts the individuals died around the time of this storm.

TEACHER'S NOTES
FOOTPRINT ANALYSIS

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Footprint Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 44 and 50, respectively.

SUPPLIES

- Dental stone (1 bag)
- Photo of shoeprint from crime scene (1)
- Evidence casting (1)
- Shoe Data Pages from SoleMate (1 set)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Yard stick or meter stick
- Water
- Computer with Internet access

RUNNING THE LAB

During Lab 1, students will enter their data into the spreadsheet downloaded from www.LyleAndLouise.com. Visit the "Downloads" page, create/login to an account, and register your product to download the supplemental material for this module.

Prior to starting the lab, the teacher should measure a distance of 20 meters so that students can measure their stride length. This distance can be marked outside or in the halls by the classroom. If 20 meters is too long or short, feel free to measure a different distance, however, if the distance is changed, the teacher needs to instruct students to change the measurement distance in their table (cell A3) to the correct number of centimeters.

SAFETY PRECAUTIONS

1. When pouring the dental stone, cut a small corner of the bag so that the dental stone can be squeezed out of the bag slowly. If the dental stone is not squeezed into the entire

shoeprint, students can use their fingers to gently spread the mixture into the entire casting. This plaster hardens very quickly, so students should wash their hands immediately following this lab.

NOTES

There are two spreadsheets available for download for Lab 1: one provides automatic calculations, but should the teacher prefer the students to calculate the data on their own, a blank spreadsheet is also available on the website www.LyleAndLouise.com as supplemental material for this module.

BACKGROUND INFORMATION
FOOTPRINT ANALYSIS

FOOTPRINTS are found at approximately 40% of crime scenes. Second only to DNA as the most common evidence type found, footprints are an excellent source of information because each print is unique to the wearer. Footwear marks are particularly useful in crimes where proof of presence is incriminating. The terms shoe prints, foot prints, or footwear marks are interchangeable and refer to two types of impressions left by a person's footwear: positve and negative. A positive, or twodimensional, impression is created by a person transferring matter, such as dust or blood, from their shoe to the surface they walk on. A negative, or three-dimensional, impression is created when the shoe removes residue from the surface it walks on, as would happen when a person walked through mud or cement.

When examining a footprint, investigators look for several identifying features. Class characteristics are unique to all shoes of that brand and style, such as outsole patterns, symbols, and design features. Class characteristics aid the investigators in determining the manufacturer of the shoe. The type or brand of the shoe is always determined so the exact size of shoe can then be appraised. In many cases, the impression may be such that experts can identify the specific brand and style of shoe that the criminal used, even to the possible exclusion of other brands or sizes.

Each shoe has individual characteristics which are unique to that shoe. Individual characteristics of a

shoe would include manufacturing irregularities, chips or holes in the tread, and any substance added to or removed from the shoe during wear. Several items that could be picked up while the individual is walking include rocks, gum, tar, tacks, or nails. During normal wear, shoe rubber can crack or warp, and pieces of rubber may be removed. Rocks or other sharp objects may create a hole or indentation. Those individual characteristics can help narrow down the search for a specific shoe.

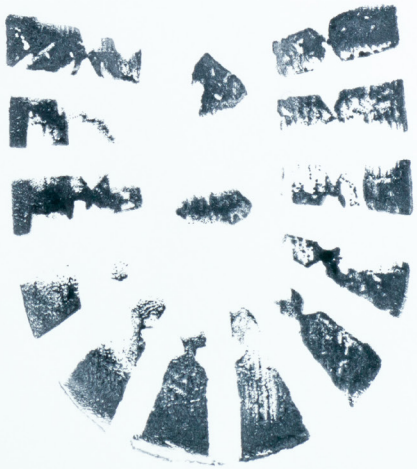
A wear pattern is formed by the gradual wearing away of rubber by the friction created between the walking surface and the sole of the shoe. The longer the shoe is worn, the more pronounced the wear pattern becomes. Wear would be more pronounced where the foot first makes contact with the ground. By looking at the wear pattern, investigators are able to asses the walking pattern of the individual. A wear pattern on the outside rear of the shoe near the heal would indicate that the walker underpronates or walks with supination (with the ankle turned out, away from the other foot). Wear on the inside of the shoe towards the toe would come from an individual who overpronates (or walks with the ankle turned in, towards the other foot). A print that is uniform across the forefront would result from a wearer that walks with neutral or normal pronation (with the foot coming into contact with the ground evenly).

When analyzing a footprint there is no minimum number of class or individual characteristics needed to establish identification: one characteristic alone could be used to identify a shoe, as long as the characteristic was clear, detailed, defined, and contained significant features in common with the impression. It would be highly remarkable to find the same mark in the same position on two different shoes making positive identification with a suspect's shoe possible, however, if the similar characteristic was merely a simple hole or pinprick that could be easily found on multiple shoes and more identifying characteristics would be sought.

Additional information may be appraised from footprints that may indicate direction and rate of movement, sex, and whether the individual knows he or she is being tracked. Smaller footprints that are slightly pigeon-toed with a small stride would indicate that the prints likely belong to a woman, as men tend to walk with their toes pointed straight forward or tilted slightly outward. Deep prints, with the front of the foot pressed deeper into the ground than the rest of the print, and a long stride would indicate a faster pace of walking or running. The depth of a footprint can also be useful in giving a rather accurate weight for the person if the weight was evenly distributed along the print. Prints that appear consistently deeper on one foot indicates that the person was carrying something on that side.

A person's gait, such as their stride length and width, can also be determined by footprints. Investigators will study the stride length, or the distance between two heel prints of the same foot. When stride length is used in correlation with shoe size, investigators can make an estimation of height. Foot length is approximately 15% of the person's height. Though this ratio does not apply to 10-20% of the population, it does help to narrow down the suspects and give a very good idea of the individual sought.

When considering the vast variety of surfaces that yield prints, it has become necessary to develop multiple techniques to lift the prints with the least amount of distortion. Before the print is lifted, photography is an essential step of any crime scene investigation as it provides visual evidence of the original footprint. A photograph will depict the footprint in relation to the crime scene, allowing investigators to view the complete scene after all of the evidence has been collected. Three-



dimensional footwear impressions are most often lifted by casting. Casting, or taking a mold of the impression, will provide a true-to-size physical model of the print. When there is worry that the print might be disturbed by the pouring of the casting material, the surface is first prepped. For prints deposited in sand, forensic scientists will spray the print with an aerosol glue or even aerosol hairspray. Water can be drawn away from the surface of a muddy print by using a lab instrument called a pipette, followed by a hot air source, such a hair dryer. Once the print has been prepped and a frame placed around the print, the casting material is poured into the impression.

Two-dimensional prints are found on surfaces such as glass, wood flooring, cardboard, or fabric and may be lifted using a hydraulic press and gelatin lifters or electrostatic devices. Gelatin lifters are sheets of paper with a strong adhesive on one side that lift the print from most surfaces. More porous surfaces, such as cardboard or fabric, would require the use of a hydraulic press to push down on the gelatin and, thus, enable a print to be lifted in clarity. Electrostatic devises are good for lifting prints from hard to access areas, such as carpeting, wood, and fabric. The electrostatic device uses a highvoltage power unit to charge a metallic film. The film is then placed over the impression where the charge causes the matter forming the impression to cling to the film. Prints can be lifted from almost any surface in this manner, including a human body. Very rarely are criminals careless enough to leave prints made of mud. These would require much effort from the crime scene technicians in lifting the prints.

In 2007, the United Kingdom Forensic Science Service launched the world's first national database of shoe imprints. This database holds detailed information about shoe prints found at all crime scenes across the country. In addition, the shoes of thousands of suspects are added to the database each year. As new shoe patterns are added to the database, they are matched against prints in the database. Foster

+ Freeman Ltd., based out of Worchestershire, England, has developed a program system called SICAR which is frequently used by police departments in Europe, the United Kingdom, and the United States. The SICAR system has a coding technique that can create a coded description from the shoe mark's patterns in as little as two minutes. The code is then used to determine the frequency of that shoe print at the crime scene and is compared against other prints in the system to find a possible match. The system also has an image compositor that will aid in identifying partial prints. Several partial prints can be scanned into the system which joins them together to present a more complete image.

The United States does not currently have a national database exclusively for footprints, however, research funded by the U.S. Department of Justice is currently being completed by computer scientists at the University at Buffalo and State University of New York. The State University of New York is working on developing algorithms for matching shoe prints. They are hoping to automate the process to make it a query search similar to that of Google search, however research is not yet completed. There are also two commercial databases, Treadmark and Solemate, that help identify the types of shoes found at a crime scene. Treadmark uses four parameters to help identify outside sole impressions to ease the time-consuming recovery. Solemate is a database holding manufacturer information and several pictorial images to help determine the type of shoe the print belongs to. This database has over 12,000 different shoes, including work, sports, and casual shoes.

PRE-LAB QUESTIONS
FOOTPRINT ANALYSIS

1. What is a two-dimensional footprint?

2. What is a three-dimensional footprint?

3. What are individual characteristics?

4. How do strides indicate whether the walker is a male or female?

5. What is the correlation between foot length and height?

6. When investigators are making a casting of a footprint, what do they do to prepare the print?

7. How long do footprints last at the scene of the crime?

PRE-LAB SOLUTIONS
FOOTPRINT ANALYSIS

1. **What is a two-dimensional footprint?**
   It is created by a person transferring matter from their shoe to the surface they walk on.

2. **What is a three-dimensional footprint?**
   It is created when the shoe removes residue from the surface it walks on, as when a person walks through mud or cement.

3. **What are individual characteristics?**
   Individual characteristics are specific to an individual shoe, such as rocks in the tread, marks from nails or tacks, manufacturing irregularities, etc.

4. **How do strides indicate whether the walker is a male or female?**
   Smaller footprints that are slightly pigeon-toed with a smaller stride indicate that the prints likely belong to a woman. Men tend to walk with their prints straightforward or even tilted outwards.

5. **What is the correlation between foot length and height?**
   Generally the foot length is approximately 15% of the person's height.

6. **When investigators are making a casting of a footprint, what do they do to prepare the print?**
   Investigators spray it with an aerosol glue or may even use hairspray. Water can be drawn away from the surface of a muddy print and heated with an air source.

7. **How long do footprints last at the scene of the crime?**
   The time frame depends on the surface and location on which the print was left. Prints left in blood may last for years, but prints left in water or sand my disappear after a short time.

THE EVIDENCE
FOOTPRINT ANALYSIS

AS investigators collect evidence from in and around the cabin, they find a shoeprint in the mud outside near the tire tracks. All other footprints have washed away in a recent storm, but this print was preserved by the overhanging trees. Since it does not match the shoes of the victims inside the cabin, detectives suspect that this print was left by another person present at the scene of the crime. The print is photographed, and then a cast is made of the shoeprint.

While photographing the blood spatter and droplets that are covering the inside of the cabin, investigators also notice a trail of smudges leading toward the kitchen door. Thinking that the smudges are from the bottom of someone's shoes as they fled the scene, detectives search until they find a partial, smudged shoeprint near the body of the woman. Again, the print does not match the shoes of either victim and could indicate a second suspect if it does not match the print found outside the cabin. The second print is photographed and all evidence is sent to the crime lab for analysis.

Investigators drew a map of the crime scene. The footprints on the diagram are smudges or impressions that investigators thought were possible footprints, but only one inside the cabin was confirmed by experts to be a distinct footprint.

LAB PROCEDURE
FOOTPRINT ANALYSIS

LAB 1: COMPARING FOOT LENGTH TO HEIGHT

In your lab group, use a ruler or a meter stick to measure your foot length and height in centimeters.

1. Enter the data into your spreadsheet. The spreadsheet will calculate the ratio of height to foot length for each group member.

2. On the second sheet, the spreadsheet will show your group scatter plot for the data. It will also display an equation with the R-value, which is the relationship between the data. A good R-value will be close to 1.0. Comparing Foot Length to Height and Stride Length

COMPARING FOOT LENGTH TO HEIGHT AND STRIDE LENGTH

3. Walk the premeasured distance while counting the number of strides taken in the given distance at the typical walking pace. If additional persons were measured have them do the same.

4. Enter the number of strides for each person into the spreadsheet in column E.

5. Have each person run the premeasured distance while counting the number of strides taken in the given distance at the individual's typical running pace.

6. Enter the number of strides for each person into the spreadsheet in column F.

ANALYZING THE DATA

7. The spreadsheet will automatically calculate the length of each person's stride while walking and running by dividing the distance by the number of strides.

8. Study each scatter plot. Determine if foot length can be used to predict height. Test your hypothesis by measuring an additional person's foot length and using your graphs to predict the height. Now measure the height of that person.

9. Examine your data for ratios of stride length to height. Determine if stride length can be used to predict height. Test your hypothesis by measuring an additional person's stride length and using your graphs to predict their height.

10. Analyze your data to compare foot length to height.

LAB 2: CASTING YOUR SHOE PRINT

1. Press your shoe evenly into a tray of damp dirt or into a flat section of damp dirt outside. Make sure the dirt is only damp—muddy dirt will not keep a good impression! Lift the foot straight up in order to preserve the shoe print.

2. Measure shoeprint (length and width) and record measurements.

3. Add 150 mL (150 g) of water to your bag of dental stone. Mix in the bag by hand kneading. for a minimum of 2 minutes. The consistency of the water and dental stone mixture should be equivalent to thin pancake batter. Refer to directions upon the dental stone bag.

4. If desired, a cardboard strip can be placed around the impression to frame the shoe print and contain the casting material. If using an inexpensive casting material (such as Plaster of Paris), a framing strip would be needed to keep the material from running, however, due to the consistency of dental stone, this frame is not necessary for this particular lab.

5. Cut a small corner of the bag and squeeze the dental stone so that it forms an even layer in the shoe impression. Where possible, do not pour the plaster directly into the impression, as this may damage the impression. Instead, pour the dental stone onto the ground adjacent to the shoe print and allow it to run into the impression. Let the mixture flow slowly into the entire impression.

6. Allow the dental stone to set for at least 30 minutes. After removing, do not clean immediately. Allow casting to set (once removed from dirt) for 12 hours before gently removing dirt with a damp paper towel. NOTE: Casting material mixed to a thinner consistency will require additional time to set before removal.

PART 2: EXAMINING YOUR CASTING

7. Once casting has dried, examine the shoeprint. Look for and record the class characteristics identified on your group casting, such as tread patterns, specific designs or logos, etc. Describe or draw on your data collection sheet. (Class characteristic: A mark that would be common on any shoe of this type.)

8. Identify wear patterns specific to your casting. Describe or draw on your data collection sheet. (Wear patterns: Any erosion of the shoe's sole.) Make a prediction as to whether your group member walks with a pronated, neutral, or supinated foot.

9. Identify individual characteristics on your casting, such as random nicks, cuts, or slices on the shoe's sole. Describe or draw on your data collection sheet. (Individual characteristic: A mark that makes a particular sole unique and, thus, identifiable.)

LAB 3: EXAMINING THE EVIDENCE

1. Look at the photograph and crime scene layout provided from the cabin murder scene. Note the length of the shoes and any other characteristics you can see from the photograph. Attempt to identify at least 5 class/individual characteristics or wear patterns.
2. Examine the provided evidence casting.
3. Make measurements in regards to tread patterns, distance between tread, etc. Record all measurements for evidence casting and photograph.
4. Identify wear patterns on the evidence casting.
5. Measure the shoe length and make a prediction about the suspect's height.
6. Investigators have retrieved a database of shoes from a forensics company called SoleMate, which has a collection of men's athletic shoes. Compare the casting and the photograph to the database of athletic shoes and try to find a match. Investigators searched the forensic database, SoleMate, to find all the tread patterns for the athletic shoes ever purchased by most of the men involved in this case.
7. Use the cabin crime scene layout, the photograph, and the casting to recreate the crime scene.

DATA COLLECTION
FOOTPRINT ANALYSIS

MY GROUP CASTING. THIS SHOE PRINT BELONGS TO.....

CLASS CHARACTERISTICS	WEAR PATTERNS	INDIVIDUAL CHARACTERISTICS

EVIDENCE PHOTOGRAPH AND CASTING: .....

PHOTOGRAPH OBSERVATIONS AND MEASUREMENTS	CASTING OBSERVATIONS AND MEASUREMENTS

POST-LAB QUESTIONS
FOOTPRINT ANALYSIS

1. What is the average foot length to height ratio for your group?

2. What is the average foot length to height ratio for the group measured?

3. Can you accurately predict height based on foot or stride length? Why or why not?

4. What were the wear patterns that you found most often on your examination of the castings?

5. What did you observe in the photographs? Provide specific details about each shoe print in the photgraphs.

6. Were the footprints from the outside and inside made from the same shoe?

7. What is your conclusion about the evidence shoe print and the suspected type and size of shoe? Are they the same shoe?

POST-LAB SOLUTIONS
FOOTPRINT ANALYSIS

1. **What is the average foot length to height ratio for your group?**
   Answers will vary.

2. **What is the average foot length to height ratio for the group measured?**
   Answers will vary

3. **Can you accurately predict height based on foot or stride length? Why or why not?**
   No, because it is not always an exact ratio. A short person could have large feet, and a tall person could have very small feet.

4. **What were the wear patterns that you found most often on your examination of the castings?**
   Answers will vary.

5. **What did you observe in the photographs? Provide specific details about each shoe print in the photographs.**
   Answers will vary.

6. **Were the footprints from the outside and inside made from the same shoe?**
   No, they were not. This shows that at least two people other than the victims were at the cabin.

7. **What is your conclusion about the evidence shoe print and the suspected type and size of shoe? Are they the same shoe?**
   Answers will vary.

TEACHER'S NOTES
BLOOD DETECTION

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Blood Detection and Evidence Processing. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 55 and 60, respectively.

SUPPLIES

- Hydrogen peroxide (1 bottle)
- Phenolphthalein solution (1 bottle)
- Cotton swabs (1 set)
- Positive control and testing cards (1 set)
- Carpet samples from the crime scene (1 set)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Rulers
- Lab gloves
- Distilled water
- Camera (optional)
- Tweezers (optional)

RUNNING THE LAB

During Lab 1, remind students that the reaction should be observed within three minutes, or they will have to repeat the experiment. Teachers should also prepare several common household items for testing (See Notes.)

During Lab 2, students should follow correct evidence processing procedures as they test the substance on the carpet.

SAFETY PRECAUTIONS

1. Phenolpthalein solution is extremely lightsensitive. When not in use, store in a dark place so that the reagent may be used again.

NOTES

Lab 1 suggests that students test materials other than the cards for false positive reactions. The teacher may bring in some of the items listed below for testing or ask students to volunteer to bring one or two of these common household items for use in class the next day.

The items below may give a false positive reaction in the presumptive blood test. The teacher may bring in any of the suggested items, as well as test any other desired substances, so that students can see both positive and negative responses.

The following items may give a false positive on the Kastle Meyer presumptive blood test:

- Horseradish sauce
- Ketchup
- Red food coloring
- Red juice (pomegranate or cherry)
- Juice from fresh potato
- Juice from fresh horseradish
- Wasabi
- Juice from fresh cucumber
- Juice from fresh apple or pear

BACKGROUND INFORMATION
BLOOD DETECTION

BLOOD is a type of biological evidence frequently found at crime scenes that can be used to connect a suspect to a victim or object. Blood stains found at a crime scene can play a large role in eliminating or identifying a person as a potential suspect.

The two major components of blood are plasma and formed elements. Fifty-five percent of the total blood volume is plasma, the fluid portion of blood, consisting of carbohydrates, lipids, hormones, inorganic salts, serum proteins (such as antibodies), and clotting elements. Forty-five percent of the total blood volume is formed elements, consisting of red blood cells (erythrocytes), white blood cells (leukocytes), and platelets. The red blood cells, through the use of a protein called hemoglobin, are responsible for transporting oxygen to the tissues of the body, and, in turn, removing carbon dioxide from tissues. The white blood cells play an important role in immune response and antibody production in the lymph nodes. Platelets are responsible for initiating and participating in blood clotting.

The two main elements of blood used in forensic labs, with the exception of those performing DNA testing, are red blood cells and serum proteins. On the surface of the red blood cells are chemical structures called antigens that are grouped into systems determined by their relationship to one another. A commonly used antigen group

system is the ABO group, which was used until the 1990s for blood typing. Serum proteins, such as antibodies, are frequently used for various tests. An antibody activates or destroys a specific antigen, which allows for particular reactions to occur when certain groups of antigens and antibodies are mixed.

It is crucial that bloodstains found at a crime scene are documented, collected, tested, preserved, and analyzed correctly, as failure to perform each task properly can weaken or destroy potential evidence. The testing procedure is designed to reveal if the stain is blood, whether it came from an animal or human, and, if it is of human origin, how closely the blood can be linked to an individual.

When an investigator is confronted by a stain that looks like blood at a crime scene, it is difficult to know for certain that the stain is blood. After careful documentation, the investigator may identify blood through two different types of tests: presumptive and confirmatory tests. Presumptive tests, conducted first because they are easier, faster, and more cost-efficient, can be performed at the crime scene by a trained police officer and are based on the peroxidase-like activity of hemoglobin contained in red blood cells. Peroxidases are enzymes that quicken the oxidation of a number of classes of organic compounds. These tests are called presumptive because if a test result is negative, blood is absent, but if a test result is positive, blood is presumed to be present. As numerous compounds may cause false positive reactions, a confirmatory test must be performed following a positive presumptive test.

In color change presumptive tests, a sterile swab is moistened with distilled water and placed in contact with a small sample presumed to be blood. A drop of both a presumptive reagent and hydrogen peroxide is then added to the swab. An immediate color change indicates the possible presence of blood. Alternatively, a presumptive test may be performed by placing a thread or fragment of the dried material on a spot plate and adding the above reagents as in the swab test. When performing the presumptive test, a substrate control test is required which will confirm that the test result is not brought about by the material that the stain was on. This is done by taking a swab of the original, unstained surface (as close as possible to the stain) and adding all similar reagents as the non-substrate control swab. Results for all presumptive tests must be recorded immediately before the sample is oxidized by air exposure, as this may result in a false-positive reading.

A phenolphthalein test, better known as the Kastle-Meyer test, is one of the most frequently used color tests. In a positive reaction, reduced phenolphthalein will turn bright pink in an alkaline solution. This occurs because the phenolphthalein is oxidized by hydrogen peroxide in the presence of hemoglobin. Phenolphthalein reagents, however, have been known to give false positives when vegetable materials are present. As a result, after the evidence is collected and transported to the lab, a confirmatory test is performed.

The results of the presumptive test can assist the investigator in collecting the bloodstains. If the test was negative, only two or three samples from the stain must be collected. Investigators collect the stain sample by, preferably, transferring the whole item, or extracting the blood using one of several methods. The most common method involves taking a sterile, moistened swab or thread and rolling/swabbing the bloodstain. The swab or thread is then completely dried and placed in a paper bag, envelope, or box. Another well-known method is tape lifting the bloodstain. Fingerprint tape can be taken and used to carefully lift the bloodstain, which is then placed on vinyl acetate backing. All collected items must be

There are many presumptive tests that can be used depending on the preference of the investigator, the forensic lab, and the situation. Some of the tests used are listed in the table below.

PRESUMPTIVE TEST	INDICATION OF POSITIVE	SITUATION USED	REAGENTS	FALSE POSITIVES
Benzidine (Adler Test)	Blue to dark blue	On visible stains	Reduced phenolphthalein (phenolpthalin), hydrogen peroxide, in alkaline medium	Vegetable material (e.g. potatoes and horseradish)
Phenolphthalein (Kastle-Meyer Test)	Bright pink color	On visible stains	Reduced phenolphthalein (phenolpthalin), hydrogen peroxide, in alkaline medium	Vegetable material (e.g. potatoes and horseradish)
Tetramethylbenzidine (TMB) / Hemastix	Green to bluegreen color	On visible stains / Field tests	TMB, hydrogen peroxide, in acetic acid medium TMB, diisopropylbenzene dihydroperoxide, buffering material	Oxidizing agents, catalyst, and vegetable peroxidase Cosmetic substance

completely dried and placed in their own separate, correctly labeled, paper bags. Plastic bags are only used for transporting moist blood evidence for no more than two hours. If moist biological evidence is left in any plastic container there is a great possibility of microorganism growth which may alter the evidence, degrade DNA, and/or inhibit future testing. Collected bloodstains should be refrigerated, unless the bloodstain was found in soil, then it should be frozen so that microorganisms present will not degrade the DNA.

Though forensic scientists currently have various tests that can be used to detect and analyze blood, advancements are continually being made. Blood is a complex system and scientists are discovering new information and techniques to handle this evidence every year.

PRE-LAB QUESTIONS
BLOOD DETECTION

1. What are the two major components of blood?

2. What test did forensic scientists use to type blood until the 1990's?

3. What information are blood detection tests designed to reveal?

4. What is one of the types of presumptive tests for blood?

5. What is the most common presumptive tests for blood?

6. Why are presumptive tests performed before confirmatory tests?

7. If a presumptive test has a positive result, can investigators guarantee that blood is present?

PRE-LAB SOLUTIONS
BLOOD DETECTION

1. **What are the two major components of blood?**
   The two major components are plasma and formed elements.

2. **What test did forensic scientists use to type blood until the 1990's?**
   ABO blood grouping

3. **What information are blood detection tests designed to reveal?**
   The testing procedure is designed to reveal if the stain is blood, whether it came from an animal or human, and, if it is of human origin, how closely the blood can be linked to an individual.

4. **What is one of the types of presumptive tests for blood?**
   Color change presumptive tests.

5. **What is the most common presumptive tests for blood?**
   The Kastle-Meyer, or phenolphthalein, test.

6. **Why are presumptive tests performed before confirmatory tests?**
   Presumptive tests are more cost-efficient, and they can be done easily and quickly at the crime scene by a police officer on site.

7. **If a presumptive test has a positive result, can investigators guarantee that blood is present?**
   No, if a test is positive, blood is probably present, however there are some elements that can cause false positives.

THE EVIDENCE
BLOOD DETECTION

An abandoned, blue Ford Ranger bearing the Tumbling Water Land Development Co. logo was found in New Mexico with its gas tank completely empty. As the New Mexico authorities examined the truck for potential evidence, they found suspicious smudges on the driver's side floor. At first glance, the smudges appeared to be mud, but upon closer examination, one investigator noted that he could see traces of a reddish substance mixed in with the mud. Therefore, thinking the stain could possibly be blood, he photographed the evidence and removed the suspected area of carpet to allow it to be examined at the lab.

LAB PROCEDURE
BLOOD DETECTION

LAB 1: PRESUMPTIVE TESTING FOR BLOOD

1. Prior to performing presumptive tests on the evidence from the pickup truck, you will practice the presumptive tests using some positive controls, as well as some substances which also can give a positive result. Wear gloves when handling these chemicals.

2. Cut each card in half in the middle of the stain. This will allow you to repeat the experiment in case there is any confusion about the results.

3. Place the card half on top of a blank card so you can see the reaction.

4. Add one drop of distilled water to the control card and rub it into the stain with a cotton swab.

5. Add one drop of phenolphthalein solution. If any color change occurs at this point then the reagent is contaminated and the test should be considered invalid.

6. Add one drop of the hydrogen peroxide solution.

7. A pink color should appear between 30 seconds and three minutes to indicate that the dried material is most likely blood.

8. If a pink color is not observed or appears after three and a half minutes have passed, the test is considered negative.

9. Record your results on your Data Collection Sheet.

10. Test all substances on the provided cards, recording predictions and reactions of each one.

11. Test other teacher-provided substances in the same manner, dabbing a small amount of the substance on a blank card, and then adding the water, phenolphthalein, and hydrogen peroxide. Observe and record the reactions. HINT: Compare your shade of pink to the positive control card if you are unsure if you are getting the right color to indicate a positive result.

LAB 2: PROCESSING THE EVIDENCE

1. Obtain your evidence from your teacher, signing and dating in the appropriate location on the Chain of Custody portion of the Evidence label.

2. Carefully cut open your evidence, opening it at an end that is NOT sealed by evidence tape.

3. Examine your evidence. Measure the stain and record several detailed observations about your evidence, including size, shape, color, and any other pertinent details.

4. If available, use a digital camera to take three or four pictures of the evidence from different angles.

5. If available, use a magnifying glass to look closely at the carpet square for other materials on the fabric.

6. Take a cotton swab and wet it with distilled water. Rub the cotton swab in the stain.

7. Rub the cotton swab on a blank card, then perform the presumptive test on the material you swabbed. Add one drop of phenolphthalein and observe the reaction. Add one drop of the hydrogen peroxide solution. A pink color should appear between 30 seconds and one minute to indicate that the dried material is most likely blood. If a pink color is not observed or appears after three minutes have passed, the test is considered negative.

8. Use your scissors to cut three or four small sections of the stain out of the carpet. Lay these pieces on blank cards, and then add the water, phenolphthalein, and hydrogen peroxide as previously described. A pink color should appear between 30 seconds and one minute to indicate that the dried material is most likely blood. If a pink color is not observed or appears after three minutes have passed, the test is considered negative.

9. If possible, take a picture of the color change observed.

10. Repeat the test on the sample from another part of the stain.

11. Determine whether the substance on your carpet scrap is blood.

12. Complete your Data Collection sheet.

13. When you have reached a conclusion, return your stain to the evidence wrapper and reseal it.

DATA COLLECTION
BLOOD DETECTION

LAB 1:

SUBSTANCE	PREDICTION: POSITIVE OR NEGATIVE?	LAB OBSERVATIONS (COLOR OF DEVELOPMENT, TIME TO SEE PINK)	LAB RESULT: POSITIVE OR NEGATIVE?
POSITIVE CONTROL			
NEGATIVE CONTROL			
SUBSTANCE #1			
SUBSTANCE #2			

LAB 2:
RECORD 4 OR 5 PHYSICAL DETAILS ABOUT EVIDENCE:

DRAW A SKETCH OF YOUR EVIDENCE. INCLUDE MEASUREMENTS

DESCRIBE YOUR PROCEDURE FOR PROCESSING THE EVIDENCE AND THE RESULTS YOU SEE.

POST-LAB QUESTIONS
BLOOD DETECTION

1. What did you observe when you tested the positive control card?

2. What did you observe when you tested the negative control card

3. What common food items provided a false positive in the presumptive blood test?

4. Why do police officers perform a presumptive test in the field? Based on your experiments, why is it important to do a confirmatory test later?

5. What did you learn about correctly processing evidence? Why is this procedure important?

6. What did your group conclude about the stain on the carpet? Did your test detect the presence of blood?

7. Based on your knowledge of the crime(s), what is your hypothesis about the events surrounding the substance on the carpet of the truck?

POST-LAB SOLUTIONS
BLOOD DETECTION

1. **What did you observe when you tested the positive control card?**
   The pink reaction occurred between one minute and three minutes.

2. **What did you observe when you tested the negative control card?**
   If a pink reaction was observed, it occurred later than three minutes.

3. **What common food items provided a false positive in the presumptive blood test?**
   Answers will depend on the food items that were tested.

4. **Why do police officers perform a presumptive test in the field? Based on your experiments, why is it important to do a confirmatory test later?**
   Police test for the presence of blood, but forensic technicians must confirm the presence of blood in case the stain was ketchup or horseradish, which can give a false positive.

5. **What did you learn about correctly processing evidence? Why is this procedure important?**
   Answers will vary.

6. **What did your group conclude about the stain on the carpet? Did your test detect the presence of blood?**
   Yes, there was blood on the carpet.

7. **Based on your knowledge of the crime(s), what is your hypothesis about the events surrounding the substance on the carpet of the truck?**
   Answers will vary.

TEACHER'S NOTE
QD

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Questioned Documents Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 67 and 76, respectively.

SUPPLIES

- Receipts (12)
- Photocopies of Receipts (1 set of 3 sheets)
- Thin Layer Chromatography plates (12)
- Solvent, 30 mL (1 set of 6 bottles)
- Microcapillary pipettes (100)
- Protractor (1)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

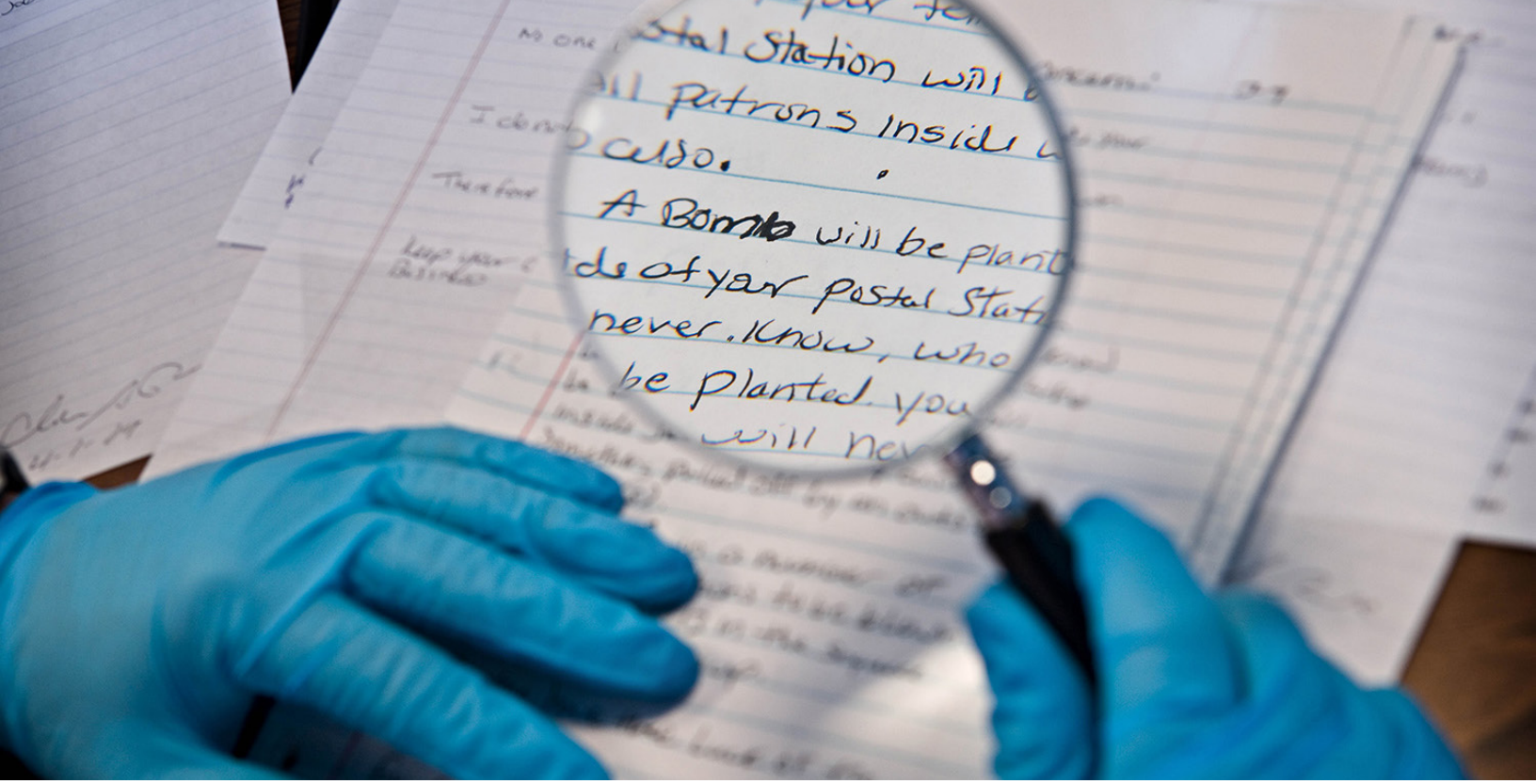
- Glass microscope slides
- Scissors
- Wax pencils (optional)

RUNNING THE LAB

During the handwriting analysis portion, distribute the three pages of photocopied receipts for analysis. During the chromatography portion, distribute the hand-written receipts for chromatographic ink analysis.

NOTES

- Choosing good relative characters during the handwriting analysis is essential for the successful completion of the lab. Make certain that the difference between relative characters and absolute characters is well understood. You may wish to brainstorm good relative characters before measuring begins.
- Glass microscope slides are recommended for use
- as a base plate when working with the solvent mixture. The solvent contains acetone, therefore plastics should be avoided. Glass petri dishes also work well.
- While dissolving the ink from the paper, make certain that samples are not contaminated with ink from neighboring numbers. You may instruct students to circle each number with a wax pencil to prevent the solvent from spreading, otherwise, simply make certain that sufficient room is left between numbers and that only one or two drops of solvent are used per number.
- When running the TLC plates, there will be approximately ten to fifteen minutes of down time. It is recommended that the lab area be cleaned and the data collection sheet filled in during this time.



BACKGROUND INFORMATION QD

THE forensic document examiner is concerned with determining questions of origin of a document or some portion of a document. In most cases this means examining handwriting found on a page to determine the author, while in others document examiners determine which of a number of office machines produced a printout or photocopy, the relative times different portions of the same document were produced, or if sections of a document were altered after the initial document was created. With handwriting, document examiners focus on "characters", which are defined as the shape of any typed or handwritten mark, letter, or numeral.

Much of document examination is concerned with the identification of handwriting. Forensic document examiners have, through their collective experience and training, developed a number of principles governing handwriting identification. Although these principles are not quantifiable, they are working hypotheses that forensic document examiners have found useful during their investigations.

No two people write exactly alike. This means that if two writing samples written by two separate people are compared, then some character in the sample will differentiate one from the other. This does not mean that an arbitrary character or set of chosen characters will separate samples, but some character will. Because of this principle, even if an examiner cannot differentiate between two samples, it does not mean that there is no

difference. The best that can be said is that there is a high degree of similarity between samples, however differences may still exist that even a trained examiner may overlook.

No person writes exactly the same way twice. It was previously believed that a person's handwriting exhibited very little variability, however, it is now recognized that a single writer produces a great deal of variability. This causes handwriting recognition analysis to become a task of determining whether a given sample falls within a writer's natural variability. If, however, a sample of writing falls within more than one person's natural variability, no determination can be made between them. For this reason, when a forensic handwriting analysis is performed, the examiner will ask for multiple handwriting samples. Armed with the added samples, the examiner can determine the mean of the writer's variation, referred to as that writer's "master pattern".

Each writer's master pattern is unique; it is created during childhood and adjusted throughout a writer's life. During childhood, when a person learns to write, they are provided with letters in a copybook that act as a template. Through practice, the child copies the letters until they become second nature, and he or she no longer needs to think about the steps needed to create individual letters. At this stage, the letterforms still greatly resemble those in the copybook and are nearly identical to his or her classmates'. These letters are easily read, but are neither aesthetic nor quickly written. As the child matures, their desire to write more quickly and to incorporate letterforms they admire into their own handwriting will significantly alter the way they write. His or her handwriting will still have a foundation from the copybook, but many individual characters will be introduced by the time the student becomes an adult and their handwriting style becomes more stable.

Different writers also have differing degrees of graphic maturity, which is defined as the amount of conscious attention the writer must give to the act of writing. New writers have less graphic maturity and must consciously think about how to form letters. When the writer has no doubt as to how the letters are formed, they can create letters as a single act. Experienced writers can write groups of letters and words as a single unit; there is no hesitation as to what letter follows next, and the writer can focus on the word level. At the final level, the writer creates phrases and sentences as a single act; the writing is often very quick, and the writer's thoughts may be several sentences ahead. An increased speed in writing follows increased graphic maturity as the muscle movements needed to create letters, words, and sentences are subconscious acts that are quickly performed.

A given act of writing is also affected by the state of the writer at the time. A writer who is tired, cold, under the influence of drugs, nervous, hurried, or influenced by any number of other factors will write differently than they will under ideal conditions. Additionally, a writer who is writing on an uneven surface or with a defective writing implement will produce writing that varies significantly from their normal writing. In these situations, the writer often produces writing that appears to come from someone with a lower degree of graphic maturity than they actually possess.

Finally, handwriting can be influenced by a writer's psychological condition, such as schizophrenia, alcoholism, or other psychological conditions. Unique characters may be incorporated into a writer's master pattern because of this condition. Through treatment of the condition, those characters may be dropped from the writer's habit, however, a specific condition or personality trait does not introduce the same character into handwriting for all writers.

CHROMATOGRAPHY

CHROMATOGRAPHY is a method of separating the components of a mixture. Just as filtration separates components based on size and centrifuging separates components based on density, chromatography separates components based on their solubility in a solvent and their adsorption to some medium, called the adsorbent.

Currently, several types of chromatography exist, including paper chromatography, thin layer chromatography (TLC), high performance liquid chromatography (HPLC), and gas chromatography (GC).

Chromatography works based on the affinities for the solvent and the adsorbent of the component of a mixture. First, some of the mixture is placed on the adsorbent. As the solvent travels along the adsorbent and contacts the mixture, it carries the mixture along with it. The amount of each component that dissolves into the solvent differs with each component, and each component has different affinities for the solvent and adsorbent. These affinities are competitive — a component with a strong affinity for the solvent and weak affinity for the adsorbent will move far along with the solvent; a component with opposite affinities will move little.

This affinity is characteristic for each component, however, the absolute distance along the adsorbent a component moves depends on the amount of time the system is allowed to run. To account for this, the ratio between the distance the component moved and the distance the solvent moved it used in comparisons:

$$R_f = \frac{d_c}{d_s}$$

This ratio is referred to as the 'retention factor'. It is useful for comparing substances analyzed together, for example, on the same TLC plate or paper slip. It is also useful for comparing substances analyzed using the same solvent and adsorbent under the same environmental conditions, however, because environmental conditions do affect this ratio, the retention factor is not useful for comparing substances analyzed at different laboratories or at different times. To do this, the analyst must run known standards side-by-side with the mixtures of interest.

Forensic document examiners look for a number of features when characterizing handwriting, such as letter form. Although we typically think of each letter as being written only a single way, there is a great deal of variation in how a given letter can be written. The illustration below shows seven capital letter G's, some written as a block letter, others as cursive. Of the block letters, one is made with a single stroke, the remainder with two, though the final stroke is a different shape in each. One of the cursive letters is made using two strokes, and one is simply an exaggerated form of the lower case form. Form alone, however, should not be used as a definitive character because a writer can easily change the character's form if trying to disguise writing. The same writer created all of the forms in the illustration.

Line quality is also used in handwriting characterization and is related to the speed at which the writing was produced. Slow writing causes shaky lines of uniform thickness and definite stop-points. Quick writing creates smooth lines with tapers at the end where the pen is lifted from the page as it continues to move. Writing speed is related to the graphic maturity of the writer if the writing is produced under normal circumstances, however, poor line quality or slow speed can indicate a writer with a higher degree of graphic maturity is writing under unfavorable conditions, trying to disguise their writing, or forging the writing of another.

Absolute features, such as letter height, the slant of letters compared to the baseline, or the spacing between words, are not useful for handwriting characterization, as these features vary normally between writing acts. The ratios between letter heights, stem slants, or letter spacing, however, are much less variable. In two documents written by the same person for example, the stems of the letter b shown in the figure below were 6.28 mm and 11.8 mm respectively. The ratios of the ball to the stem in the same letter, however, were 0.452

and 0.464. Although a writer can easily scale, tilt, or space their writing, they do not typically change the relative relationships between characters. Additionally, forensic document examiners have discovered that when asked to change these ratios, participants in the study had difficulty maintaining the difference and would revert back to their normal ratio.

Disguised writing is typically written more slowly than normal writing and can appear to be written by someone with less graphical maturity than the actual writer. If the examiner has a writing sample that is known to have come from the same person, they may suspect that the one with a seemingly lower graphical maturity was intended to be disguised in some way. Disguised writing typically has shakier lines, lines that end in full stops instead of tapers, and an absence of feather marks on the page where the pen was not completely removed between letters or words. Writers attempting to disguise their handwriting commonly change the form of letters, their slant, and their spacing, but it rarely occurs to someone to change the ratio of letter heights, how letters are connected, or the shape of cross bars and punctuation.

Although handwriting identification and verification compose a large amount of forensic document examiners' work, they are also called on for a variety of other document authentication tasks. Some of these are similar to handwriting identification but involve looking for unique features in office and duplication equipment. Through wear and use, printers and photocopiers will accumulate dust and defects that are transferred to the document created, often in the form of specks or lines. Using these marks, a document examiner can exclude a machine from having created a specific document. If police investigators can limit the number of machines that could have created the document, the document examiner can possibly make a match.

Additionally, because these features change over time, the document examiner can compare the questioned document to others made on the same machine and determine approximately when the document was created.

Forensic document examiners are also called on to determine if a large document has been tampered with by the removing or replacing of pages or the adding or erasing of text. To do this they may examine staple holes and paper types. Also, by using special light sources and filters such as IR and UV lights, the document examiner can determine if different inks were used on the same document. If the entire document was purportedly created at the same time, this could be forensically important. The analysis of inks can also be performed chemically using chromatography. Since this method is destructive, it is only done when nondestructive means do not work and there is strong suspicion of tampering.

By carefully studying details in documents, a forensic document examiner may catch a forgery or pinpoint the author of a ransom note. If they can reduce the possibilities in an investigation by excluding suspects and scenarios, they can also eliminate false leads for investigators.

PRE-LAB QUESTIONS
QD

BACKGROUND

1. Give two reasons handwriting changes from the copybook forms learned as a child.

2. Why are relative relationships in handwriting more important than absolute measures?

3. What is chromatography?

4. Give two tasks other than handwriting identification that forensic document examiners perform.

PROCEDURE

5. When choosing relative relationships, to how many of the samples must they be applicable?

6. How far up will you place the start line on your TLC plate? Why must it be in pencil?

7. How many spots will you place on each plate?

8. When should you remove the TLC plate from the development chamber?

9. How do you calculate the retention factor?

PRE-LAB SOLUTIONS
QD

BACKGROUND

1. **Give two reasons handwriting changes from the copybook forms learned as a child.**
   As people age, they write more quickly and tend to incorporate aesthetically pleasing forms, which changes their handwriting from the copybook style.

2. **Why are relative relationships in handwriting more important than absolute measures?**
   Absolute measures vary from each writing act to the next; relative relationships vary less.

3. **What is chromatography?**
   An analytical technique to separate chemical components of a mixture by their solubility.

4. **Give two tasks other than handwriting identification that forensic document examiners perform.**
   Answers will vary. Printer/copier identification, document dating, paper and ink typing, document tampering analysis, currency forgery, and indented writing recovery, as well as many others, are all tasks for a forensic document examiner.

PROCEDURE

5. **When choosing relative relationships, to how many of the samples must they be applicable?**
   Relative relationships must be applicable to all 12 handwriting samples.

6. **How far up will you place the start line on your TLC plate? Why must it be in pencil?**
   1 cm. Pencil will not travel during the experiment, whereas ink will.

7. **How many spots will you place on each plate?**
   5

8. **When should you remove the TLC plate from the development chamber?**
   When the solvent front has reached 1 cm from the top of the plate.

9. **How do you calculate the retention factor?**
   Rf = (distance spot traveled) / (distance solvent front traveled)

THE EVIDENCE
QD

Drug dealers and other criminals prefer the use of cash to other monetary methods so that their actions cannot easily be traced. The Internal Revenue Service (IrS), however, monitors cash deposits into bank accounts, as well as land and car sales.

As a result, criminals may use a legitimate business to disguise their deposits. The business pretends to receive more money in income than they actually received from customers, then the illegal funds are added to the company's bank account. Later the business will transfer this money into the criminal's account, typically minus a service fee, in a process known as 'money laundering'.

A business laundering money requires receipts for the additional income in the event of an IRS audit. Because of this, criminals often pay taxes on their illegal income to deflect suspicion.

During the investigation of John Gretzky, the Highland Park detectives found twelve receipts on his desk; all of the other receipts for Tumbling Water Land Development Company were kept in a filing cabinet in Louise Mondelo's office. Suspicious that Gretzky may be involved in some sort of fraud, police confiscated the receipts for analysis.

Investigators believe that John Gretzky may have been editing receipts to reflect sums larger than those actually brought into the company in order to cover up illegal income. They further believe he may have been fabricating other receipts and forging Louise Mondelo's name to them. Therefore, these receipts were given to the forensic questioned document examiners for analysis.

LAB PROCEDURE QD

SIGNATURE ANALYSIS

1. Look at the photocopies of the 12 receipts; they are on three separate pages. Three of the receipts are signed by John Wayne Gretzky, nine are signed by Louise Mondelo.

2. Examine the letter forms on the receipts. On your Data Collection sheet, note uncommon forms like the one shown in Example I. If the form only occurs on one or two of the signatures, note the receipt number as well.

3. Look at approach and departure strokes at the beginning and end of capital letters and words. Make notes of observations.

4. Examining only John Gretzky's signatures, note if any letterforms are inconsistent between signatures. repeat, examining only Louise Mondelo's signatures.

5. Examine the connectors between letters. Make a note of letters that do not connect to the next letter in a word, like in Example II.

6. Note letters with lines that end abruptly and do not taper.

7. Examine the relative relationships within the shape of letters. Develop four of these and write short descriptions for them on the data collection sheet. Examples III through

VI show some to consider. Only choose relationships that can be measured in all of the samples.

8. Measure these ratios on each of the receipts. Record your measurements.

9. Analyze notes and measurements. If any of Louise's signatures were forgeries, they can be separated into two groups. Assign each receipt to a group on the Data Collection Sheet.

10. Determine if one group of Louise's signatures are similar to John Gretzky's. If so, Gretzky can be identified as a suspect.

CHROMATOGRAPHY OF INK

1. Dispense 5 dropper-fulls of solvent into the development chamber. Secure the lid on the jar.

2. Shake up the solvent in the development chamber to saturate the air inside.

3. In pencil, gently draw a line on the front (white side) of the TLC plate, approximately 1 cm from the bottom. Be careful not to scratch the surface.

4. Beginning approximately 0.5 cm from the edge of the TLC plate, equally space 5 dots in pencil on the pencil line. Below the line, label each dot with the letters A through E.

5. Record the value on the receipt slip and the name of the person who signed the receipt onto the Data Collection sheet.

6. On the Data Collection sheet, assign the first digit in the value the label 'A', the second the label 'B', and so on.

7. For each digit in the value of the receipt, cut out an approximately 0.5 cm2 square from an ink-dense area. Closely trim off any excess paper around each sample.

8. Place each sample on a glass microscope slide in the same order as they appear on the receipt. Make sure the pieces are at least 1 cm apart.

9. Cut out a small ink-dense piece from the end or beginning of the signature. Try and be as nondestructive of the signature as possible.

10. Place the signature sample at the end of the glass slide.

11. Put one drop of solvent onto the first sample. Make certain that the solvent does not touch any of the other samples.

12. Press the end of a fresh microcap onto the first digit. The rubber bulb is not needed simply hold the glass microcap carefully and the inksolvent mixture should rise up the pipette.

13. Position the microcap over the first dot on the TLC plate. Gently press the tip of the microcap onto the dot and allow all of the sample to spread out onto the plate.

14. Using a fresh microcap, repeat steps eleven through thirteen with the remaining digits and the signature sample.

15. Open the lid on the development chamber, and insert the TLC plate so that the samples are toward the bottom of the chamber. Be careful not to let the sample dots come into direct contact with the solvent.

16. Place the lid back on the development chamber. Do not disturb the set-up until ready to remove the plate.

17. Allow the solvent to travel up the plate for at least 10 minutes. The longer it runs, the more separation will occur, but do not allow the solvent to reach the top of the plate.

18. Take the plate out of the development chamber. With a pencil, immediately draw a line across the plate to mark how far the solvent traveled.

19. Repeat steps 1 18 with each of the remaining receipts, using a new TLC plate and microscope slide with each.

20. Allow the solvent to evaporate from the plates completely. Follow steps 21 23 for each plate.

21. Measure the distance in cm between the bottom line and the top line. Record this distance as the Total Distance Traveled.

22. For each sample, measure and record each dc — the distances between the bottom line and each distinct spot in that sample's lane, and record the color of each spot.

23. Finally, for each spot, calculate and record the retention factor (R_f)— the ratio of the distance traveled by that spot to the total distance the solvent traveled.

ANALYZE THE DATA

24. In the row for receipts, write a code that shows where different inks were used on the receipt by writing the code in the Ink Index for each ink in the order ran on the plate. For example, if a plate had all of ink 'Z' except for the forth spot, which was 'Y', the code would be Z Z Z Y Z.

DATA COLLECTION
QD

Unusual letterforms:

Approach and departure strokes on capitals and words:

Inconsistent letterforms:

Disconnected letters:

Abrupt stops:

RELATIVE RELATIONSHIPS

WRITE DESCRIPTIONS OF THE RELATIONSHIPS:

A. .....

B. .....

C. .....

D. .....

RECEIPT #	A	B	C	D	GROUP

RECEIPT 1

NUMBER: _____ VALUE: _____ SIGNATORY: _____

DIGIT		COMPONENT 1			COMPONENT 2			COMPONENT 3		
		COLOR	D_C	R_F	COLOR	D_C	R_F	COLOR	D_C	R_F
A										
B										
C										
D										
E	(SIG)									

TOTAL DISTANCE TRAVELED: _____

RECEIPT 2

NUMBER: _____ VALUE: _____ SIGNATORY: _____

DIGIT		COMPONENT 1			COMPONENT 2			COMPONENT 3		
		COLOR	D_C	R_F	COLOR	D_C	R_F	COLOR	D_C	R_F
A										
B										
C										
D										
E	(SIG)									

TOTAL DISTANCE TRAVELED: _____

POST-LAB QUESTIONS
QD

1. Were any of Louise Mondelo's signatures on the receipts similar to John Gretzky's? Which?

2. Did John Gretzky forge Louise's name? Explain your reasoning.

3. What additional information/evidence would be useful in your investigation?

4. What digits were in a different ink?

5. Give a hypothesis for which ink was added later.

6. Examining the ink patterns for the values of all signatures, what patterns exist?

7. Compare the ink pattern on the receipts you believe are forged to those you believe are authentic. What conclusions or avenues for further investigation can you purpose from this evidence?

POST-LAB SOLUTIONS
QD

1. Were any of Louise Mondelo's signatures on the receipts similar to John Gretzky's? Which?
Signatures on receipts 501092 and 501093 are similar to JW Gretzky's.

2. Did John Gretzky forge Louise's name? Explain your reasoning.
Most likely, yes. Reasoning will vary.

3. What additional information/evidence would be useful in your investigation?
Additional exemplars of John Gretzky and Lyle Mondelo's handwriting.

4. What digits were in a different ink?

Receipt	500519: First Digit (1)
	500745: First Digit (1)
	500757: Second Digit (1)
	500907: First Digit (2)
	500963: Last Digit (0)
	501002: First Digit (1)

5. Give a hypothesis for which ink was added later.
The ink that is different makes the most sense, though students should realize that they cannot prove this.

6. Examining the ink patterns for the values of all signatures, what patterns exist?
Answers will vary. Mostly 1's were added to the beginning of the receipt values, though one 2 was added at the beginning and one trailing 0 was added. In general, space on the value block was exploited.

7. Compare the ink pattern on the receipts you believe are forged to those you believe are authentic. What conclusions or avenues for further investigation can you purpose from this evidence?
Answers will vary. Likely conclusions are that John Gretzky created forgeries. This is supported by the use of the same ink by Gretzky on the forged receipts as for the ones he filled out legitimately and those he most likely added an additional digit to. It is also supported by the dates being out of order with the receipt numbers.

TEACHER'S NOTES
FINGERPRINT

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Fingerprint Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 85 and 92, respectively.

SUPPLIES

- Hinge lifters (30)
- Fingerprinting brushes (1)
- Dusting powder (1)
- Professsional fingerprinting ink pads (1)
- Evidence fingerprint from the crime scene (1)
- Fingerprint cards from the suspects (1 set)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Lab gloves
- Overhead transparencies or clear glass surface, such as an available window or glass from a picture frame
- Weigh boat, petri dish, or paper bowl for powder
- Magnifying glass (optional)

RUNNING THE LAB

During all print examination lab activities students can refer to the notes, or the teacher can make a list of unique characteristics and patterns on the board for student reference.

During the dusting for prints portion of the lab, students should wear gloves after leaving their print. To use the powder, pour a very small amount into a weigh boat, petri dish, or paper bowl, and have students dip their brush into the powder and shake off excess. Too much powder will obscure the prints.

SAFETY PRECAUTIONS

1. Fingerprinting ink can be easily removed from hands with hand sanitizer and a paper towel. Soap and water will also work, but hand sanitizer is the quickest method.

NOTES

Students will need a surface from which to lift prints. The best prints will come from a glass surface or an overhead transparency. It is recommended that teachers give each group a blank transparency so they can press their print to the sheet, then carefully lift one print. If preferred, teachers can also use a square of glass, such as the glass from a picture frame. If none of these options are available, teachers may use windows in the classroom. The dusting powder will easily wipe off of all suggested surfaces. Also, when instructing students on the proper print dusting method, they should be reminded to brush very lightly then gently blow excess dust off of the print so that they can see the quality of their print.

BACKGROUND INFORMATION
FINGERPRINT

FINGERPRINTS are impressions of the friction ridges on the finger that are transferred onto a surface by some substance or by oil and perspiration that naturally exists on the body. Friction ridges exist on finger pads, and the patterns are determined by the dermal papillae (located between the epidermis and dermis layer of the skin).

Fingerprints are unique to an individual, and, therefore, can be used as a personal identification. Fingerprints are unique, not because of their shape or pattern, but by the relative locations of the minutiae (characteristics of the ridges). Some examples of minutiae include: ridge endings, bifurcations, lakes, short ridges, islands, and crossovers. Fingerprints will remain unchanged during an individual's lifetime, although scarring may obscure the minutiae. General ridge patterns allow for prints to be systematically classified. The three basic identifying patterns used for fingerprint analysis are loops, arches, and whorls.

Loops appear in sixty to sixty-five percent of the population and are comprised of ridgelines that enter on one side, turn around in a curve, and exit out the same side. The pattern area of the loop is surrounded by two diverging ridges. A loop consists of a core (center of the pattern) and only one delta. This mark looks like the Greek letter

delta (▲) and is a triangulation, or a dividing, of the ridges. By definition, the existence of a core and exactly one delta makes a pattern a loop. There are two types of loops: loops that open towards the little finger are called ulnar and others that open toward the thumb are called radial.

Arches appear in about five percent of the population and consist of ridgelines that enter from one end and flow out the other side, usually forming a wavelike pattern. Arches have neither a core nor a delta. Any pattern without a delta should be considered to be an arch pattern. Arches are the most simple fingerprint, but they are very uncommon, especially on the little fingers. The arch type is either plain or tented. Plain arches have only a gentle rise, while tented arches have a sharp rise in the center.

Whorls are displayed in thirty to thirty five percent of all prints and consist of ridgelines that are generally rounded in shape and make at least one complete circuit. Any fingerprint pattern that contains at least two deltas will be a whorl pattern. Whorls are very common, especially on the thumb, index, and ring fingers. There are four types of whorls: central pocket loop whirls, plain whorls, double loop whorls, and accidental whorls. Plain whorls consist of one or more ridges that make a complete circuit with two deltas; if an imaginary straight line is drawn from one delta to the other, at least one circular ridge within the inner pattern of the circuit will intersect the line. Central pocket loops consist of one or more ridges that make a complete circuit with two deltas; if an imaginary straight line is drawn from one delta to the other, at least one circular ridge within the inner pattern of the circuit will intersect the line. Central pocket loop whorls consist of one or more ridges that make a complete circuit with two deltas; if an imaginary straight line is drawn from one delta to the other, none of the circular ridges with in the inner pattern will intersect the line. Double loop whorls are made up of two separate loops on

LOOP

ARCH

WHORL

one fingerprint, with their own set of two deltas. Accidental whorls contain two or more different patterns, but are not arches and are not covered by other categories.

There are four different types of fingerprints: known prints, patent prints, plastic prints, and latent prints. Known prints are deliberately collected from the subject by an ink impression or scanning. There are two types of ink impressions, rolled and flat (also known as plain). Most often the rolled type of impression is used to ensure that all details of the ridges are obtained. A rolled impression of the fingers is taken by coating the finger pad with ink and rolling the finger from one side of the nail cuticle to the other. The thumbs are rolled towards the center of the body (e.g. right thumb is rolled from right to left) and the fingers are rolled away from the center of the body (e.g. the fingers on the right hand are rolled from left to right).

Patent (or visible) prints are made by fingers coated with a substance (e.g. blood, ink, dirt). Plastic prints are three-dimensional impressions made in pliable surfaces (e.g. wet paint, wax, soap). Patent and plastic prints can be easily located at a crime scene, as they are easily visible with an un-aided eye. On the other hand, latent prints are invisible to the naked eye and require enhancement that will make the print visible. Latent prints are impressions made by the transfer of natural oil or perspiration present on the finger.

Development of latent prints can be achieved through chemical, powder, lighting, and photographic methods. The method of treatment depends on the surface where the print is located. Prints on non-absorbent surfaces (e.g. mirror, tile, and painted wood) can be developed by treatment with powders or cyanoacrylate (Super Glue). The powder type used varies based upon the background of the print. Some examples are black powder, magnetic-sensitive powder, and fluorescent powder. Super Glue fuming has become a popular test for non-absorbent surfaces. In this test the cyanoacrylate ester in the super glue interacts with a latent print to give it a white appearance.

For porous surfaces (e.g. cloth, paper, and cardboard) chemical treatments are utilized, such as iodine fuming, ninhydrin, or physical developer (silver nitrate-based reagent). Iodine fuming is the oldest method used for visualizing latent prints. Iodine crystals are heated in a chamber with the latent print and the iodine fumes that form combine with the oils in the latent print to make it visible. Iodine prints, however, are not permanent and are, thus, quickly documented and photographed. Many new chemical treatment processes are now available. For example, latent prints may also be developed through fluorescent techniques. The most widely used fluorescence technique in labs and crime scenes is the alternate light source. An alternate light source is any high intensity light source, other than a laser, that filters the origin light and induces luminescence at the wavelength known to excite the latent print.

After the prints are detected and developed they must be preserved for future inspection and evidence. A photograph is taken before any attempts at preservation are made. If the object that the prints are located on is small, then the object is preserved in its entirety. Conversely, if the object is too large, the prints can be preserved by a lifting technique after the prints have been developed with a powder. The most commonly used type of lifter is a wide adhesive tape, similar to Scotch tape. After the powder has been transferred onto the tape it is placed onto a labeled card that provides a greater contrast with the powder and allows for detailed examination of the print.

Usually, when fingerprints are lifted from a crime scene they are not in a perfect condition making

THE HENRY CLASSIFICATION SYSTEM

It is necessary for fingerprint analysis to have a method of classification. There are several different classification systems used in the world. The most popular tenprint classification systems include the Roscher system (implemented in Germany and Japan), the Juan Vucetich system (used in Argentina), and the Henry Classification System (used in most English-spoken countries).

The Henry Classification System uses the loops, whorls, and arches approach. The primary classification of the Henry system categorizes ten-print fingerprints into one of the primary groups, with 1,024 possible groups.

As seen in the table below, each finger is numbered from one to ten beginning from the right thumb, numbered one, and ending with the left pinky, numbered ten. Depending on the presence or absence of the whorl pattern, each finger is assigned a value.

If a whorl pattern is present on fingers number one and two they are assigned a value of 16, three and four a value of 8, five and six a value of 4, seven and eight a value of 2, and the last two, nine and ten, a value of 1.

If loops and arches are present they are given the value of 0. Then the odd numbered fingers and even numbered fingers values are summed separately. To the total value of each, odd and even, the value 1 is added. The sum of odd finger value + 1 is divided by the sum of even finger value + 1, which gives the fraction that represents the primary group ratio. On the table, a sample individual has whorl patterns on the right index finger, right ring finger, left index finger, and left pinky. As displayed below, that individual would have a 3:26 (or 3/26) grouping ratio.

	R THUMB	R INDEX	R MIDDLE	R RING	R PINKY	L THUMB	L INDEX	L MIDDLE	L RING	L PINKY
ASSIGNED NUMBER	1	2	3	4	5	6	7	8	9	10
VALUE (IF WHORL IS PRESENT)	16	16	8	8	4	4	2	2	1	1
EXAMPLE	0	16	0	8	0	0	2	0	0	1
HENRY CLASSIFICATION FORMULA	$\frac{\text{Sum of Odd finger value + 1}}{\text{Sum of Even finger value + 1}} = \text{Grouping Ratio}$									
GROUPING RATIO FOR EXAMPLE	$\frac{0+0+0+2+0+1}{16+8+0+0+1+1} = \frac{3}{26}$									

analysis of the print difficult. Photographed or scanned fingerprints from a scene can be inputted into computer software to create a digital image. Through the use of digital imaging, a developed print that is obscured can be further enhanced by removing the background and, thus, clarifying the details within the print. Digital imaging is utilized extensively in forensic laboratories and is especially valuable in examining latent prints.

Currently, many countries use the Automated Fingerprint Identification System (AFIS) to classify fingerprints. AFIS is a computer system that automatically searches electronically stored fingerprints and generates a hit list once a fingerprint is scanned. AFIS has become a successful tool in the capture of many unknown criminals. Through AFIS, finding a matching fingerprint for a single print found at a scene takes only hours instead of months or years.

GLOSSARY
FINGERPRINT

MINUTIAE: Characteristics of the ridges, which include ridge endings, bifurcations, lakes, short ridges, and crossovers.

LOOPS: Ridgelines that enter on one side, turn around in a curve, and exit out the same side.

ARCHES: Ridgelines that enter from one end and flow out the other side, usually forming a wavelike pattern.

WHORLS: Ridgelines that are generally rounded in shape, where the ridges make at least one complete circuit.

KNOWN PRINTS: Fingerprints that are deliberately collected from the subject by an ink impression or scanning.

PATENT PRINTS: Fingerprints that are made by fingers coated with a substance, such as blood, ink, dirt, etc.

PLASTIC PRINTS: Fingerprints that are three-dimensional impressions made in pliable surfaces, such as wet paint, wax, soap, etc.

LATENT PRINTS: Fingerprints that are made by the transfer of natural oils or perspiration present on the finger. These prints are more commonly found at crime scenes than any other prints.

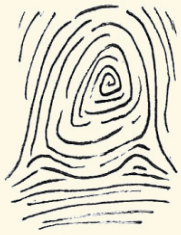
AFIS (AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM): A computer system that automatically searches electronically stored fingerprints and generates a hit list once a fingerprint is scanned.

QUALITY PRINTS DIAGRAM

NOT ROLLED FULLY | TOO LIGHT | INK UNEVENLY DISTRIBUTED | TOO DARK | ACCEPTABLE

CLASSIFYING FINGERPRINTS
FINGERPRINT

THE THREE MAJOR FINGERPRINT PATTERNS ARE LOOP, WHORL, AND ARCH.

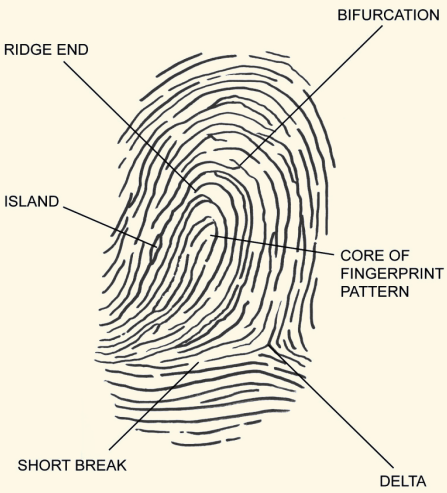
		
LOOP	WHORL	ARCH

OTHER FINGERPRINT PATTERNS INCLUDE:

		
DOUBLE LOOP	TETRARCH	CENTRAL POCKET LOOP

IDENTIFY THE PATTERN ON THE FINGERPRINTS BELOW.

		
PATTERN:	**PATTERN:**	**PATTERN:**
		
PATTERN:	**PATTERN:**	**PATTERN:**



BIFURCATION: The forking, or dividing, of one line into two or more branches.

CORE: The approximate center of the finger impression.

DELTA: That point on a ridge at or nearest to the point of divergence* of two lines. Resembles a Greek delta (▲)

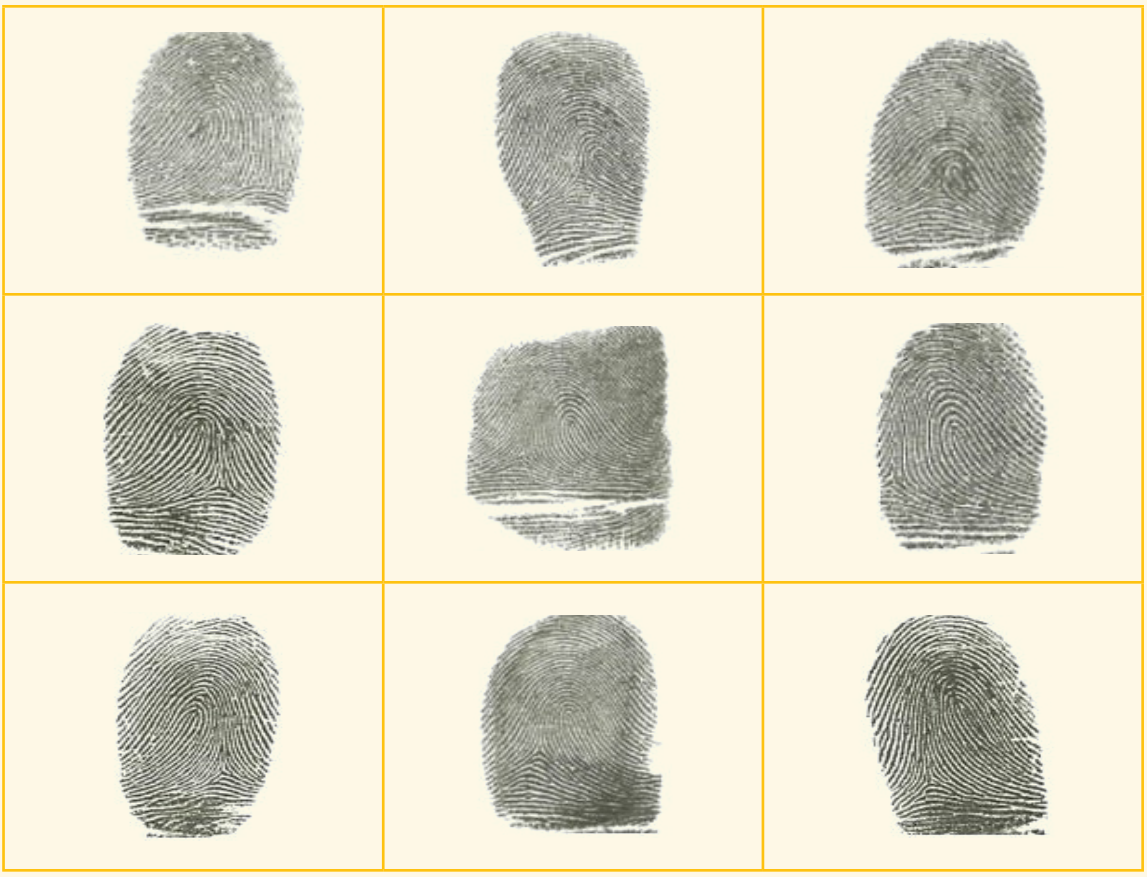
***DIVERGENCE:** The spreading apart of two lines which have been running parallel, or nearly parallel

SHORT BREAK: Where a ridge stops and starts

ISLAND: Ridges that split and come back together

RIDGE END: Where a ridge stops and does not restart

LABEL THE PARTS ON THE FINGERPRINTS BELOW.



PRE-LAB QUESTIONS
FINGERPRINT

1. What are the three basic categories used for fingerprint analysis?

2. Describe the pattern of one of the three basic categories?

3. What is minutiae? What are some examples of minutiae?

4. What is a known print?

5. How do forensic technicians analyze an incomplete print lifted from a crime scene?

6. Name one popular classification system.

7. What is AFIS?

PRE-LAB SOLUTIONS
FINGERPRINT

1. **What are the three basic categories used for fingerprint analysis?**
   Loop, arch, whorl

2. **Describe the pattern of one of the three basic categories?**
   Answers will include definitions for loop, arch, or whorl.

3. **What is minutiae? What are some examples of minutiae?**
   Characteristics of the ridges. Examples: ridge ending, bifurcation, delta, lake, short ridge, crossover.

4. **What is a known print?**
   A print that is collected from the subject, usually by an ink impression or scanning.

5. **How do forensic technicians analyze an incomplete print lifted from a crime scene?**
   Computer software creates a digital image. The print can be enhanced by removing the background and clarifying the details within the print.

6. **Name one popular classification system.**
   Roscher system, Juan Vucetich system, and the Henry classification system.

7. **What is AFIS?**
   The Automated Fingerprint Identification System. It automatically searches electronically stored fingerprints and generates a hit list once a fingerprint is scanned.

THE EVIDENCE
FINGERPRINT

During the investigation of John Gretzky, the Highland Park detectives visited the office of the Tumbling Water Land Development Company. When they walked through the office, they noticed that the safe is open and empty. Upon looking closer, the detectives found fingerprints on the door of the safe. As the only two people with authorized access to the office safe were Lyle and Louise, all suspicious prints were lifted for further examination.

When questioned, John told the investigators that the safe was always locked when the office was empty and that he did not know the code to open the safe. Fingerprint analysts have determined that all of the prints were left by the same person.

LAB PROCEDURE
FINGERPRINT

LAB 1, PART 1: ROLLING PRINTS

1. Wash hands thoroughly with soap and water and dry completely before beginning. Excessive oil from fingers or water on fingertips will affect the quality of the print.

2. Work in pairs. One person will have their prints taken, while another will be rolling their prints.

3. Instruct the individual who is having their prints rolled to look away from the fingerprinting pad and paper, not to try to help in the fingerprinting process, and to relax.

4. Hold the individuals right hand at the base of the thumb with your right hand. Cup your hand over the individual's fingers, tucking under those fingers not being printed.

5. When rolling the thumb in ink, remember that ink should cover the thumb from the edge of the nail to the other and from the crease of the first joint to the tip of the finger. Applying light and even pressure to the thumb, start at the edge of the nail and roll the thumb counter-clockwise (right to left) to the other nail.

6. Repeat this motion on the fingerprinting card. In the R. Thumb box, set down the individual's thumb at the edge of the nail and roll counter-clockwise across the paper to the other edge. Be careful to lift each finger straight up after rolling to avoid smudging.

7. Repeat these steps for all fingers on the right hand, but change the direction you are rolling. For fingers on the right hand, make sure you are rolling clockwise (left to right) from edge of nail to the other.

8. For the left hand, start again with the thumb and follow the same steps, with the only change being the direction of rolling. When rolling the thumb from the left hand, roll in a clockwise direction. When rolling the rest of the fingers, roll in a counter-clockwise direction.

9. To record prints at the bottom of the card, apply a small amount of ink to the surface of each finger on the right hand. Holding the person's wrist, simultaneously press their fingers flat on the card without rolling the hand. Additionally, ink a flat print of the thumb.

TIPS:

- Refer to the "Quality Prints Diagram" on the Glossary page for images of poor quality prints.
- Do not apply excessive pressure when rolling a fingerprint! Generally, the weight of the finger is the maximum pressure needed to clearly record a fingerprint.
- When you are having your prints rolled, do not try to help roll your finger or press it down. Look away and allow the other person to do all the work. When a subject tries to "help" with rolling their fingerprints the print is typically smudged or unevenly rolled.
- The direction of rolling is usually considered "awkward to comfortable". The beginning position of rolling a fingerprint usually feels a little uncomfortable. If it feels comfortable at the beginning the print is likely being rolled in the wrong direction!
- The easiest way to clean ink from your fingers is by using hand sanitizer and a paper towel. Soap and water may also be used, but the ink is unlikely to come off as easily.

LAB 1, PART 2: EXAMINING PRINTS

1. Once you have completed rolling your fingerprints, carefully examine your fingerprint cards and set them before you.
2. Look for the overall pattern (loop, whorl, or arch).
3. Examine the ridges of the fingerprint itself and look for places where the ridges merge together, split apart, where there is a hook off the main ridge, etc.
4. Fingerprint examiners often look for 12-15 unique features per finger. Choose one of your fingerprints and find and record 10-12 unique features.
5. The Henry Classification System allows for a logical categorization of ten-print fingerprint records based on pattern types. The Henry System assigns a numerical value to each finger with a whorl pattern. Look at the chart on your Data Collection Sheet to see the values assigned to each finger if it contains a whorl. Determine your Henry Classification number using the appropriate numerical value if a whorl is present. If a whorl is not present assign a zero to that finger. Add up the numbers on the top and the bottom (along with an additional 1 in both the top and the bottom) to get your Henry Classification number.

LAB 2: DUSTING FOR PRINTS

1. Clean your hands thoroughly with hand sanitizer or soap and water. Make sure to dry your fingers completely.

2. Once fingers are clean and dry, touch your index and middle fingers from each hand to the side of your nose or on your forehead at the hairline.

3. Without touching anything else, press your fingers (the ones you touched to your face) onto a window, a dry erase board, or an overhead transparency sheet.

4. Take your brush and dip it into a small amount of dusting powder in your weighing boat. Lightly tap the brush over a piece of paper so that any excess powder falls off of the brush. NOTE: Excessive powder can contaminate the prints.

5. As lightly as possible, brush a small amount of powder across your fingerprints with short and quick strokes. NOTE: Excessive pressure will wipe away part of the print.

6. Carefully examine the four prints you dusted and select the best print to lift.

7. Peel apart the hinge lifter and press one side to the dusted print. Do not rub the hinge lifter on the print; press gently on the print in one solid motion to adhere to the dusting powder on your print.

8. Pull the tape away from the print in one quick and fluid motion, then carefully press the two ends of the hinge lifter together to preserve your print. Again, be carefully not to rub the print.

9. Write your name at the bottom of the hinge lifter.

10. Trade hinge lifters with another student, if available. Take out your fingerprinting card from the previous lab and fold over the top so that the name is not visible. Trade those with the same student that has your lifted prints.

11. Without looking at the name, attempt to identify which lifted print matches which card. Look for unique features to help discern between the different prints.

12. Once you have matched the print to the card, examine the prints on the card and the hinge lifters.

13. On your data collection sheet, record at least 12 unique characteristics about your classmate's fingerprints. If time permits, trade the prints and cards with another student and try to match the lifted prints to cards again.

LAB 3: EXAMINING THE EVIDENCE

A print has been lifted from the safe at the office of the Tumbling Water Land Development Company, and investigators wish to identify to whom the print belongs. Detectives have pulled the fingerprint records of Lyle and Louise Mondelo, as well as the fingerprint records of John Wayne Gretzky.

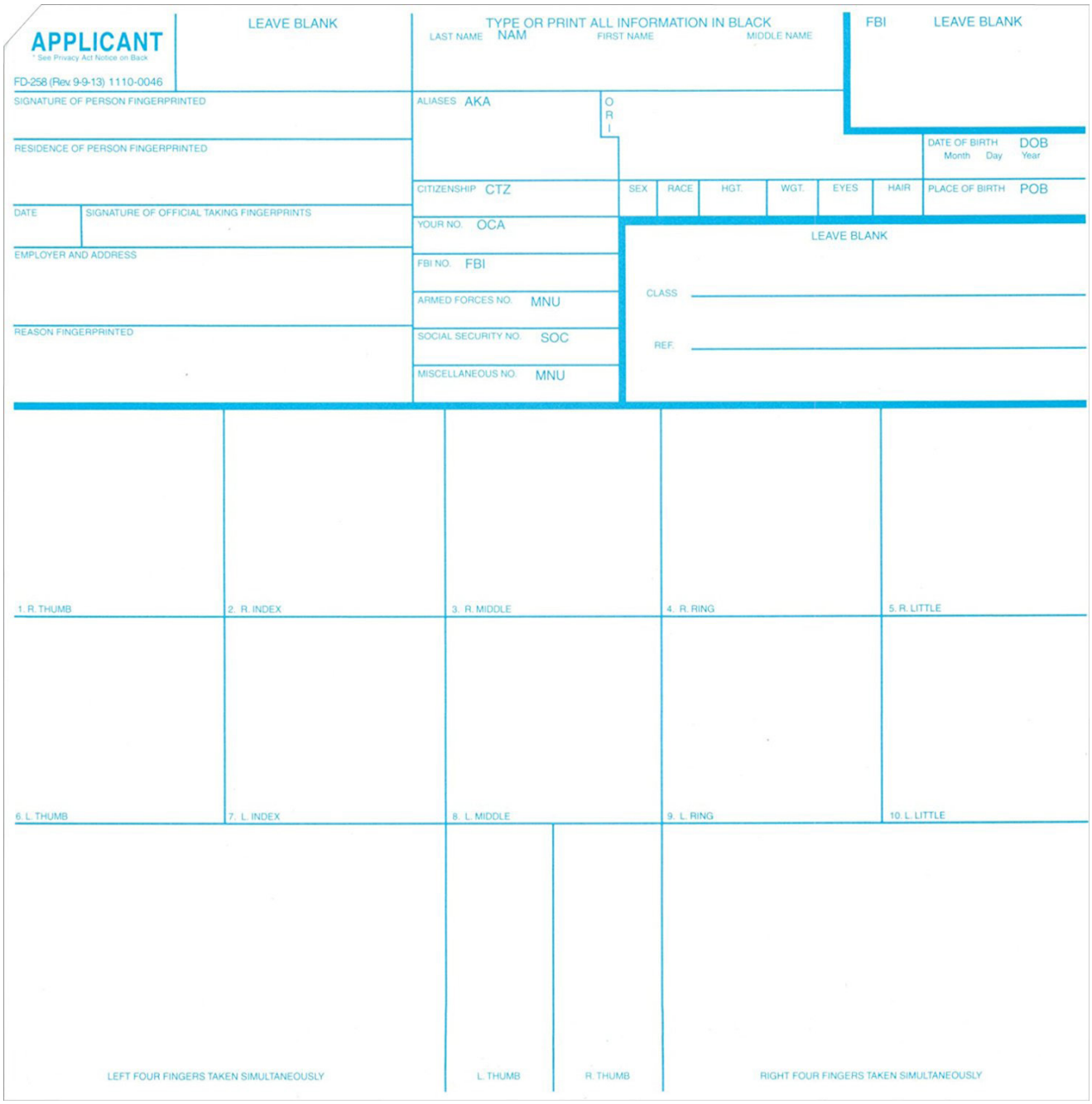
1. Look at the evidence print. Determine the overall pattern.

2. Examine the ridges of the fingerprint itself and record at least 12 unique characteristics about the suspect fingerprint.

3. Next, look at the fingerprint cards of Lyle and Louise Mondelo and John Wayne Gretzky.

4. Use the knowledge you have gained about fingerprint patterns and a variety of unique characteristics to see if the evidence fingerprint matches any of the fingerprint cards.

BLANK TEN PRINT CARD
FINGERPRINT



DATA COLLECTION
FINGERPRINT

IDENTIFY THE PATTERN ON THE FINGERPRINTS BELOW.

RIGHT	
	CLASS
LITTLE FINGER	
RING FINGER	
MIDDLE FINGER	
INDEX FINGER	
THUMB	

LEFT	
	CLASS
LITTLE FINGER	
RING FINGER	
MIDDLE FINGER	
INDEX FINGER	
THUMB	

FILL IN THE CHART BELOW WITH YOUR OWN VALUES AND ADD THEM TOGETHER TO DETERMINE YOUR HENRY SYSTEM SCORE.

				+1	=	
				+1		

MY CLASSMATE'S: FINGERPRINTS:

RIGHT	
	CLASS
LITTLE FINGER	
RING FINGER	
MIDDLE FINGER	
INDEX FINGER	
THUMB	

LEFT	
	CLASS
LITTLE FINGER	
RING FINGER	
MIDDLE FINGER	
INDEX FINGER	
THUMB	

EVIDENCE FINGERPRINT:

OVERALL PATTERN OR CLASS:
UNIQUE FEATURES:

POST-LAB QUESTIONS
FINGERPRINT

1. What is the proper technique for rolling a fingerprint? Where do you start and end on each finger?

2. When rolling prints from your left hand, which way do you roll your fingers and thumb?

3. Describe the proper technique for lifting a print.

4. What was the most common unique characteristic you recorded from the fingerprints that you examined?

5. Of all the fingerprints you examined, what was the most common overall pattern?

6. What technique or process did you use when comparing prints to given fingerprint cards?

7. Who did the evidence fingerprint belong to?

POST-LAB SOLUTIONS
FINGERPRINT

1. **What is the proper technique for rolling a fingerprint? Where do you start and end on each finger?**
   Describe process. Rolling from "awkward to comfortable", pressing lightly, rolling from edge of nail to other edge

2. **When rolling prints from your left hand, which way do you roll your fingers and thumb?**
   Fingers: Counter Clock-wise, Thumb: Clock-wise

3. **Describe the proper technique for lifting a print.**
   Describe process. Apply a very small amount of powder to the brush, dust powder lightly across print, press the lifter lightly to the print without rubbing, lift straight up

4. **What was the most common unique characteristic you recorded from the fingerprints that you examined?**
   Answers will vary

5. **Of all the fingerprints you examined, what was the most common overall pattern?**
   Answers will vary.

6. **What technique or process did you use when comparing prints to given fingerprint cards?**
   Answers will vary

7. **Who did the evidence fingerprint belong to?**
   Unknown. The print did not belong to Lyle or Louise. John Wayne Gretzky has been ruled out as a suspect.

TEACHER'S NOTES
BITE MARKS

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Bite Marks Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 100 and 106, respectively.

SUPPLIES

- Base Plate Wax (1 pack of 10 pieces)
- Base Plate Wax labels
- Bite Mark Photos (1)
- Matching Bite Impressions (1)
- Bite Impression from Victim (1)
- Protractors (1)

RUNNING THE LAB

During the main section of the lab students will each make two impressions and will place them into 'evidence'. At this point, you will need to follow the steps below to facilitate the scenario.

1. Assign each student a number to place on their impressions.

2. At this stage, look for students who did not follow the lab procedure correctly and created impressions that are different from all others — for example, the impression may be made on a corner or side, or may be improperly labeled.

3. Either have students remake these impressions, or assign them numbers but then set them aside for your own use later.

4. After class, remove from evidence the bite impressions made by students who failed to follow directions correctly or produced different looking impressions.

5. Label the bite impressions that match the bite mark in the photograph (included with the kit) with their number. Alternatively you could simply add the impressions that came with the kit to evidence, but observant students will realize that there are more impressions than students and will deduce that one must match.

6. In the next lab session, pass out the impressions such that each student receives two. Be certain that no student gets two copies of the same impression or their own impressions. If you removed some impressions, you will have just enough, but the exact number is not critical.

7. Tell your students that these impressions are from patrons of the bar where John Gretzky claims to have been bitten.

8. In addition, give each student access to an impression from the female car crash victim (included with the kit) to determine if she was the biter.

Do not give students the photograph immediately as students will often look for common features between the photo and the impressions and come to a visual, subjective conclusion instead of a wellmeasured objective one. Instead, have them first develop characters to separate all of the samples collected from the bar patrons. Additionally, encouraging students to choose continuous features over categorical ones will make separation of characters via multivariate analysis easier.

MULTIVARIATE ANALYSIS

This lab contains a section on Multivariate Analysis. To aid you with these calculations a Microsoft Excel spread sheet is available for download at www.LyleAndLouise.com. Visit the "Downloads" page, create/login to an account, and register your product to download the supplemental material for this module.

This spreadsheet will calculate the percent difference of each of the samples from the photo. Smaller values indicate a closer match. To be legally useful, values should be under 5%.

BACKGROUND INFORMATION
BITE MARKS

FORENSIC odontology, also called forensic dentistry, is a unique field that combines the skills of a specially trained dentist with those of law enforcement. The forensic dentist's primary duty is human identification. Forensic odontologists are responsible for examining evidence from cases involving violent crime, child abuse, elder abuse, missing persons and mass disaster scenarios. The end result of these analyses is the identifying of victims or suspects and the establishing of investigative leads. A perpetrator of a crime often leaves evidence at a scene. Bitten food or chewed objects may be recovered by scene investigators and examined by a forensic dentist. Should autopsy investigations reveal bite marks on the skin of a victim, the forensic odontologist can compare the bite marks with replicas of a suspect's teeth.

Dental evidence includes anything relating to human dental anatomy or derived from the oral environment. Tooth shapes, metal restorations, skull and jawbone irregularities or even skull fragments may possess features that can be associated with a single person. The hardy nature of teeth under catastrophic conditions makes forensic dentists essential in identification, since teeth are often all that remains in these cases.

Although forensic dentistry crosses into many aspects of criminal investigation, the majority of the dentist's case load are two types of case:

1. missing and unidentified persons
2. recognition, documentation, and preservation of bite mark evidence

Dental evidence becomes important for human identification cases when fingerprints or personal effects can not be obtained from skeletonized remains. Bite mark evidence is also important when attempting to identify the perpetrator of a violent crime or place a suspect at a scene.

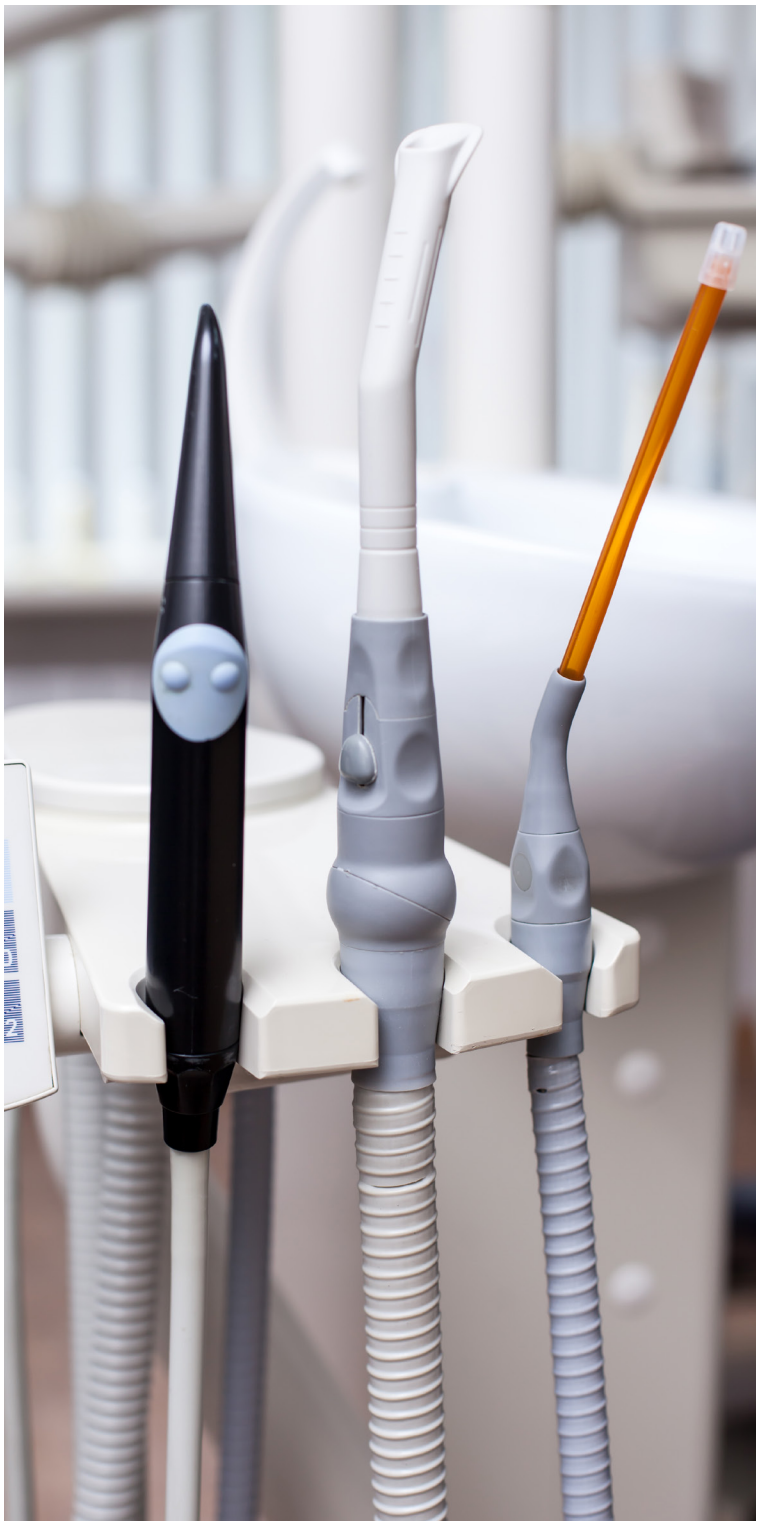
Teeth marks can be found in soft objects such as gum, food, and on human skin. The former are usually left at crime scenes, while the latter may be found on the bodies of victims, living or deceased, or even on a suspect.

Both victims and suspects may bite during the course of a violent assault. The patterns produced by teeth in any biting incident must be photographed, and sometimes even impressed, for three dimensional modeling. The analysis of a bite pattern's possible link to a particular "biter" depends on accurate and reliable collection of the evidence. This includes immediate documentation as soon as these marks are noticed; especially when the individual exhibiting the mark is still alive, as natural healing will soon eliminate the bruises and cuts that are evidence.

Bite mark analysis attempts to connect a biter to the unique pattern left behind on a person or object, which is linked in some way to a crime. This is based on two assumptions: that the characteristics of the teeth involved in biting are unique in all individuals and that this supposed uniqueness is transferred and recorded in the injury. The ability of skin to register sufficient detail of a biter's teeth is also highly variable. Many bite marks are not well-defined or are distorted due to the physical properties of skin itself. Therefore, while bite mark evidence may be useful in including or excluding possible suspects, it is difficult to identify a single individual as the biter in such skin injuries.

In order to make a comparison between individuals suspected of leaving bite impressions on a particular piece of evidence, the crime scene investigator or medical examiner must recognize that a wound is a bite mark. Because of the large degree of variability in teeth, bite marks are difficult to generalize, however, the typical bite mark is a circular or oval injury consisting of two opposing, symmetrical, U-shaped arches separated at their bases by open spaces. Along the margin of the arches are a series of round, almost circular, bruises. These bruises can be used to identify the size, shape, arrangement, and distribution of the contacting surfaces of the teeth. A series of small bruises or cuts, arranged in a semicircle, may also be observed. Full bite patterns are often not present on a single piece of evidence; many times only the upper or lower teeth marks are left. Often this lack of a complete set of marks is due to some interfering object.

Because human teeth are arranged in predictable patterns, forensic dentists rely on the variations that occur in tooth size, shape, and position between individuals to provide the uniqueness required for a forensic comparison. Teeth change through a person's lifetime through chewing food, and secondary use as tools. These changes are based on personal activity, health, and dental treatment. These activities can result in creation of a unique dental profile for an individual. Once a bite mark has been identified, the dentist must evaluate it for this "uniqueness" in preparation for a comparison to a typical example.



EVALUATION OF A BITE MARK

A human bite mark may have a variety of characteristics and show considerable variation due to incomplete teeth marks and the surface on which the bite is imprinted. Upper and lower teeth may not be equally represented. Bite features may be distorted due to victim movement or the jaw movement of the biter. Bite marks of high value as evidence exhibit markings from a significant number of teeth. The essential step in bite mark analysis is the determination of which teeth made specific marks. This identification is made using the following set of criteria:

- Front teeth are seen as the primary biting teeth in bite marks. There are six upper front teeth and six lower front teeth (the central and lateral incisors and the cuspids).
- The upper jaw (maxilla) is wider than the lower jaw (mandible).
- A bite mark showing the upper and lower front teeth will show a total of twelve teeth marking the skin.

Following these observations, the next step is the determination of which marks were made from upper and from lower teeth. The upper four front teeth make rectangular marks, and the

central incisors are significantly wider than the lateral incisors. Both the upper and lower cuspids tend to leave round or oval-shaped marks. The lower four front teeth make rectangular marks that are all similar in width.

Equally as telling as marks are portions of a bite imprint that are empty or missing an impression. Areas between known biting teeth that show significantly fainter bruising are attributed to teeth that did not impact the skin due to some feature present on the tooth. The likely reason for this is that the edge of the tooth has suffered some damage, like chipping, or that the tooth is simply shorter than the two neighboring teeth. Gaps may be seen between marks and can have several explanations:

- The suspect may have no tooth present.
- One tooth is shorter due to its normal shape or some previous damaging event.
- An object, such as clothing, interfered with the tooth contacting the skin.
- The skin moved during the act of biting.
- There was variation in the biting mechanism itself.

In addition to these bite mark pattern observations, the physical parameters of the injury are also measured. Distances between teeth marks that are adjacent or opposite one another in a bite mark are compared to a suspect's dental features at the corresponding positions.

Once all the available bite mark evidence has been documented, a forensic odontologist is usually asked to compare the bite mark from the crime to that of a suspect identified by the case's investigators. A dentist can examine the suspect's teeth and make a dental impression to produce life-size models of their teeth and dental arch. A dental stone mixture is poured into the impressions, hardens, and duplicates the dentition. Special notes are made of unusual characters, such as chipped, worn, or missing teeth. Each of these factors can have an effect on the injury pattern caused by a bite. The dental stone models of the suspect are then compared to the photographs of the bite mark. These photographs are typically scaled to a 1:1 ratio so that transparent overlays of dentition can be used during the comparison, however, if only measurements are being used and the photograph has a ruler or other fixed distance in the image, a simple ratio can be used later to correct measurements with different scales.

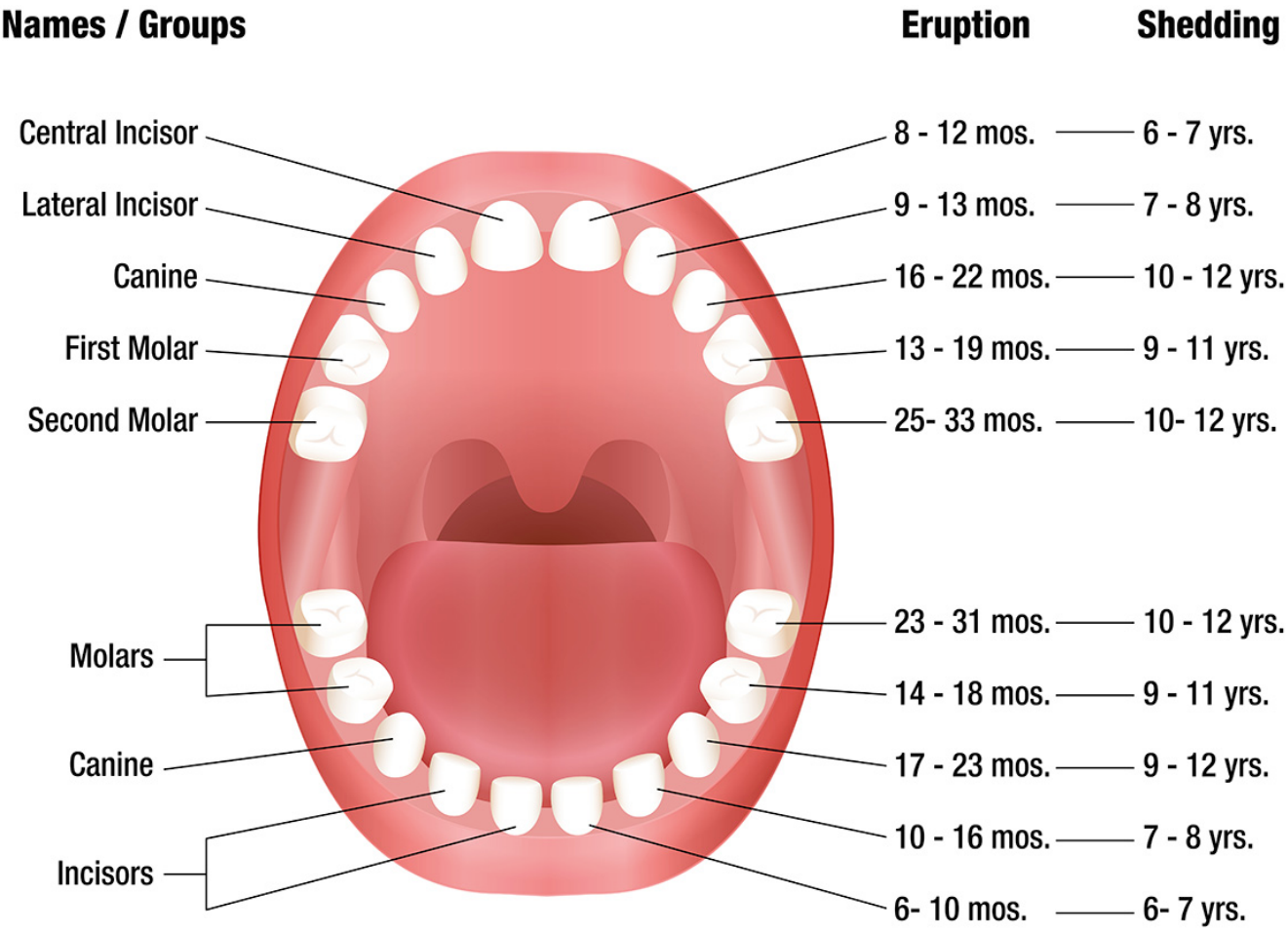
The first characters considered are the general arch size and shape. If there is a major discrepancy between these, the suspect can be eliminated with no additional analysis. If the arch does not exclude the suspect, the stone models are oriented in the direction corresponding to the position of the bite mark. Allowances are made for varying amounts of pressure applied to the surface of the skin during the attack. Prominent features of the dentition are inspected first for agreement or concordance with the bite mark. Secondary features must also match, or a reasonable explanation must be offered for the discrepancy. Wax bite impressions can be used to capture just the biting edges of a suspect's teeth and are also useful for comparison purposes. Digital imaging techniques can also be used to correct the distortion often seen in bite marks and allow for a more accurate comparison.

DRAWING CONCLUSIONS

Bite mark analysis uses characters such as tooth size and shape, chips and fractures, jaw shape, tooth alignment, missing teeth, and the

dimensions of the dentition to identify one person from another. The weight given to these features in establishing a positive match is based solely upon the opinion of a forensic dentist, as there are no databases of these unique characters. Bite mark evidence is, therefore, subjective and has been subject to some scrutiny in court. Although the forensic dentist is an expert, the forensic importance of a bite mark is an educated opinion. There are no guarantees the same bite mark evidence would be interpreted in the same way by two or more forensic odontologists.

ADULT TEETH DIAGRAM
BITE MARKS



CHOOSING CHARACTERS BITE MARKS

When attempting to match bite marks with a suspect mark, it is important that the characters measured are able to separate different samples. If samples are well separated, it is immediately obvious which sample matches.

Some characters will not vary significantly but will cluster around one or sometimes two values. Figure 1 shows measurements of a character with little variation; the suspect mark is plotted as a star. Two of the samples are outliers and can be easily removed from consideration, however, even though the suspect mark is on the edge of the cluster and one sample mark is very similar, all nearby samples should be included for further analysis because of possible measurement errors.

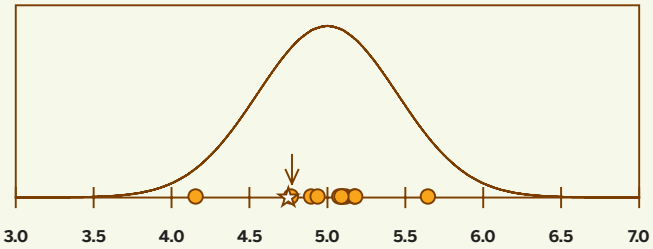
Characters with significant variance across the population sampled will permit better sample separation. Figure 2 shows such a character. Note how at least five samples can be readily removed from consideration. Both characters can be approximated by a bell curve, and, in the figures, both have means of 5.0, however, the variance is higher in Figure 2, resulting in a flatter hump and a more even distribution. In both figures arrows point to the sample that is closest to the suspect mark.

When characters combine, their separating power increases. Figure 3 shows measurements from the two characters plotted on different axes. Note how some samples, which were part of the clump near the center in one or the other characters alone, are now separated from the center by the inclusion of the other character. Also note that the two suspects that were closest to the suspect mark when looking at only one character alone are now removed from the suspect mark.

Because of measurement error and distortion caused by biting pliable materials, such as flesh, the closest sample is not necessarily a match – indeed none of the samples may be a match, however, those samples within some predefined error tolerance should be included as possible matches. In Figure 3 this error tolerance is shown as the shaded ellipse around the suspect mark. In this case, the size of the tolerance is equal to five percent of three standard deviations around the mean of each character. It is an ellipse because the standard deviation is a measure of variance in the sample, which is different for each character. The spreadsheet provided is designed to help you calculate this error range.

FIGURE 1.

Character with low variance



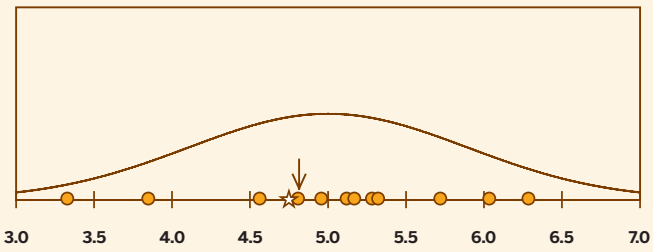
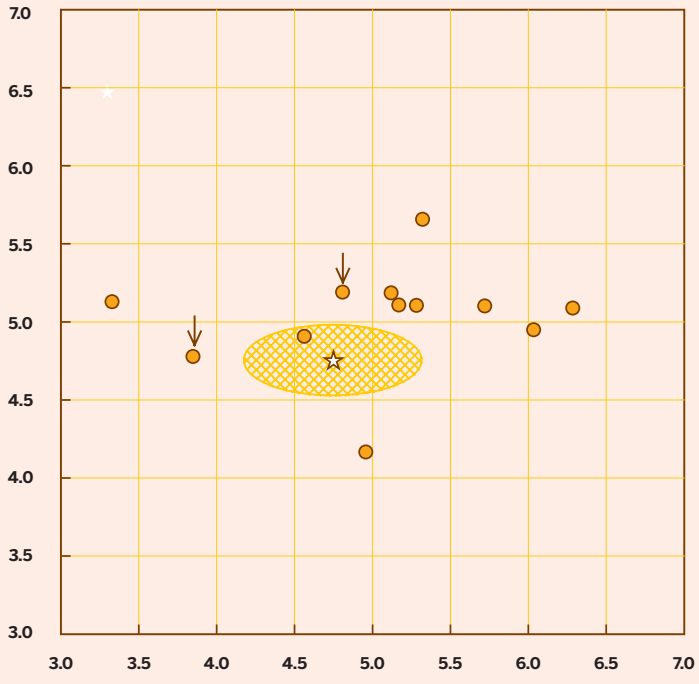


FIGURE 2.

Character with high variance

FIGURE 3.

Both characters combined, further separating samples



PRE-LAB QUESTIONS
BITE MARKS

BACKGROUND

1. What makes teeth good for victim identification?

2. How should a bite mark on a person be documented?

3. When evaluating a bite mark, what should be the first thing determined?

4. When comparing bite marks, what are three points of comparison mentioned in the text?

5. Why might multiple forensic odontologists have different opinions on the same bite mark evidence?

PROCEDURE

6. How many wax impressions should each person make?

7. How will you determine the orientation of the bite mark in the photo?

8. What mathematical trait makes a character good for separating samples?

PRE-LAB SOLUTIONS
BITE MARKS

BACKGROUND

1. **What makes teeth good for victim identification?**
   Teeth are very durable and, therefore, capable of withstanding conditions that destroy other body tissues, and are unique to each person.

2. **How should a bite mark on a person be documented?**
   The bite mark should be photographed and a cast taken of the impression.

3. **When evaluating a bite mark, what should be the first thing determined?**
   Which teeth made the specific marks.

4. **When comparing bite marks, what are three points of comparison mentioned in the text?**
   Arch size and shape, unusual features (chips, wear, missing teeth), and tooth size, shape, and alignment

5. **Why might multiple forensic odontologists have different opinions on the same bite mark evidence?**
   There is not a single set of objective criteria that all forensic odontologists follow.

PROCEDURE

6. **How many wax impressions should each person make?**
   Two

7. **How will you determine the orientation of the bite mark in the photo?**
   Front upper teeth form larger rectangles than teeth from the lower jaw, which are smaller and closer together.

8. **What mathematical trait makes a character good for separating samples?**
   The amount of variability in the character. Alternately: variance, standard deviation.

THE EVIDENCE
BITE MARKS

On the day the car accident was discovered, John Wayne Gretzky was brought in for questioning by police investigators. During the interrogation, investigators discovered a bite mark on John Gretzky's forearm, which he claimed to have received during a bar fight the previous night.

In an attempt to confirm or refute Gretzky's claim, investigators collected wax impressions from regular patrons of the bar to compare to the impression on John Gretzky's arm.

Investigators, with the assistance of morgue workers, also took a wax bite impression of the adult car crash victim for comparison.

LAB PROCEDURE
BITE MARKS

1. Fold a piece of the pink baseplate wax in half to form a square.

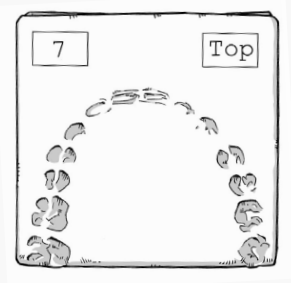
2. Use gloves or place wax impressions in plastic bags to protect from transferring saliva from one student to another.

3. Insert the folded end into your mouth so that all of your teeth will make an impression when you bite down.

4. Bite the wax slowly and cleanly. Bite hard enough to leave an impression with your teeth, but not hard enough to bite through the wax.

5. Remove the wax from your mouth.

6. Using one of the stickers included with the kit, label the side with the impression of your upper teeth, the side that was facing up when you bit, with a 'Top' in the upper right corner.



7. Flip the wax over, and label the upper right corner with a 'Bottom' with a sticker.

8. Repeat steps 1 through 6 with another piece of wax to make an additional impression.

9. Complete the worksheet, Impression Characterization.

10. Enter your impressions into evidence by taking them to your instructor who will assign you a number. Using the stickers provided, number your wax impressions.

11. Use gloves or place wax impressions in plastic bags to protect from transferring saliva from one student to another.

12. Record your name in the suspects sheet beside the number given to you by your instructor.

MEASURING BITE PATTERN CHARACTERS

The comparison and matching of bite marks is not an exact science. Since no bite pattern database exists, no statistical information can be determined. Although recommendations exist, each forensic odontologist will weigh characteristics of a bite mark differently and may

reach different conclusions as to whether two impressions match.

1. Identify quantifiable bite pattern characters that describe the shape, size, and arrangement of a bite impression. Measurements may include the distance between teeth, the distance between a tooth and a baseline, or the angle an incisor makes to a baseline.

2. Adequately describe each character on the Data Collection sheet.

3. For each impression, measure and record each character.

MULTIVARIATE ANALYSIS

1. Enter your data into the Spreadsheet template provided by your instructor.

2. The template will calculate a term representing the percent difference each wax impression was from the photographed impression using the values of the characters you input. Record on your data collection sheet which impression has the smallest difference.

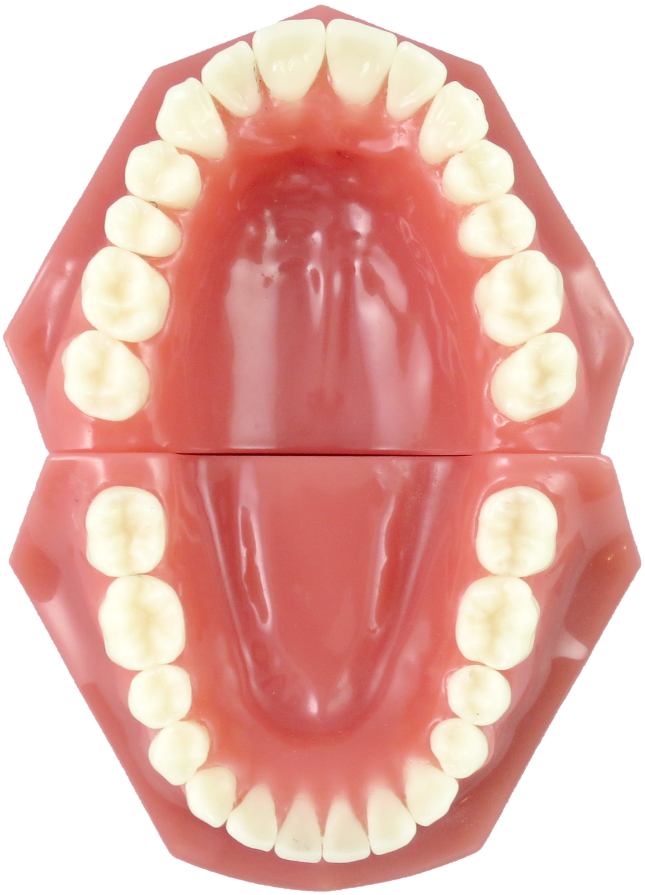
3. Compare the impression with the smallest difference with the photograph.

IMPRESSION CHARACTERIZATION
BITE MARKS

Compare the impression of your teeth with the diagram. Place the appropriate mark over teeth that exhibit the following characters:

- ✖ Tooth is missing from your impression, but not necessarily from your mouth.
- \ Tooth has only a faint impression.
- ➜ Draw an arrow from a tooth pointing in the direction of a misalignment.

Wisdom teeth are often missing, either because they have not yet erupted, or because they have been surgically removed. Front teeth are commonly chipped or misaligned.



Take measurements on your wax impression of the distances between specific teeth in your upper dental arch.

A. 2nd Left Molar to 2nd Right Molar: .....

B. 2nd Left Molar to 1st Right Premolar: .....

C. 2nd Left Molar to Central Right Incisor: .....

D. Right Cuspid to Left Cuspid: .....

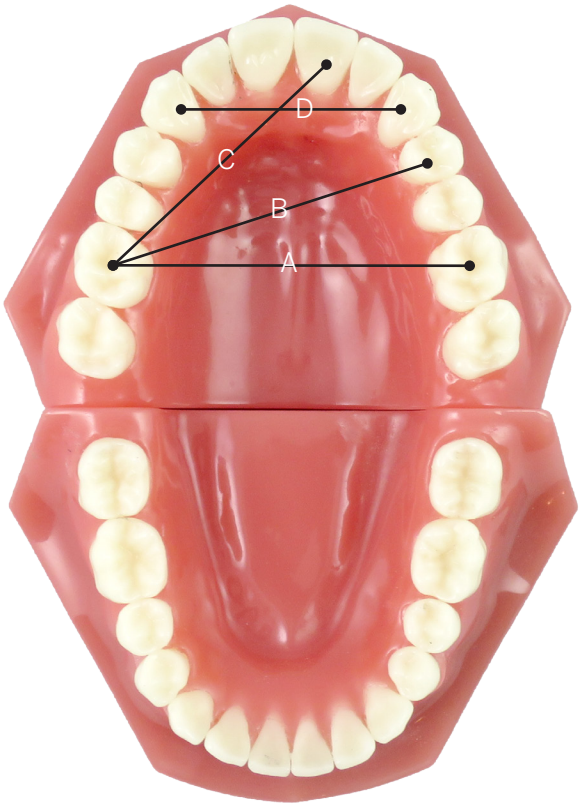
Now find similar measurements that characterize the size and shape of the lower dental arch. Draw them on the diagram and take those measurements on your wax impression.

A. ....

B. ....

C. ....

D. ....



DATA COLLECTION
BITE MARKS

CHARACTER DESCRIPTIONS

A. .....

B. .....

C. .....

D. .....

E. .....

F. .....

		A	B	C	D	E	F
IMPRESSION NUMBER							
CRASH VICTIM							
PHOTO							

POST-LAB QUESTIONS
BITE MARKS

1. Did one of the bite mark samples match the mark on John Wayne's Arm? If so, which one?

2. Was John Wayne lying about the bite? Explain how you know this.

3. Which of your characters had the largest variance?

4. Which character was the most useful for separating samples from the suspect mark? Why?

5. Which character was the least useful? Why was it not useful?

6. Did the most useful characters have high variance? If not, explain what caused it to be useful.

7. What class of character is more useful for finding a match than those with high variance?

POST-LAB SOLUTIONS
BITE MARKS

1. **Did one of the bite mark samples match the mark on John Wayne's Arm? If so, which one?**
   Answer will vary dependent on which bite impression, if any, was substituted with the impression provided.

2. **Was John Wayne lying about the bite? Explain how you know this.**
   Answer depends as above.

3. **Which of your characters had the largest variance?**
   Answer will vary with the characters chosen.

4. **Which character was the most useful for separating samples from the suspect mark? Why?**
   Answer varies.

5. **Which character was the least useful? Why was it not useful?**
   Answer varies.

6. **Did the most useful characters have high variance? If not, explain what caused it to be useful.**
   Answer varies.

7. **What class of character is more useful for finding a match than those with high variance?**
   Those characters are identified as unique to a suspect mark and, thus, separate only samples like the suspect mark from all others which are clustered.

TEACHER'S NOTES
GLASS

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Glass Fragment Identification. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 111 and 117, respectively.

SUPPLIES

- Microscope Slides (1 Box of 72)
- Microscope Cover Slips (1 Box of 100)
- Refractive Index Liquid (1 set of 3 bottles)
- Glass Samples (1 set of 4 containers)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Microscope
- Laboratory Gloves
- Safety Glasses/Goggles
- Sodium Lamp or 589 nm Wavelength Filter (Optional)

RUNNING THE LAB

During the labs, instruct students that the refractive index of the item being sampled may be inferred from the liquids if it does not match the liquids. For example, if the refractive index of the item does not match a liquid and is determined to be greater than 1.45 and less than 1.47 it may be inferred that the refractive index is 1.46.

SAFETY PRECAUTIONS

As this lab involves the analysis of broken glass fragments, the presence of sharp edges are a possibility. Extreme caution should be used when handling broken glass and students should be reminded to exercise diligence to prevent injury.

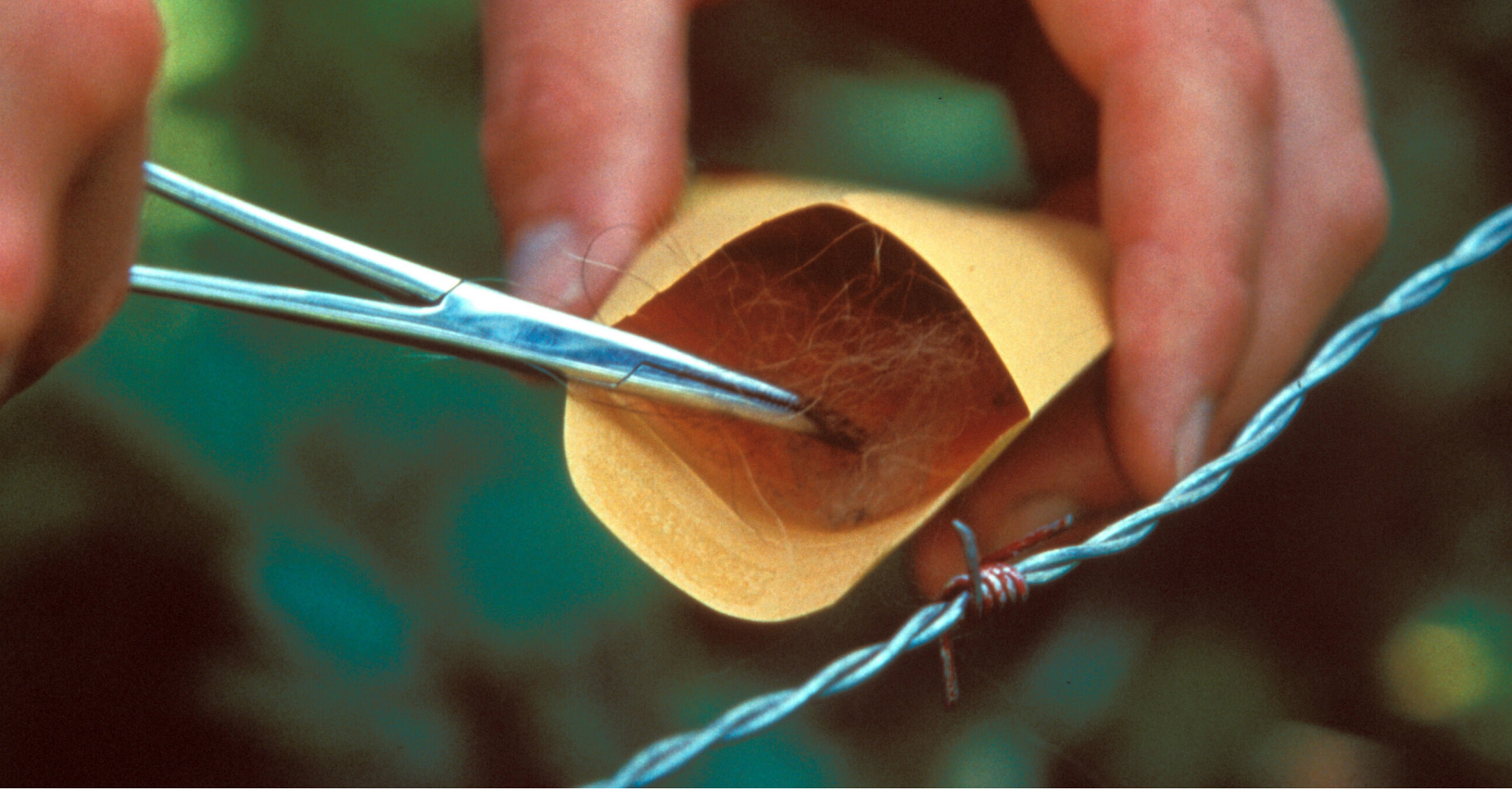
Students should be reminded to only handle glass while wearing appropriate personal protective equipment including, at a minimum, gloves and eye protection. Additionally, students should take pre cautions to avoid breathing dust generated by the finely ground glass samples.

NOTES

1. It is recommended that the microscopes used be equipped with adjustable light sources and diaphragms, as lowering the light level and closing the diaphragm will aid in analysis.

2. The optional sodium lamp or wavelength filter listed under "Other Supplies and Equipment Required" may be utilized as a light source during microscopic examination to aid in visualization of the Becke line.

3. Students should be advised that smaller fragments are more easily analyzed than large fragments



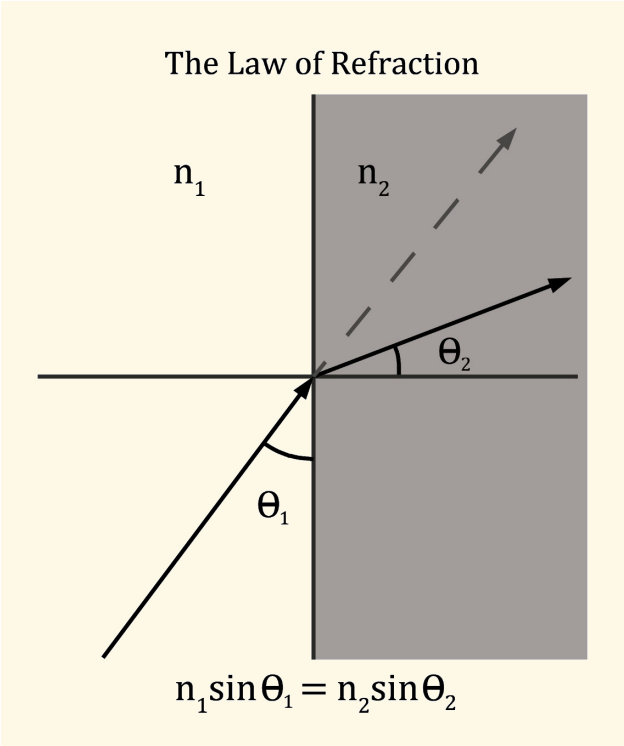
BACKGROUND INFORMATION
GLASS

ONE item of trace evidence that may be generated at a crime scene is broken shards of glass. Glass shards are frequently generated at a crime scene by the breaking of windows or, in the instance of automobiles, collisions. While broken glass may result in additional information at a crime scene, such as blood and DNA evidence in the event of cuts, in the absence of this evidence the broken glass itself may connect a suspect to a victim, a suspect to a crime scene, or a victim to a crime scene.

In the absence of a physical identification of glass shards, additional analysis is often required. One method for the further analysis of glass is determination of the refractive index (RI) of the glass shards. Once the RI of the evidentiary (questioned) glass is determined it can then be compared to the glass from the crime scene. For instance, if broken glass fragments are collected from the clothing of a burglary suspect, the RI of those fragments can be determined. The RI of this glass can then be compared to the RI of the glass from a broken window of the burglarized home. Should those two glass samples exhibit the same RI, a potential connection could be made between the suspect and the crime scene. Should the two glass samples exhibit differing RIs, the suspect could potentially be excluded. Additionally, if evidentiary glass is from an unknown source, the RI of the glass may indicate what type of glass the unknown is.

GLASS TYPE	REFRACTIVE INDEX RANGE
VEHICLE HEADLIGHT	1.47-1.49
TELEVISION	1.49-1.51
WINDOW	1.51-1.52
BOTTLE	1.51-1.52
OPHTHALMIC LENS	1.52-1.53

The RI of a substance is a measure of the speed at which light travels through that medium. This is expressed as a ratio of the speed of light in a vacuum to the speed of light traveling through the medium being analyzed. As a result of light traveling through mediums of differing RIs, the light be comes refracted, or bent. This means that because of the change in speed of the wave of light, the direction of that wave also changes.



The RI of a substance may be calculated from the amount of refraction exhibited by the light as it passes through varying mediums based upon the change in the angles of the wave. The angle at which the light enters the medium is known as the angle of incidence. The angle at which the wave is bent is called the angle of refraction. This calculation is performed according to the following formula:

$nD=\sin\theta 1/\sin\theta 2$

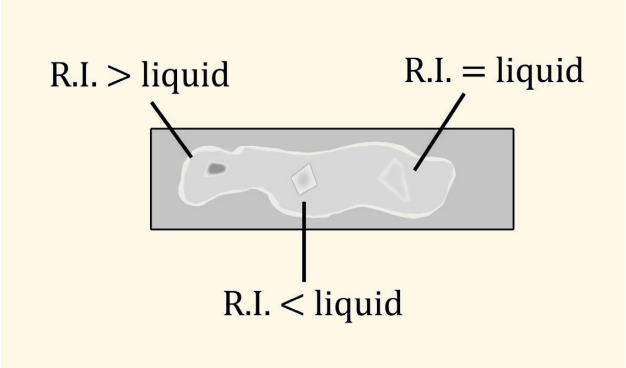
Where:

nD =Refractive Index

$\theta 1$=Angle of Incidence

$\theta 2$=Angle of Refraction

The RI of an unknown piece of glass may be determined in several ways. Manually, the RI may be determined microscopically. In this analysis several drops of a liquid of known RI are placed upon a microscope slide. The glass sample to be analyzed is cleaned and is then placed in the liquid upon the slide. During microscopic analysis the edge of the glass shard will be identifiable by a bright outlining halo. This line is called the Becke line. The distance between the microscope magnifier and the sample changes as the microscopic focus is adjusted. As this distance changes the Becke line can be observed moving into or away from the glass chip being analyzed. If the Becke line moves toward the glass as the distance between the magnifier and the sample increases, then it can be determined that the RI of the broken glass is larger than the known RI of the liquid. Conversely, if the Becke line moves toward the glass as the distance between the magnifier and the sample decreases, then it can be determined that the RI of the glass fragment is less than the known RI of the liquid. Once it is determined that the RI of the unknown glass is either larger or smaller than the known RI of the liquid being used, the glass is removed from the slide, washed, and the analysis is repeated



with a different liquid of known RI shifted in the direction of the RI of the glass. For example, if it was originally determined that the RI of the questioned glass was larger than that of the first liquid, a second liquid is selected with a larger RI and the glass is reanalyzed. This process continues through the use of liquids of known RI by decreasing the RI range bracketing the RI of the glass. When the Becke line is observed to disappear, the proper RI has been selected and the RI of the liquid is equal to the RI of the glass.

In addition to comparisons made by RI, forensic glass samples may be identified and compared by their atomic composition, the individual atoms comprising the glass molecules. This may be done in several ways, such as through the use of X-ray Diffraction (XRD) or Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS).

PRE-LAB QUESTIONS
GLASS

1. What is one type of trace evidence that may be present at a crime scene?

2. What information can trace evidence provide?

3. What is commonly the first step in glass analysis?

4. How is refractive index calculated?

5. If the refractive index of a medium is known to be 1.50, and the angle of incidence is 46.8°, what is the angle of refraction?

6. When placed in liquid of a different refractive index, what is the bright outlining halo surrounding a glass fragment called?

PRE-LAB SOLUTIONS
GLASS

1. **What is one type of trace evidence that may be present at a crime scene?**
   Glass shards generated from the breaking of windows or automobile collisions.

2. **What information can trace evidence provide?**
   It may connect a suspect to a victim, a suspect to a crime scene, or a victim to a crime scene.

3. **What is commonly the first step in glass analysis?**
   An attempted physical match.

4. **How is refractive index calculated?**
   $n = \sin\theta_1 / \sin\theta_2$
   Where: n = Refractive Index
   θ_1 = Angle of Incidence
   θ_2 = Angle of Refraction

5. **If the refractive index of a medium is known to be 1.50, and the angle of incidence is 46.8°, what is the angle of refraction?**
   $n = \sin\theta_1 / \sin\theta_2$
   $1.50 = \sin(46.8\,^\circ) / \sin\theta_2$
   $\sin\theta_2 = \sin(46.8\,^\circ) / 1.50$
   $\sin\theta_2 = 0.486$
   $\sin\theta_2 = 29.1\,^\circ$

6. **When placed in liquid of a different refractive index, what is the bright outlining halo surrounding a glass fragment called?**
   Becke line

THE EVIDENCE
GLASS

As crime scene investigators begin to suspect foul play in the deaths resulting from the vehicle crash along Backbone Mountain, they retraced the path of the vehicle and stumbled upon several pieces of broken glass lying together in the roadway above the crash site. These glass fragments were collected and retained for further analysis.

When the abandoned Tumbling Water Land Development Co. truck was found along the highway in New Mexico, the local authorities were contacted. As investigators inspected the truck they noticed that one of the front headlights was broken. Remembering the broken glass near the Backbone Mountain crime scene, they collected a sample of glass from the broken headlight and sent it to the forensic trace evidence laboratory for analysis.

LAB PROCEDURE
GLASS

LAB 1:
MICROSCOPIC DETERMINATION OF REFRACTIVE INDICES OF KNOWN SAMPLES

1. Glass edges may be sharp. Do not handle glass fragments without wearing proper personal protective equipment, including gloves and goggles, and avoid breathing dust generated by the finely ground glass samples.

2. Select a reference glass container, carefully open the container, and remove several pieces of glass. Prepare a microscope slide by placing one to two pieces of glass onto the slide. (Note: Smaller fragments are more easily analyzed than larger fragments)

3. Place 1-2 drops of Liquid 1 (Refractive Index=1.45) onto the glass fragment ensuring that the liquid surrounds the edges of the fragment; cover with a coverslip.

4. Place the slide onto the microscope stage; at the lowest power of magnification, focus the microscope on the glass fragment.

5. Once the glass fragment has been properly focused, switch the microscope to the next highest magnification objective and refocus the microscope. (Note: Closing the microscope diaphragm will likely aid in glass fragment visualization)

6. Repeat this procedure until the objective, when focused, allows the glass fragment on the slide to fill the majority of the field of view while still allowing all edges of the fragment to be viewed.

7. Adjust the microscope diaphragm and light intensity until the Becke line, the halo of light at the edge of the glass fragment, is easily visible.

8. Once the microscope has been properly focused, carefully adjust the focus noting the direction of movement of the Becke line as the objective lens moves toward and away from the sample.

9. If the Becke line is observed moving toward the glass as the distance increases, the refractive index of the sample is larger than the known refractive index of the liquid. If the Becke line is observed moving toward the glass as the distance decreases, then it can be determined that the RI of the glass fragment is less than the known RI of the liquid.

10. Record your observations on the Data Collection page.

11. Carefully remove glass fragment slide from microscope.

12. Repeat steps 2-12 with additional fragments of the same known glass sample and Liquid 2 and Liquid 3.

13. Based upon your analysis, record the experimentally determined refractive index on the Data Collection Page.

14. Repeat steps 2-14 with the other reference glass sample.

LAB 2: PROCESSING THE EVIDENCE

15. Carefully open your package of questioned glass obtained from the crash site on Backbone Mountain.

16. Analyze the glass sample in the same manner as described for the known samples in Lab 1.

17. Once your analysis of this sample is complete and your observations and the experimentally determined refractive index have been recorded, return the evidence to the package and reseal it.

18. Repeat steps 1-3 for the known glass sample taken from the headlight of the abandoned truck.

19. Once evidence analysis is complete, determine whether the evidentiary sample of glass collected from the roadway is consistent with that of the glass taken from the broken headlight of the abandoned truck. Discuss your theories as to why or why not.

DATA COLLECTION
GLASS

LAB 1: MICROSCOPIC DETERMINATION OF REFRACTIVE INDICES OF REFERENCE SAMPLES

BOTTLE GLASS (SODA-LIME GLASS)

LIQUID USED	OBSERVATIONS	AS DISTANCE INCREASES, BECKE LINE MOVES (CIRCLE)	APPROXIMATE REFRACTIVE INDEX
Refractive Index Liquid 1 (n=1.45)		Toward Glass Toward Liquid	
Refractive Index Liquid 2 (n=1.47)		Toward Glass Toward Liquid	
Refractive Index Liquid 3 (n=1.49)		Toward Glass Toward Liquid	

VEHICLE HEADLIGHT GLASS (BOROSILICATE GLASS)

LIQUID USED	OBSERVATIONS	AS DISTANCE INCREASES, BECKE LINE MOVES (CIRCLE)	APPROXIMATE REFRACTIVE INDEX
Refractive Index Liquid 1 (n=1.45)		Toward Glass Toward Liquid	
Refractive Index Liquid 2 (n=1.47)		Toward Glass Toward Liquid	
Refractive Index Liquid 3 (n=1.49)		Toward Glass Toward Liquid	

LAB 2: PROCESSING THE EVIDENCE

QUESTIONED GLASS SAMPLE-COLLECTED FROM BACK-BONE MOUNTAIN NEAR VEHICLE CRASH SITE

LIQUID USED	OBSERVATIONS	AS DISTANCE INCREASES, BECKE LINE MOVES (CIRCLE)	APPROXIMATE REFRACTIVE INDEX
Refractive Index Liquid 1 (n=1.45)		Toward Glass Toward Liquid	
Refractive Index Liquid 2 (n=1.47)		Toward Glass Toward Liquid	
Refractive Index Liquid 3 (n=1.49)		Toward Glass Toward Liquid	

COMPARISON GLASS SAMPLE-COLLECTED FROM ABANDONED TRUCK IN NEW MEXICO

LIQUID USED	OBSERVATIONS	AS DISTANCE INCREASES, BECKE LINE MOVES (CIRCLE)	APPROXIMATE REFRACTIVE INDEX
Refractive Index Liquid 1 (n=1.45)		Toward Glass Toward Liquid	
Refractive Index Liquid 2 (n=1.47)		Toward Glass Toward Liquid	
Refractive Index Liquid 3 (n=1.49)		Toward Glass Toward Liquid	

POST-LAB QUESTIONS
GLASS

1. Based upon your experimentally determined refractive indices of both the bottle glass and headlight glass, which medium would change the path of light traveling through it the most?

2. Did you determine the glass collected from the site near the vehicle crash to be consistent with the glass collected from the truck's broken headlight? Explain your reasoning.

3. Based upon your examination of the evidence presented, can it be concluded that the abandoned truck's broken headlight produced the broken glass on the road near the Backbone Mountain crash site?

4. Based upon your knowledge of the crime(s) and your examination of the evidence presented, what is your hypothesis about the events surrounding the deposition of the broken glass?

5. If further comparison of the glasses was desired, what techniques could be utilized?

POST-LAB SOLUTIONS
GLASS

1. **Based upon your experimentally determined refractive indices of both the bottle glass and headlight glass, which medium would change the path of light traveling through it the most?**
   Bottle Glass

2. **Did you determine the glass collected from the site near the vehicle crash to be consistent with the glass collected from the truck's broken headlight? Explain your reasoning.**
   Yes, reasoning will vary, but both samples should have a similar refractive index.

3. **Based upon your examination of the evidence presented, can it be concluded that the abandoned truck's broken headlight produced the broken glass on the road near the Backbone Mountain crash site?**
   No, the evidence presented cannot prove decisively that glass fragments collected from the crime scene match the headlight lens from the abandoned truck, as the glass from any vehicle with the same headlight as the abandoned truck cannot be excluded as the source of the glass found at the crime scene.

4. **Based upon your knowledge of the crime(s) and your examination of the evidence presented, what is your hypothesis about the events surrounding the deposition of the broken glass?**
   Answers will vary. As examination of the glass fragments should conclude that the broken headlight from the truck cannot be excluded as the source of the glass on the roadway near the vehicle crash, students should suspect the truck's involvement in the crash.

5. **If further comparison of the glasses was desired, what techniques could be utilized?**
   X-ray Diffraction (XRD) or Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS)

TEACHER'S NOTES
DRUG TESTING

THESE notes are provided to assist in the preparation and execution of the laboratory experiment on Drug Testing and Analysis. Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. A solutions key for the preand post-lab questions can be found on pages 123 and 132, respectively.

SUPPLIES

- Drug Testing Reagent Kit (1 set of 2 bottles)
- Unknown powder (1 pod)
- Strip of known powders (1 strip)
- Spot plates (2)
- Powder dispenser spatulas (1 set of 7)
- All GC-MS Data (1 set)

OTHER SUPPLIES AND EQUIPMENT REQUIRED

- Lab gloves
- Distilled water
- Pipettes for dispensing distilled water
- Permanent marker for labeling

RUNNING THE LAB

During the white powder test, instruct students to label their spatulas with each specific powder name. This will allow them to use the spatula to mix the powder with the liquids later in the lab while preventing cross contamination. Also, students should place a very small amount of the white powder in each well, then add three or four drops of liquid and mix.

SAFETY PRECAUTIONS

1. During cleanup, place all well plates and spatulas in a plastic garbage bag and tie the top for immediate disposal.

2. Chemicals should be used in small quantities during the white powder test. Three or four drops will be sufficient.

NOTES

- For extra enrichment, students may examine the powders under a microscope before adding the liquids. This will allow them to make additional observations.

- The videos for this lab can be accessed on the website at www.LyleAndLouise.com. Visit the "Downloads" page, create/login to an account, and register your product to download the supplemental material for this module.

BACKGROUND INFORMATION
DRUG TESTING

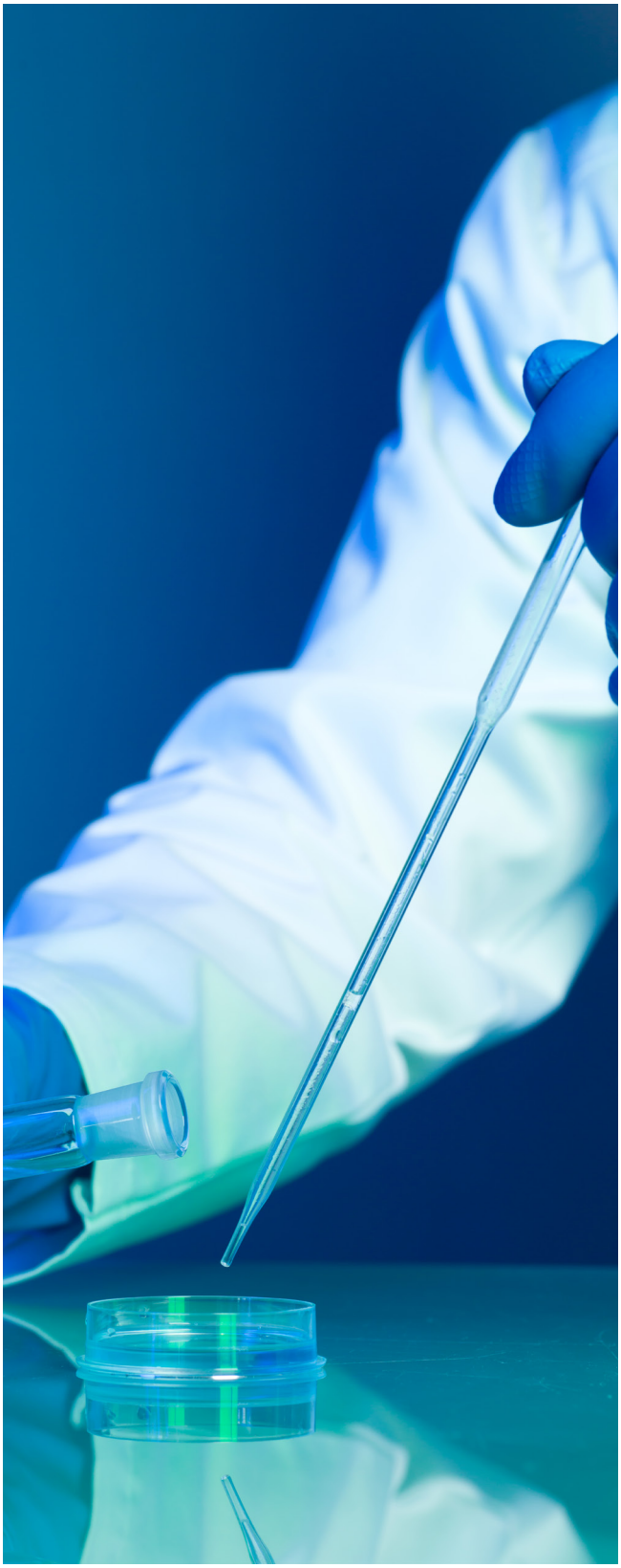
FORENSIC laboratories perform drug testing and analysis on many different kinds of drugs or chemicals. Common samples which are tested for the presence of drugs include blood, urine, hair, and other bodily fluids. These samples may be recovered from a crime scene, be in an individual's possession, or be acquired in drug screening for school, sports, or employment. Drug screening differs from compound identification in that the expert is looking for a specific substance. In contrast to screening, in identification an unknown substance is identified through the running of multiple tests. These identifying tests determine if controlled or illegal substances are present.

Many times a positive identification can be made on the visual appearance of the substance, such as marijuana or intact prescription pills, however, it is not possible to determine, with certainty, the identity of a plastic bag of unknown powder which could contain cocaine, methamphetamine, or a variety of other controlled or legal substances. The identification of the exact drug is important because an individual is often punished for the type of drug and the amount they possess based

upon State and Federal guidelines. Each state closely mirrors the federal guidelines, but may vary in their penalties for possession. Criminal penalties also vary from substance to substance.

The work done by forensics experts varies from case-to-case, however there are two main categories of tests that must be used to properly identify an unknown substance: presumptive tests and confirmatory tests. When the exact identification of a particular substance or drug is in question, presumptive screening tests (sometimes referred to as preliminary tests or spot tests) are completed. This allows for a quick, initial identification or exclusion of the substance. To perform preliminary testing, drug experts must have an idea of what they are testing so that they may choose the correct presumptive test to identify the suspected substance. If the presumptive test generates a positive result, then a confirmatory test is performed to confirm the presumptive results. The presumptive test, however, can incorrectly return a positive result, which is called a false positive. A false positive test result means that the test has returned positive for the suspected substance, but is actually another substance.

Colorimetric tests are presumptive tests and include the tests that screen for illegal drugs. Samples for testing can be obtained straight from the substance or indirectly from blood, urine, saliva, or other bodily fluids. Color tests are highly sensitive and do not require expensive equipment or any special skills to perform. Most of these tests utilize high concentrations of sulfuric acid which serves as a reagent (a special substance used in a chemical reaction to detect the presence of an unknown compound or drug), which is then combined with the unknown sample and the color change is observed. The color change is then compared to a known reference color range and allows the unknown drug to be identified.



Confirmatory tests are more specific, accurate, and expensive. A great advantage to these tests, however, is that they do not have the same risk of producing false positives. These tests are needed in order to accurately identify substances so that drug evidence may be admissible in a court of law. The equipment required for these tests is expensive, and a forensic drug chemist is required to analyze the information produced by these machines.

The most important and widely used confirmatory test is Gas Chromatography-Mass Spectrometry (GC-MS).

Each unknown substance is made of many different molecules that, when combined create, a separate chemical compound (i.e. cocaine, LSD, HTC, etc.). A drug technician inserts a minute amount of the unknown substance into the GC-MS. The gas chromatograph then takes this chemical compound and reduces its chemical structure to individual molecules. The difference in the chemical properties of each molecule will separate the molecules as they travel the length of the column. The molecules take different amounts of time to exit the gas chromatograph, which enables the mass spectrometer to capture and detect the molecules individually. After the GC produces these fragments, the MS is used to classify the chemical compounds and create a ratio with its mass and electrical charge, called the mass-to-charge ratio. With this information about the unknown chemical substance, a forensic scientist is able to identify the chemical fragments and place them back in the proper order, thus restoring the whole chemical compound using their expertise and knowledge of general and organic chemistry.

Ultraviolet Spectrophotometry is a confirmatory test similar to the GC-MS. In this analysis the unknown substance is identified through detection of the light being reflected by the main elements of the compound. This is analyzed and compared to a known sample range that helps identify the unknown drug.

PRE-LAB QUESTIONS
DRUG TESTING

1. Why must forensic technicians perform a confirmatory test after receiving a positive result on a presumptive test?

2. What is a false positive?

3. Why is it important to identify the exact drug and the quantity?

4. Describe the function of a GC-MS.

PRE-LAB SOLUTIONS
DRUG TESTING

1. **Why must forensic technicians perform a confirmatory test after receiving a positive result on a presumptive test?**
   False positives frequently occur, therefore a confirmatory test is required in order to identify the substance.

2. **What is a false positive?**
   A false positive test result means that the test you have run has returned positive for the suspected substance, but, in reality, it is another substance completely.

3. **Why is it important to identify the exact drug and the quantity?**
   In most jurisdictions an individual is punished based on both the type of drug and the quantity that they possess.

4. **Describe the function of a GC-MS.**
   The gas chromatograph takes the chemical compound and reduces its chemical structure to molecules. The difference in the chemical properties of each molecule will separate the molecules as they travel the length of the column. The molecules take different amounts of time to exit the gas chromatograph, which enables the mass spectrometer to capture and detect the molecules individually. After the GC produces these fragments, the MS is used to classify the chemical compounds and create a ratio with its mass and electrical charge, called the mass-to-charge ratio.

THE EVIDENCE
DRUG TESTING

In the abandoned truck in New Mexico, authorities found a large bag of an unknown, white, powdery substance. They immediately sent the bag to their drug testing laboratory. Upon receiving the bag of powder, forensic drug chemists decided that they must first determine what common cutting agent, if any, was utilized in the suspected drug sample. Because they did not know the identity of the powder, they wished to then analyze the sample by Gas Chromatography-Mass Spectrometry to determine if a controlled substance was present in the powder and, if so, the identity of the drug and the concentration of the drug in the evidentiary sample.

LAB PROCEDURE
DRUG TESTING

LAB 1

1. Label your two reaction plates. Label each vertical column of wells as follows: PP (Plaster of Paris), PS (Powdered Sugar), CS (Corn Starch), and S (Salt). On the second reaction plate, label the first two columns BA (Boric Acid), and TP (Talcum Powder). Label one more column with a question mark (for the unknown powder).

2. On the horizontal rows, label the top with DW (Distilled Water), IA (Isopropyl Alcohol), and LI (Lugol's Iodine). Repeat this process for the second plate.

3. Open the first powder, Plaster of Paris. Using a clean wooden spatula, place a small scoopful of the powder in each well in the PP column.

4. Close the first powder, then open the second powder, Powdered Sugar. Using a new wooden spatula, place a small scoopful of the powder in each well in the PS column.

5. Repeat these steps for each powder, including the unknown evidence powder. Be careful to use a new spatula for each new powder to prevent cross contamination. Ensure the lid for each powder is closed before scooping the next powder. Avoid placing too much powder in each well, as only a small amount is necessary for analysis.

6. Record physical observations of each powder on the Data Collection Sheet. Note the physical characteristics, such as the color of the substance and whether it is a powder or crystal.

7. After recording your observations, place several drops of distilled water in each well of the first row (DI) of powders. Record the reactions you observe on your Collection Sheet.

8. Follow the same procedure for each of the remaining two liquids, recording the reactions you observe after dropping each liquid into the wells of powder.

9. Examine your data for the known substances, and then compare it to the unknown powder. Decide the cutting agent, if any, in the powder found in the truck.

LAB 2, PART A

Your instructor has provided you with a set of data generated on a GC-Mass Spec. Forensic chemists use GC-Mass Spectrometry to test for illegal drugs in the same way you will be analyzing this data set.

The first set of data (Knowns) is generated by analyzing several known drugs to produce their mass spectra for comparison purposes. Forensic chemists can also rely on tables of mass values, if they are available, for reference.

The second data sheet (Unknown) is the analysis of the drug sample itself.

You will compare the mass spectrum produced from the crime scene with the spectra of known drugs. By comparing the peaks on the spectra, which represent ions of various masses, you can identify what drugs, if any, are present in the white powder from the crime scene.

1. Analyze the known spectum for Oxycodone. Two graphs of the same sample are included. Analyzing the first graph:
   - ❖ What measurement is represented on the X Axis?.....
   - ❖ What measurement is represented on the Y Axis?.....
2. Analyzing the second Oxycodone graph:
   - ❖ What measurement is represented on the X axis? .....
   - ❖ What measurement is represented on the Y axis? .....
   - ❖ Which graph is associated with the GC portion of the analysis?.....
   - ❖ Which graph is associated with the Mass Spec portion of the analysis. .....
   - ❖ What is the significance of the different peaks or lines observed on each graph? .....
   - ❖ The five different included knowns are: .....
3. Analyze each known GC/MS graph individually and, using a metric ruler, record the major peak heights in mm. Fill in the table on your data collection sheet.
4. The crime scene sample will now be analyzed. Measure the major peaks of this sample in mm and record this data in your data collection sheet.
   - ❖ Which of the five known drugs does the unknown drug resemble most?.....
   - ❖ Do significant differences exist between the unknown drug from the crime scene and the known drug it resembles the most? If so, what? .....
   - ❖ What is the source of additional peaks present in the crime scene sample that are not present in the known sample?.....

LAB 2, PART B

Your instructor has provided you with a second set of data generated on a GC-Mass Spec. Forensic chemists use GC-Mass Spectrometry to test for the quantity of an illegal drug in the same way you will be analyzing this data set.

The first set of data (Knowns) is generated by analyzing a very accurate series standards of known amounts of methamphetamine to produce their mass spectra for comparison purposes.

1. Review the known data set.
    - What four concentrations of drugs were used in this analysis? .....
    - What does 1.0 mg/ml signify? .....
      .....
      .....
      .....
2. Measure the primary peaks of these four concentrations of methamphetamine data in mm using the cm ruler and record these values in your data sheet. This data will be used to:
    - Enter and format data in an Excel spreadsheet in a form appropriate for graphing
    - Create a scatter plot from spreadsheet data
    - Insert a linear regression line (trendline) into the scatter plot
    - Use the slope/intercept formula for the regression line to calculate a concentration (x value) for a known peak height (y value).
3. Open Excel and enter your data into the first two columns in the spreadsheet.
4. Title the spreadsheet page in cell A1
5. Label Column A as the concentration of the known solutions in cell A3.
6. Label Column B as the peak height in mm for each of the four concentrations in cell B3.

CREATING THE INITIAL SCATTER PLOT

7. Highlight the data to be graphed.
8. Choose the Chart Wizard icon from the tool bar. If the Chart Wizard is not visible, you can also choose Insert > Chart...
9. When the first dialogue of the wizard comes up choose XY (Scatter) and the unconnected points icon for the Chart sub-type, then click Next.
10. The Data Range box should reflect the data you highlighted in the spreadsheet. The Series option should be set to Columns, which is how your data is organized
11. Click Next >
12. Label your chart.
    - Enter an appropriate Chart Title
    - Enter Concentration (M) for the Value X Axis
    - Enter Peak Height for the Value Y Axis
13. Click on the Legend tab and click off the Show Legend option, then click Next >
14. Keep the chart as an object in the current sheet and click Finish.

The initial scatter plot will now appear on the same spreadsheet page as your original data.

- Your data should look as though it falls along a linear path
- Horizontal reference lines were automatically placed in your chart, along with a gray background
- Your chart is highlighted with square 'handles' on the corners. With your graph highlighted, you can click and drag the chart to where you would like it located on the spreadsheet page. Grabbing one of the four corner handles allows you to resize the graph.

CREATING A LINEAR REGRESSION LINE (TRENDLINE)

When the chart window is highlighted, besides having the chart floating palette appear, a Chart menu also appears.

15. From the Chart menu, add a regression line to the chart by choosing Chart > Add trendline...

16. A dialogue box will appear. Select the Linear Trend/Regression type.

17. Choose the Options tab and select Display equation on chart, then click OK to close the dialogue box. The chart now displays the regression line.

USING THE REGRESSION EQUATION TO CALCULATE DRUG CONCENTRATION

The linear equation shown on the chart represents the relationship between concentration (x) and peak height (y) for the compound in solution. The regression line can be considered an acceptable estimation of the true relationship between concentration and peak height.

You have been given the GC Mass Spec graphs for one solution of unknown concentration.

1. Using the linear equation, calculate the concentration of the unknown solution. As the value of y (peak height) is known, you will solve for x (concentration). A sample calculation of this is shown below:

   $y = 2071.9x + 0.111$

   $y\ 0.0111 = 2071.9x$

   $(y\ 0.0111) / 2071.9 = x$

2. Write your equations below.

.....

.....

.....

.....

.....

CALCULATING THE AMOUNT OF DRUG IN THE CRIME SCENE SAMPLE

After calculating the concentration of drug in the unknown sample from the crime scene, you must determine what percentage of the white powder is actually drug. It is critical to know how much drug was actually present in the sample, as this affects what level of crime the suspect can be charged with. In the federal system, different drug quantities can result in different minimum samples necessary for sentencing. In the crime scene sample, 2.0 mg of white powder was dissolved in 1.0 ml.

3. Using the graph and the solution, record the number of milligrams of drug present in the sample below.

.....

.....

.....

.....

4. To calculate the percentage of drug, divide this concentration by the original 2 mg/ml, then multiply this value by 100. Record what percentage of the sample is drug below.

..... %

The New Mexico State Police weighed the material recovered from the crime scene and determined that they had recovered 13 g of white powder.

5. Determine the grams of drug recovered by multiplying the percentage of drug in the sample by the number of grams of powder recovered. Record your answer below.

.....

.....

.....

.....

.....

.....

DATA COLLECTION
DRUG TESTING

WHITE POWDER NAME	PHYSICAL OBSERVATIONS	REACTION	SPEED OF REACTION
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:
		DW: IA: LI:	DW: IA: LI:

LAB 2, PART A: MAJOR PEAK HEIGHTS FOR KNOWN DRUGS AND UNKNOWN SUBSTANCE

OXYCODONE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

AMPHETAMINE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

METHAMPHETAMINE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

COCAINE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

KETAMINE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

UNKNOWN SUBSTANCE

PEAK TIME (IN MINUTES)	PEAK HEIGHT (IN MM)

POST-LAB QUESTIONS
DRUG TESTING

1. Why is it important to do a presumptive test before performing a confirmatory test?

2. Which powders had the strongest reactions during the white powder test?

3. Which two powders reacted the most similarly to each other?

4. According to your white powder test, what is the identity of the cutting agent in the powder found at the scene of the crime?

5. What data do you get from a GC-Mass Spec?

6. In measuring the peaks of the unknown and comparing it to the known samples, what drug was found at the scene of the crime?

7. What was the concentration of the drug that was found? Why is it important to know the concentration and amount?

POST-LAB SOLUTIONS
DRUG TESTING

1. **Why is it important to do a presumptive test before performing a confirmatory test?**
   A presumptive test rules out many other drugs before running it through a Mass Spec to confirm the drug.

2. **Which powders had the strongest reactions during the white powder test?**
   Answers may vary.

3. **Which two powders reacted the most similarly to each other?**
   Answers may vary.

4. **According to your white powder test, what is the identity of the cutting agent in the powder found at the scene of the crime?**
   Corn starch.

5. **What data do you get from a GC-Mass Spec?**
   You learn the drug found at the crime scene, as well as the concentration of the drug.

6. **In measuring the peaks of the unknown and comparing it to the known samples, what drug was found at the scene of the crime?**
   Methamphetamines.

7. **What was the concentration of the drug that was found? Why is it important to know the concentration and amount?**
   It is important to know the concentration and amount because that is often how sentencing is determined.

LAB SOLUTIONS
DRUG TESTING

LAB 2, PART A SOLUTIONS

- What measurement is represented on the X Axis _____(Time the material is retained on the column)
- What measurement is represented on the Y Axis? _____(Peak height in m counts)
- What measurement is represented on the X Axis? _____(m/z mass to charge ratio) (% of intensity of signal)
- What measurement is represented on the Y Axis? _____(% of intensity of signal)
- Which graph is associated with the GC portion of the analysis? _____(Graph 1).
- Which graph is associated with the Mass Spec portion of the analysis. _____(Graph 2).
- What is the significance of the different peaks or lines observed on each graph?_____ (They represent a chemical that has separated from other chemicals in a mixture. Each group of different peaks is a signature or fingerprint for that unique drug of its individual components. The tallest peaks are most abundant.)
- The five different included knowns are:_____(oxycodon, amphetamine, methamphetamine, cocaine, ketamine)
- Which of the five known drugs does the unknown drug resemble most?_____ (methamphetamine)
- Do significant differences exist between the unknown drug from the crime scene and the known drug it resembles the most? If so, what? _____(Yes, there seems to be additional peaks.)

- What is the source of additional peaks present in the crime scene sample that are not present in the known sample? _____(The chemical components of the white powder used as a diluents or unique chemicals specific to chemical synthesis of this batch of methamphetamine).

LAB 2, PART B SOLUTIONS

- What four concentrations of drugs were used in this analysis?. _____(0.25 mg/ tion of the analysis? ml; 0.5 mg/ml; 0.75 mg/ml;1.0 mg/ml).

- What does 1.0 mg/ml signify? _____ (There is a concentration of 1.0 mg of methamphetamine for every 1 milliliter of solvent the chemical is dissolved in).

EVIDENCE SUMMARY

BLOOD SPATTER ANALYSIS

The evidence collected in this lab cannot prove conclusively that a specific person performed these violent acts, however this lab does provide details about what occurred during the attack. If everything in the lab was performed correctly you should have obtained the following information:

- The male victim was discovered near medium velocity spatter suggesting a hand-held weapon. Low-velocity spatter was found near the female victim, as was a piece of slightly bloodied firewood.
- A bloody object was carried across the room between the male and female victim at a height of approximately 100 cm (3 ft).
- The male victim was attacked at least once while standing, and at least once while lying on the ground.
- No blood spatter was found resulting from the firewood used as a weapon suggesting that only one blow was made.

FORENSIC ENTOMOLOGY

The evidence collected in this lab cannot prove that a specific person murdered the two victims, however it can establish a time line for the events surrounding their death. If everything in the lab was performed correctly you should have obtained the following information:

- The two victims at the cabin were murdered during the evening nine days ago.
- These victims were murdered before the storm on the same night that the Mondelo family car crashed. The timing from the data suggests the murder occurred when the storm began, but it must have been before the storm because flies are inactive during rain storms. This places the cabin murder firmly before the car crash.

Because Lyle Mondelo and the Woman in the Cabin were dead before the car crash occurred, several theories about the driver of the car can be made.

The timing of the crimes also allows students to connect the crimes to one another. It seems likely that the car crash is related to a quick get-a-way that went wrong during the rainy night.

FOOTPRINT ANALYSIS

As the shoeprints found at the crime scene do not match the shoe prints of the victims, the evidence collected in this lab cannot prove conclusively to whom the print belongs and cannot attest to the actions of that person. If everything in the lab was performed correctly you should have obtained the following information:

- The shoeprints collected at the scene did not come from the same shoe. This indicates that at least two other people were present in the cabin with the victims, however one shoe print was found outside and could have been left at any time.
- The evidence should only prove the type of shoe, not the wearer of the shoe. A hypothesis may be formed about the events surrounding the crime and how the prints were left.

BLOOD DETECTION AND EVIDENCE PROCESSING

The evidence collected in this lab cannot prove conclusively that any specific person was present at the crime scene and cannot attest to the actions of that person. If everything in the lab was performed correctly you should have obtained the following information:

- The test run on the controls and other items should show some of the different objects that can give a false positive with the Kastle Meyer test.
- The test run on the evidence sample should prove that blood was presumed to be present on the carpet in the truck.
- The evidence does not prove that the blood in the truck came from the victims in the cabin, however it is compelling that blood somehow ended up on the floor of an abandoned truck.
- It should be concluded that foul play could be involved.

QUESTIONED DOCUMENT ANALYSIS

The handwriting evidence collected in this lab is largely based on the subjective opinion of the forensic document examiner; relative relationships and chromatography analysis, however, should hold up to cross examination for even less experienced document examiners (like your students). If everything in the lab was performed correctly you should have obtained the folowing information:

- Two receipts were found on John Gretzky's desk with signatures that do not match Louise Mondelo's.
- The above two receipts were filled out in their entirety with the same ink as receipts filled out in their entirety that were signed JW Gretzky.
- These receipts also had receipt numbers out of sync with dates.
- The forgeries of Louise Mondelo's signature share some characteristics with John Gretzky's handwriting. As a result of these facts, a reasonable person may conclude that John Gretzky forged two receipts.
- A number of non-forged receipts with Louise Mondelo's signature have additions to the numeric part of the receipt in the same ink used by John Gretzky and the forgeries.
- Total additions from alterations and forgeries equal exactly $20,000.

FINGERPRINT ANALYSIS

The evidence collected in this lab cannot prove conclusively that any specific person was or was not present at the scene and cannot attest to the actions of that person. If everything in the lab was performed correctly you should have obtained the following information:

- A fingerprint was found on the safe in the TWLDC office that does not match any of the prints on the 10-print cards for Lyle, Louise, or John.
- This evidence does not prove that John was not present in the office, but the print is not a close enough match to confirm that he was the person who deposited the print onto the safe. A hypothesis may be formed about who performed the crime, but it was not Lyle, Louise, or John.

BITE MARKS ANALYSIS

The evidence collected in this lab cannot prove conclusively that a specific person bit John Gretzky, however it can prove that the adult victim of the car accident did not make the mark. If everything in the lab was performed correctly you should have obtained the following information:

- The adult car crash victim did not create the bite mark found on John Wayne Gretzky's arm.
- John Gretzky did not lie about being bitten at a bar the night before being questioned, and a bite impression from a man at the bar closely resembles the impression on John Gretzky's arm.
- John Gretzky was at a bar the night the car accident occurred.

GLASS FRAGMENT IDENTIFICATION

The evidence collected in this lab cannot prove conclusively that any specific person was present at the crime scene nor who was the driver of the abandoned truck. In addition, the evidence presented cannot prove decisively that glass fragments obtained from the crime scene match the headlight lens of the abandoned truck, as the glass from any vehicle with the same headlight as the abandoned truck cannot be excluded as the source of the glass found at the crime scene. If everything in the lab was performed correctly you should have obtained the following information:

- Vehicle headlight glass is discernable from other types of glass by its refractive index, which ranges from 1.47-1.49
- While the evidence cannot prove who was the driver of the abandoned truck and cannot prove the truck was the source of the broken glass collected from the vehicle crash site, the evidence does show the glass collected from the crime scene to be vehicle headlight glass and that the glass is consistent with that of the broken headlight of the abandoned truck found in New Mexico.

DRUG TESTING AND ANALYSIS

The evidence collected in this lab cannot prove conclusively that any specific person was present at the scene and cannot attest to the actions of that person. If everything in the lab was performed correctly you should have obtained the following information:

- The white powder lab results should have indicated that the dilutant in the substance was cornstarch.
- By looking at the data from the GC-Mass Spec, the illegal substance found in the powder could be identified as methamphetamine.