## National Science Education Standards:

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WELCOME to The Shoe Must Fit, a footprints analysis lab in the Mystery of Lyle and Louise. A brutal murder case is unfolding in a small Appalachian town. Already the case spans two crime scenes and five people are dead. When investigators discovered the second crime scene—a small cabin with two victims of a brutal double homicide—they discovered a partial bloody shoe print in the kitchen. In their examination of the outside of the cabin, officers found tire tracks in the dried mud with a shoe print pressed into the nearby dirt.

In this lab, students will examine the relationship between foot length and height and will utilize this relationship to predict height based on foot length. Students will then take castings of their own shoes, examine them, and develop a method for analyzing shoe prints. After learning about wear patterns, class and individual characteristics, and other shoe print analysis techniques, students will examine the shoe prints discovered at the crime scene. Students will then measure and analyze the evidence casting from the cabin, determine if the shoe prints from inside and outside of the cabin are consistent with the same shoe, and develop a hypothesis about the identity of the criminal(s).

Once the lab results have been analyzed, students may conduct a mock trial to hold a suspect accountable for their actions.

Teacher’s notes can be found at the beginning of the manual and copies may be freely made of all materials for your students.
The Mystery of Lyle and Louise

Teacher’s Notes

These notes are provided to assist in the preparation and execution of the laboratory experiment. A solutions key for the pre- and post-lab questions can be found on pages 11 and 12, respectively.

Supplies

First, inventory the supplies included in the lab kit. Supplies have been provided for up to six groups of students.

- Dental stone for each group (6 bags)
- Photos of shoeprint from crime scene (1 envelope with 6 photos)
- Evidence castings (6)
- Shoe Data Pages from SoleMate (6 sets)

Other Supplies and Equipment Required

- Yard stick or meter stick for each group
- Water
- Computer with Internet access for each group

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.

Following this lab, the teacher should collect all foot length and height data from the groups so that this information can be compiled into a class spreadsheet for comparison.

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.
Teaching Timeline

Groundwork

Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. Covering this material once should be sufficient for all laboratory modules.

Schedule 1: This lab schedule is designed to take 5 days, with one hour of class time per day.

Day 1:

Distribute lab procedures for Lab 1.

Instruct students to perform the first 10 steps of the procedure for Lab 1.

Collect group data to compile into a class table.

Day 1, after class:

Paste all footprint data for foot length and height into a class spreadsheet. (All data can be pasted into the cells, but the only necessary information for discussion is name, foot length, and height.)

Day 2:

Analyze class data and discuss accuracy of using foot length to predict height.

Cover material in Footprints Analysis. Do not go into detail about class characteristics, individual characteristics, and wear patterns.

Assign pre-lab questions as homework.

Day 3:

Instruct students to follow Part 1 of Lab Procedure 2.

Review pre-lab questions.

While the castings are drying, make a list on the board or on a poster of the different types of class and individual characteristics, as well as the wear patterns that result from walking with a pronated, neutral, or supinated foot. Save this list for student reference during the next class period.

Day 4:

Instruct students to follow Part 2 of Lab Procedure 2 and complete their data collection sheet.

Day 5:

Instruct students to follow the procedure for Lab 3. Discuss student theories about the case.

Instruct students to complete post-lab questions at the end of class or for homework.
Teaching Timeline

Schedule 2: This lab schedule is designed to take 3 days, with 1.5 hours per class.

**Day 1:**

Distribute lab procedures for Lab 1.

Instruct students to perform the first 10 steps of the procedure for Lab 1.

Collect group data to compile into a class table.

**Day 1, after class:**

Paste all footprint data for foot length and height into a class spreadsheet. (All data can be pasted into the cells, but the only necessary information for discussion is name, foot length, and height.)

**Day 2:**

Analyze class data and discuss accuracy of using foot length to predict height.

Instruct students to follow Part 1 of Lab Procedure 2.

While castings are drying, cover material in Footprints Analysis.

Make a list on the board or on a poster of the different types of class and individual characteristics, as well as the wear patterns that result from walking with a pronated, neutral, or supinated foot. Save this list for student reference during the next class period.

Assign pre-lab questions as homework.

**Day 3:**

Instruct students to follow Part 2 of Lab Procedure 2 and complete their data collection sheet.

Instruct students to follow the procedure for Lab 3. Discuss student theories about the case.

Instruct students to complete post-lab questions at the end of class or for homework.
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 may disappear after a short time.
Post-Lab Solutions

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 entire class?
   Answers will vary

3. Why are the ratios different from one another?
   The entire class is a larger sample, so the R-value should be more accurate.

4. 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.

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

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

7. 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.

8. 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.
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, footprints, or footwear marks are interchangeable and refer to two types of impressions left by a person’s footwear: positive and negative. A positive, or two-dimensional, 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.

As long as people have been walking, there have been footprints. The world’s oldest footprint, estimated to be over 3 million years old, was discovered in 2007 at Siwa Oasis in Egypt. The first recorded forensic use of footprints occurred in the early 1800s in Warwick, England. In 1816, a young maidservant was discovered drowned in a shallow pool of water, and evidence discovered upon her body indicated that she had been violently assaulted. While investigating the damp ground around the pool of water, police discovered footprints and an impression of corduroy cloth with a patch sewn upon it. Bits of grain were found surrounding the prints and lead police to a nearby farm. Police examined the pants and shoes of a farm laborer who was threshing wheat and discovered a match to the impressions found at the crime scene.

In the more recent trial resulting from the 1994 murders of Nicole Brown Simpson and Ronald Goldman, part of the inculpatory, or incriminating, evidence came from a bloody footprint found at the crime scene. William Bodziak, an FBI footprint expert, confirmed that the prints came from size 12 Bruno Mali Shoes. Incidentally, these particular shoes are extremely rare and only 299 pairs were sold in the US. When the evidence was presented the prosecution had no proof that the defendant, Orenthal James “O.J.” Simpson, had ever purchased such shoes. Later on in the trial, however, a tabloid photograph surfaced with O.J. Simpson wearing the shoes in question. With other supporting evidence, O.J. Simpson was arraigned for the two murders.

Unabomber Theodore Kaczynski is currently serving a life sentence with no chance of parole as a result of his bombing spree that lasted from 1978 to 1995. While collecting evidence from his secluded Montana cabin, investigators discovered shoes with fake soles. By attaching soles from a smaller-sized shoe to his own shoe, Kaczynski had hoped to mislead police. Kaczynski pled guilty to his crimes.

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.
Footprint Analysis

By looking at the wear pattern, investigators are able to assess the walking pattern of the individual. A wear pattern on the outside rear of the shoe near the heel 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.

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 will be matched against prints in the database. Foster + Freeman Ltd., based out of Worcesteshire, 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. 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.
Footprint Analysis

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.

Recovering footprints is a somewhat tedious process, as all surfaces must be considered to hold prints. William Bodziak has argued that investigators do not always take the necessary care to collect possible footprints. Bodziak is often quoted for saying, “What is not looked for will not be found!” It is frequently assumed that there will be fingerprints at a crime scene, but, unfortunately, footprints are sometimes neglected. Forensic technicians are trained to remember that every step taken by the criminal will leave a mark or impression of some type, therefore, before entering the crime scene, an expert will think about what happened at the scene, if footprints are relevant to the case, and identify specific areas where footprints may be found. Items such as floors, paper, glass, cardboard, and all other surfaces that may have been walked on should be considered for possible footprints. By shining a strong, oblique light onto the floor of a darkened room, footprints that were previously hidden may be visualized. Care must be taken by the crime teams not to disturb the evidence left by the criminal. If enough time and effort is administered, most surfaces will surrender a print.

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
Footprint Analysis

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 as 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 high-voltage 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.

Depending upon the surface and location the print was left, forensic investigators may have a narrow window in which to lift the print. Prints left in blood may last for years, whereas prints left in water may evaporate, and prints made with sand may be brushed away. Realizing this complication, many forensics experts do not take the time required to properly gather prints. Prints from police officers and others on the scene may mix with the prints from the criminal complicating the process. If patience and care are executed, prints that have been layered with the prints of others at the crime scene may be lifted. Multiple prints may even be lifted at once with a gel lifter. Pages of gel are placed down gently on the surface and then numbered to retain their sequence. Additional pages are then placed down and taped to other pages. Forensics experts are then able to recreate the footsteps at a remote location.

A person interested in a forensics career in footprint analysis should seek a bachelor’s degree from an accredited four-year college with a major in criminalistics, chemistry, biology, or physics. To prepare for this, it is recommended that a high school student should pursue classes with an emphasis on sciences and mathematics. Traits of patience and perseverance also prove very beneficial to someone interested in footprints forensics. The American Academy of Forensic Sciences provides a website with a list of colleges and universities providing forensic degree programs. For more information, visit this website: www.aafs.org.
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.
The Investigation

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 sweetheart, 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 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 Lar
The Investigation

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 victim 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.
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.
The Mystery of Lyle and Louise

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.

An unknown woman of similar height and build has been identified as Louise Mondelo. Although her identity is uncertain, this other woman was found either driving the Mondelo family car with two children preliminarily identified as Wally and Jan, or in a remote fishing cabin with a man who has been preliminarily identified as Louise's husband Lyle Mondelo.
Pre-Lab Questions

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?
Lab Procedure

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

3. Each group member will walk the premeasured distance while two or three group members count the number of strides taken in the given distance at the individual’s typical walking pace.

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

5. Each group member will run the premeasured distance while two or three group members count 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 a person’s (from another group) 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 getting a person’s (from another group) stride length and using your graphs to predict the height.

10. Look at the class data to compare foot length to height. Examine the other data and compare it to your group data.

Lab 2: Casting your Shoe Print

1. In your lab group, assign one group member to press their 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 plaster 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
**Lab Procedure**

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.

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.)

10. Trade castings with another group and record class characteristics, wear patterns, and individual characteristics from their casting. Describe or draw on your data collection sheet.

**Lab 3: Examining the Evidence**

1. Look at the photograph and crime scene layout provided from the scene of the crime. Note the length of the shoes and any other characteristics you can see from the photograph. Try to find 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 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. Compare the casting and the photograph to the database of athletic shoes and try to find a match. Unfortunately they were unable to find complete shoe records for Mitch Wilson and Wally Mondelo, however records were obtained for Lyle Mondelo, John Wayne Gretzky, and Larry Gretzky, and these records were then searched against the footwear database.

7. Use the cabin crime scene layout, the photograph, and the casting to recreate the crime scene.

**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.
My Group Casting. This shoe print belongs to ________________.

<table>
<thead>
<tr>
<th>Class Characteristics</th>
<th>Wear patterns</th>
<th>Individual Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

Other Group Casting. This shoe print belongs to ________________.

<table>
<thead>
<tr>
<th>Class Characteristics</th>
<th>Wear patterns</th>
<th>Individual Characteristics</th>
</tr>
</thead>
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Evidence Photograph and Casting:

<table>
<thead>
<tr>
<th>Photograph observations and measurements</th>
<th>Casting observations and measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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The Mystery of Lyle and Louise
Post-Lab Questions

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 entire class?

3. Why are the ratios different from one another?

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

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

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

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

8. What is your conclusion about the evidence shoe print and the suspected type and size of shoe? Are they the same shoe?
Using this Kit in the Mock Trial

The Shoe Must Fit contains information that could determine how many individuals were present at the cabin with the victims. 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.

If Footprint Analysis is the only kit done in the Mystery of Lyle and Louise, a mock trial is unlikely to be useful, as prosecution has little evidence to try a suspect. Instead, leave the results as an exercise in footprint analysis. If other exercises were performed, a mock trial can help students take all of the evidence presented in the investigation and available from other kits into account and provide a more interesting and thorough trial. Information on running a mock trial follows.

Before the trial

If a more thorough social studies activity is desired, students may be instructed to read through the procedures for trial of criminal cases and the simplified rules of evidence. Additionally, lessons designed to familiarize students with the court system and judicial procedure may prove beneficial.

Brainstorming

Using the story and module evidence, list the facts of the case on the board.

Determine, as a class, who should be charged for each crime.

Put students into brainstorming groups. Give all groups five to ten minutes to develop hypotheses for each of the following:

1. Identify how each fact may support the case presented by the prosecution.
2. Identify how each fact may support the case presented by the defense.
3. Identify critical weaknesses in the reliability of each fact.

Review the brainstorming results as a class and instruct students to connect various facts and evidence to make logical assumptions about the case.

Student Roles

Allow students to select, or assign, various roles relative to the characters.

Additional students may serve as the court, filling the roles of judge, bailiff, and clerk. The judge must research court proceedings and make determinations of law, therefore the instructor may wish to take this role themselves. The bailiff is responsible for swearing in witnesses and keeping order in the court. The Clerk is responsible for recording the trial proceedings. You may wish to omit these roles or have these students work with the prosecution or defense during the planning stages. With large classes, students may also play the role of jury. Ju-
ors must attend to the trial proceedings and also review the evidence and written documents prepared by the defense and prosecution to come to a conclusion about the case. They must then either meet outside of class and come to a unanimous decision, or each write a short paper justifying their own decision.

At least one student should act as an expert witness (the forensic scientist who processed analyzed the evidence presented); if multiple laboratory modules were utilized, several students should fill this role. This student must be very familiar with the laboratory procedures used to process the evidence and should also be aware of the ways the evidence can be mishandled and the precautions taken against evidence contamination and faulty methods, as these are likely to come up in court.

The remainder of students should split, approximately evenly, into the prosecution and defense teams. The student filling the role of the accused should work with the defense. Each side should assign their members as either lawyers or witnesses called. The lawyers are responsible for building their case, developing the questions to ask their witnesses, and for identifying key witnesses called by the other side to exploit during cross examination. Each side should also identify critical weaknesses in their own case and prepare counter-arguments for these weaknesses. As there are always surprises during trial, each side should prepare strategies to deal with the unexpected.

The prosecution must provide a reasonable series of events that are consistent with the facts of the case, a motive for the events that occurred, and prove beyond a reasonable doubt that the accused is guilty. The defense may present their own accounting of the facts or undermine the prosecution’s case by showing that the prosecution’s witnesses are unreliable, that the prosecution’s version of the events make no sense or is inconsistent, or by introducing reasonable doubt into the prosecution’s case.

Unlike a real trial, witnesses may help the lawyers build their case; their primary duty, however, should be to become intimately familiar with their testimony. Expert witnesses are especially useful when dealing with forensic evidence, and each side may wish to call their own or use the other side’s expert. The students playing the role of expert witness must become very familiar with that field and be able to field questions about the accuracy and limitations of the techniques.

**Preparation**

To ensure that students will be ready to argue their case, the prosecution and defense should answer the following questions:

1. What are the facts of the case?
2. Why did these things happen?
3. Who was involved?
4. Does sufficient evidence exist to participate in the courtroom?
5. What is key to you proving your point?

Additionally, witnesses should answer the following:

1. To what are you testifying?
2. What are the most important parts of your testimony to the prosecution? The defense?
3. What weaknesses are present in your testimony? If you are an expert witness, what are the limitations of the evidence presented that is relevant to your field?