### National Science Education Standards:

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WELCOMETo Prescrip tion for Crime, a drug testing and 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 a truck is found abandoned on the highway in New Mexico, investigators find a large bag of white powder under the seat. Believing it may be a controlled substance, the powder is collected and sent to the drug lab for analysis.

In this lab, students will learn about drug testing and analysis and then perform several presumptive drug tests to determine the dilutant, or diluent, used in the creation of the unknown white powder. They will then learn about confirmatory drug testing and, after receiving data from a gas chromatography-mass spectrometer, the most commonly used instrument in confirmatory drug testing in forensic laboratories, determine the amount of drug found in the sample. Using the information obtained in their experiment, students will then form a hypothesis about the events surrounding the crime.

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.
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.

- Isopropyl alcohol (6 bottles)
- Lugol’s iodine (6 bottles)
- Strip of unknown powder (1 strip)
- Strips of known powders (6 strips)
- Spot plates (1 pack of 12)
- Powder dispenser spatulas (6 sets)
- All GC-MS Data (6 sets)

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

The known and unknown powders come in one strip with six pods of powder. Each pod contains the same powder, either from a controlled substance sample or, in the case of the evidence powder, collected from the crime scene. For easy distribution, cut or break the strip so that each pod is separate, then hand out one pod to each group. Remind them to use a different spatula for each powder.

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.
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:**

Cover the background material on Drug Testing and Analysis.

Distribute lab procedures and review so that students will be prepared for the lab the following day.

Assign pre-lab questions for homework.

**Days 2:**

Instruct students to follow the lab procedures for Lab 1. They should fill out their data collection sheet for this lab by the end of class.

**Day 3:**

Discuss the experiments that were performed on the previous day.

Watch the video clips about drug testing, pausing between each clip to talk about what is being performed. Emphasize the need for both presumptive and confirmatory tests.

Read through the procedures for Lab 2 so students will be prepared for the following day.

**Day 4:**

Instruct students to follow the procedures for Lab 2 while completing the data collection sheet, then answer the post-lab questions.

If time permits, discuss the results of this activity.

**Day 5:**

Discuss student theories about the case.

If this is your only lab from The Mystery of Lyle and Louise, prepare for a mock trial.
Teaching Timeline

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

Day 1:
Cover the background material on Drug Testing and Analysis.
Distribute lab procedures and review so that students can be prepared for the lab the following day.
Assign pre-lab questions for homework.

Day 2:
Instruct students to follow the lab procedures for Lab 1. They should fill out their data collection sheet for this lab by the end of class.
In the last fifteen or twenty minutes of class, discuss the results of their experiments.
Watch the video clips about drug testing, pausing between each clip to talk about what is being performed. Emphasize the need for both presumptive and confirmatory tests.

Day 3:
If needed, finish the video clips.
Instruct students to follow the procedures for Lab 2 while completing the data collection sheet, then answer the post-lab questions.
Following the lab, discuss student theories about the case.
If this is your only lab from The Mystery of Lyle and Louise, prepare for a mock trial.
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. What is a drug that can usually be identified just on the visual appearance of the substance?

Marijuana or intact prescription pills can often be identified just by visual appearance.

4. 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.

5. 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 different molecule will separate the molecules as the substance travels 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 separately. After the GC produces these fragments of the substance, the MS is used to classify the chemical fragments and create a ratio with its mass and electrical charge, called the mass-to-charge ratio.
Post-Lab Solutions

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 2 Solutions

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 mcounts)

• What measurement is represented on the X axis? ______________ (m/z mass to charge ratio)

• 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/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).
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.

In the United States, it is estimated that nearly 75% of evidence obtained by law enforcement and examined in forensic laboratories is drug-related. 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. Each offense is taken very seriously, and the fines or prison sentences increase dramatically with each offense.

At scene of an automobile accident where intoxication is in question, drug testing is extremely important. A sample of blood may be obtained for testing, and compounds within blood samples are often easily identified. A newer form of analysis involves testing hair samples for intoxication or other drug use. A hair follicle test will reveal intoxication immediately, and a strand of hair may retain evidence of drug or alcohol use for at least three months. Laboratories that perform these tests are operated by forensic scientists that can interpret the results of tests performed on controlled substances, clandestine samples, and pharmaceutical laboratory samples. Without interpretation these results have little value, and this interpretation is often written into a formal report that can be used as evidence in a court of law. Additionally, the forensic scientist is frequently asked to give expert testimony in court regarding these analyses.

The history of forensic drug testing and analysis dates back nearly 200 years. In the 1830’s a Scottish chemist by the name of James Marsh was summoned to aid in a murder trial. The suspect, John Bodle, was believed to have used arsenic-laced coffee to kill his grandfather. James Marsh had been working to develop a chemical test to reveal whether or not a sample contained arsenic. His original test involved mixing the sample with hydrogen sulfide and hydrochloric acid, but, while able to detect arsenic in the sample, the results had deteriorated by the time he presented it to the jury. This left reasonable doubt in the minds of the jurors, and Bodle was acquitted of the murder. After this trial Marsh developed another chemical test that detected arsenic at a more sensitive level. In this test sulfuric acid and arsenic-free zinc combined to produce arsine gas. Marsh discovered that when this gas was ignited it decomposed leaving a metallic arsenic residue which would not deteriorate with the passage of time.

In 1901 the Nobel Prize was awarded to Karl Landsteiner for his work in identifying and classifying blood into various types. His work was a starting point for many scientists and physicians in the advancements of developing tests to use blood samples in criminal investigations. With these advancements, Edmond Locard of the University of Lyons in France determined that a special crime laboratory was necessary. Locard, thus, established this lab in 1910, and became known as the ‘Sherlock Holmes of France’.

Following Locard’s lead, August Vollmer set up an American Police crime laboratory in 1924. Following this, the Federal Bureau of Investigation, founded in 1908, set up a forensic crime laboratory in 1932. In the years since, few changes to the methods used in a chemistry laboratory to identify unknown substances have been made. One drastic change, however, has been influenced by the now widespread availability and convenience of testing methods. For instance, many companies now distribute drug screening kits to law enforcement agencies that allow them to take a number of different presumptive screen-
ing tests out into the field for quicker results. These kits, relatively easy to use and widely available, allow for more decisions to be made in the field without delay and have reduced the number of unnecessary samples being sent to forensic chemistry laboratories for analysis. Also, the advancement of certain technologies, such as gas chromatography-mass spectrometry, now give results that are more accurate and specific than previous testing methods.

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.

Another presumptive test is an odor test, often used for detecting the presence of cocaine. The process of this test is similar to the color tests but differs in that the result is not a production of a specific color but, rather, a specific odor that is produced. This odor can be either a fishy or minty smell.

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 chemi-
cal 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

Common Illegal Substances
Marijuana is the most widely used hallucinogen in the United States. The active compound, or psychoactive substance, contained in the marijuana plant is tetrahydrocannabinol, or THC. THC is produced by the cannabis plant through a natural process involving the plant’s own enzymes and chemicals. The active compound in marijuana can range from 1 to 20 percent, which is almost completely contained in the female marijuana flowers.

Cocaine is one of many illegal stimulants that are abused for the sense of euphoria that they give the user. Cocaine is made from the coca plant, grown only in the Amazon. To make one pound of cocaine a total of 500 pounds of coca plant is needed. Most cocaine is made into a powder to be snorted, or it is crystallized and heated to create fumes to be inhaled, known as “crack”. A stimulant is any highly addictive chemical that directly acts on the central nervous system. It creates increased alertness and energy, and decreased appetite and need for sleep. Other commonly known stimulants are caffeine, nicotine, amphetamines, and methamphetamines.

Methamphetamine is also abused for its feelings of euphoria, with similar side effects, and has a highly dangerous nature. It is widely known as “meth”, and can be injected, snorted, smoked, or ingested orally. Under low doses and controlled administrations, methamphetamines have many uses in medicine (i.e. ADHD, obesity, narcolepsy, etc.). Meth is made in foreign and domestic labs by combining commonly available drugs and chemicals, which is why these production labs are often found in communities and neighborhoods.

Opioids are very well known and widely abused because they can be prescribed by a licensed physician. These drugs act on neuron receptors in the brain and spinal cord which block pain signals, as well as stimulate euphoria similar to cocaine and methamphetamines. Opioids are contained in commonly prescribed drugs, such as Vicodin, Lortab, morphine and some cough medicines. They are alkaloids derived from compounds such as morphine, which come from the harvested opium plant seeds.
Drug Testing and Analysis

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.

Many real-life examples show the importance of forensic testing and how it can be used to clarify questionable cases. In 1984, FedEx employees examined a damaged package of a cardboard box wrapped in brown paper. Inside they found a tube that had a number of plastic bags placed inside one another. In the innermost bag they found a white powder substance, and they subsequently called the Drug Enforcement Administration (DEA) to investigate. When an officer arrived, he removed a small trace of the powder and performed a presumptive field test which indicated the presence of cocaine. A search warrant was issued for the address to which the package was to be delivered, and the recipients were arrested and eventually convicted of drug possession.

Another example is the unexpected death of the famous actor, Heath Ledger. Ledger was an Australian and American film actor that played in well known films, such as “The Dark Knight” and “A Knights Tale”. On January 22, 2008, he was found dead by his housekeeper in his Manhattan apartment. A federal investigation into his death was pursued due to his young age and unexpected death. In his room were found numerous prescription pills, however, it was difficult to determine exactly what, or who, was responsible for his death. In the following weeks, Ledgers blood and tissue samples were analyzed and found to contain a lethal combination of prescription drugs. Without the ability to identify the compounds present in his blood at the time of death, the cause of death would have remained unknown.

A bachelor’s degree in a physical science is necessary for someone interested in pursuing a career in forensic drug chemistry. A solid background of general chemistry and organic chemistry should be obtained, as well as some coursework in pharmacology. There is additional training available up to the level of a PhD. Those working in pharmacology, pharmacokinetics, medicinal, clinical chemi-

try, or drug chemistry may also transition into the field of toxicology. There are additional certifications required by the Forensic Toxicology Certification Board.

To prepare for this career, it is recommended that a high school student should pursue an education at a properly accredited college or university to receive a bachelor’s degree. Classes with an emphasis on sciences, particularly chemistry, should be heavily included. 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.

Definitions

Presumptive Tests: If one of these tests has a negative result, the investigator can rule out the presence of an illegal substance. A positive result indicates the probable presence of a specific compound, however, due to false positives, a positive presumptive test result must be followed by a confirmatory test.

Confirmatory Tests: These tests give accurate and specific confirmatory results of the identity of a specific compound. Exact identification is only possible through a confirmatory test.

Colorimetric Tests: These tests are presumptive and indicate results through color changes when combined with certain substances.

Reagent: A special substance used in a chemical reaction to detect the presence of an unknown compound or drug.

GC-MS (Gas Chromatography-Mass Spectrometer): This instrument performs a confirmatory test by separating the molecules of a compound and identifying the exact substance.
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 Mystery of Lyle and Louise

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, police 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 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 Mystery of Lyle and Louise

The Investigation

ry Gretzky for questioning about the car accident, police discovered that they had both skipped town along with Larry’s girlfriend, Mary Brady. 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 decom; 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.
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.
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.
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. What is a drug that can usually be identified just on the visual appearance of the substance?

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

5. Describe the function of a GC-MS.
Lab Procedure

Lab 1:

1. In your group, 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 Procedure

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 spectrum 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
Lab Procedure

- 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 toolbar. 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.

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...
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.
Lab Procedure

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 and Calculations

<table>
<thead>
<tr>
<th>White Powder Name</th>
<th>Physical Observations</th>
<th>Reaction</th>
<th>Speed of Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DW:</td>
<td>DW:</td>
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<td>IA:</td>
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</table>
### Data Collection and Calculations

#### Lab 2. Part A: Major Peak Heights for Known Drugs and Unknown Substance.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Peak time (in minutes)</th>
<th>Peak height (in mm)</th>
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</thead>
<tbody>
<tr>
<td>Oxycodone</td>
<td></td>
<td></td>
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<tr>
<td>Amphetamine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methamphetamine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ketamine</td>
<td></td>
<td></td>
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<tr>
<td>Unknown Substance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Mystery of Lyle and Louise
Post-Lab Questions

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?
Using this Kit in the Mock Trial

Prescription for Crime contains information that could prove the presence and presumptively identify of an illegal substance in the powder found in the truck. 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.

If Drug Testing is the only kit done in the Mystery of Lyle and Louise, a mock trial is unlikely to be useful, since prosecution has little evidence for a suspect. Instead, leave the results as an exercise in drug testing and 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-
Mock Trial

rors 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 expect 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?