

C.S.I. Geometry Style

J. Jay Slosky
Taylor Allderdice High School

Index to Curriculum Unit:

Overview
Rationale
Objectives
Strategies
Classroom Activities
Annotated Bibliography/Resources
Appendices-Standards

Overview

One of the keys to engaging students in the study of mathematics is to show them real-life applications of mathematical principles and concepts that they study in class. While it is sometimes difficult to find many students who truly love math, there are many who love the current television shows that deal with law and forensics. Some of these are Law and Order, CSI, and the new CBS drama “Numb3rs.” This show lets people see how mathematics can be used to model complex problems that we don’t know the answer to. The program explores the real power of math beyond the usual textbook problems that we all know. *C.S.I. Geometry Style* is designed to supplement the geometry curriculum.

A main focus of the geometry course is logic and proof. This unit shows the parallel thinking involved in solving math problems and solving crimes. In geometry, students must take given information, apply known definitions and theorems and logically arrive at a desired conclusion. This type of thinking is also used in the field of criminology. The area of forensic science involves using mathematical concepts to solve problems and analyze data. In *C.S.I. Geometry Style*, students will have the opportunity to see the mathematical concepts at work in a career field that they find fascinating.

Many ninth grade geometry students also take biology as their science course. *C.S.I. Geometry Style* could be used as a cross-curricular unit with the biology teacher. The activities included in this unit might be enhanced if they are completed in an actual biology science lab.

Rationale

Forensic science has been developing for the last several centuries. Mathematics is an integral part of forensic science. Together, math and science have uncovered evidence, exposed facts, confirmed theories, discounted theories, convicted the guilty and exonerated the innocent.

The civilization of ancient China is responsible for the study of forensics that has evolved today. The Chinese have recorded information on the application of medical knowledge in the solution of crimes. In the late seventh century A.D. a magistrate by the name of Ti Jen-Chieh is known to have used both logic and forensics to solve crimes. His method of solving crimes included securing and studying the crime scene, examining physical evidence and interviewing witnesses is similar to methods of investigation employed today. The tools and resources at the disposal of forensic scientists today have evolved greatly since Jen-Chieh's days.

Mathiew Orfila is considered the father of modern toxicology. In 1814, he published a book called *Traite des Poisons*, which classified poisons used by criminals. He made significant contributions in the development of tests for the presence of blood and is credited with being the first to use the microscope in the assessment of blood and other bodily fluids.

Forensic science would not be what it is today without the microscope. Zacharias Jansen invented the compound microscope in 1590. An improvement over the conventional magnifying glass, the microscope allowed images to be viewed at a magnification of 10 times. This was useful in examining and comparing fingerprints. In the seventeenth century, magnification of up to three hundred times was used in microscopes that enabled scientists to examine hairs and fibers, blood samples, or cloths. Microscopes were further perfected in the 1880s. Stereoscopic scopes contained double eyepieces and lenses that worked together to produce a three dimensional image. In the 1920's, Philip Gravelle and Calvin Goddard developed the comparison microscope, which enabled scientists to bring two images side by side for direct comparison. This is useful in comparing two bullets to see if they were fired from the same gun and hair or fiber samples and potential matches to those samples.

Some other early contributors to forensic science were: John Evangelist Purkinji who classified fingerprints into nine major types; Adolphe Quetelet who stated his belief that no two human bodies were exactly alike; Leuchs who made strides in the study of human saliva; Henry Goddard who was the first to use bullet comparison to catch a murderer; and James Marsh who was the first to use toxicology in a jury trial.

The nineteenth century brought landmark strides in the field of forensics. Karl Landsteiner won the Nobel Prize in 1930 for discovering the human blood groups we are familiar with today. His findings formed the basis for almost all of the subsequent work in blood analysis and its application to forensic science. He identified two different blood groups, A and B, which had different antigens in the red cells. He found that blood of either type could be mixed with blood of the same type from a different person without any adverse reaction, but when the two types were mixed with each other, agglutination occurred. In time further blood classifications were discovered, and the Rhesus factor was recognized.

Blood is a very valuable piece of evidence when collected from the crime scene for several reasons. Blood can indicate how an attack was made, as well as the weapon that inflicted it. Patterns of bloodstains and splashes can help tell the story of the crime as well. The geometric shape of the blood is an indicator of how far the blood fell. If blood falls only a short distance, the marks are circular, or elliptical if they land on a slanted surface. If the drops fall a few feet before hitting the surface, the edges of the circular mark are crenellated with the degree of crenellation increasing proportionally with the fall. If the drops fall from over a distance of six feet, there are usually side spurts radiating from the site of the main drop. If there was a violent struggle, the attacker's own blood may be present at the crime scene, even if they have made attempts to clean away the evidence. Chemicals can be used to highlight bloodstains that are not easily visible, while others can be used to differentiate between blood and other substances.

Forensic blood analysis got its start in the early 1900s. In 1901, two young boys were murdered on the island of Rugen, off the coast of Germany. The two boys had gone out to play and when they didn't return, a search was organized. Their disemboweled remains were found. The authorities turned their attention to Ludwig Tessnow, a carpenter. He was seen talking to the boys earlier in the day. A search of his home turned up recently laundered clothing that had suspicious stains. He claimed that they were from wood dye, which he used daily in his profession. Police believed his story until one investigator recalled a similar crime. Three years earlier, two young girls had been found murdered in a similar style as that of the boys. Tessnow was also seen near that crime scene in stained clothes. He claimed they were dye stains. A farmer also reported that a man who looked like Tessnow was seen fleeing from his field. He discovered that seven of his sheep had their legs severed and tossed about the field. The farmer identified Tessnow from a line up as the man he saw fleeing the field. Needing more evidence to convict Tessnow, police gave Tessnow's clothing to Paul Uhlenhuth, a biologist who had recently developed a test that could distinguish blood from other substances, as well as mark the difference between human and animal blood. Uhlenhuth found dye on Tessnow's shirt as well as

human and sheep blood. With this evidence, Tessnow was charged, tried, convicted and executed. Shortly thereafter, forensic blood analysis began to progress rather rapidly in several directions.

The systematic application of fingerprinting as a means for identification was established in the 1900s, although its roots can be traced back as far as three thousand years ago in ancient China. One of the first times fingerprinting was used was when Dr. Henry Faulds, a Scot working in a Tokyo hospital, became involved in a case where a thief had left a fingerprint on a whitewashed wall. When a suspect was identified, Faulds noticed that the patterns of ridges and whorls on the suspect's fingers were quite different from those left in the whitewash. When an alternative suspect was brought in, his prints were taken, and just happened to match the whitewash perfectly. Faulds published his conclusions, which led to later classifications and descriptions of fingerprints so that matches could be reliably confirmed or rejected.

Prints are classified by the patterns of ridges on the surface of the skin, which are different in every single individual. Approximately two thirds of the human population has ridge patterns that form loops. These loops can be subdivided into radial loops and ulnar loops. Almost one third of the population has ridge patterns in whorls, which can be further split into plain whorls, double loops, central pocket loops and accidental loops. Only one in every twenty people has ridge patterns in arches, which can be described as plain or tented.

Computers are ideal for scanning and storing a given fingerprint as a digital pattern, taking account of the type and location on the print of each individual feature. These automated fingerprint identification systems (A.F.I.S.) can search a file of hundreds of thousands of digital print records for a match in less than a second, and offer a series of close matches for final scrutiny by a fingerprint expert. Computer based storage systems also allow prints to be compared on high-resolution monitors and can enhance poor-quality or smudged prints to produce a sharp image. In addition, data can be exchanged with other A.F.I.S. systems, and prints can be sent across the world to be compared and matched with locally obtained prints.

The first ever conviction based on fingerprint evidence came in 1911 in Chicago. Clarence Hiller's wife woke him in the early morning of September 19, 1910, telling him that the gas light in their daughter's room was not burning properly. When he got up to check on it, a stranger on the landing met him. Hiller challenged the intruder, and the two men fought and both fell down the stairs. The intruder then shot Hiller twice and fled, leaving him dead on the floor. Neighbors rushed to help, and the police were called, but a suspect had already been arrested less than a mile from the scene of the murder. Four off duty officers

had observed a man running as if evading pursuers, constantly turning to look behind him. When they stopped and searched the man named Thomas Jennings, they found a loaded revolver on him. There were also bloodstains on his clothing, which he claimed came from a fall from a streetcar.

The day before his murder, Clarence Hiller had painted some railings next to the window through which the killer gained access. The paint was still wet, preserving a perfect set of four fingerprints from the killer's left hand. The Chicago police force was one of the first in the United States to recognize the value of fingerprinting. When Jennings' prints were compared to those at the crime scene, they proved to be a perfect match. A match between the bullets found in Clarence Hiller's body strengthened the case against Jennings and test bullets fired from the gun found on Jennings. Jennings was convicted of murder, but his attorneys appealed on the grounds that fingerprint evidence was inadmissible. The appeal was not granted, and Jennings was sentenced to death.

Today, one of the most valuable tools available in the study of forensic evidence is the use of DNA. Criminals may have learned how to avoid leaving fingerprints at a crime scene, but they cannot hide their DNA. Inside the nucleus of every cell is a string of coded information that contains a person's particular makeup. This genetic code is unique to each individual. Since human beings share many basic characteristics, large stretches of the genetic code are similar. The DNA elements that could actually single out an individual are those extracts responsible for specific details such as physical appearance, family traits and color of eyes or hair. Although the molecular structure of DNA was discovered in 1953, it took over thirty years for the information to become available for forensic applications. In the 1980s, scientists began looking for ways to isolate DNA codes so they could be recorded and compared. Dr. Alec Jeffreys is credited with developing an aid to mapping genetic markers. His procedure came to be called "genetic fingerprinting." The pattern on the "fingerprint" is different in every case, except where identical twins or other identical multiple births are involved. Dr. Jeffreys also found that every cell in a person's body contains the same DNA and will therefore yield the same DNA fingerprint. This means that even very tiny amounts of blood, semen, saliva, perspiration, urine, even hair root, all can be used to identify a criminal suspect. DNA fingerprints are stored electronically and can be compared with others around the world almost instantaneously.

There are several advantages to DNA testing. Aside from identical twins, the chance of finding two people with the same DNA profile is currently estimated at between 100 million to one and 30 billion to one. It is a very accurate test. Since DNA is so durable, DNA testing can be done even when there are only skeletal remains. DNA testing is versatile. It can prove innocence as well as guilt. It can also be useful in investigations of similar crimes because it

can prove or disprove that a single perpetrator is responsible. The potential for DNA research is unlimited. A military DNA database would mean that there might never be another “unknown soldier.” DNA identification could also aid in the location of missing children. A DNA sample left at a crime scene could tell investigators such things as the subject’s race, eye and hair color, and physical build.

There are also some disadvantages to DNA testing. DNA tests are up to 100 times more expensive than traditional serology testing. Since the tests are done in private labs, specimens must be shipped and take a long time to process. States laws differ on how DNA testing results can be used in court. Juries are sometimes confused by the complexity of DNA and therefore might be skeptical of the results. Also, there are no national standards for forensic DNA tests.

DNA was first used in a criminal trial for the first time in England in 1987. When Lynda Mann was raped and murdered in November 1983, the only clue left by the killer was his semen, which, using traditional serology tests proved to be of a type found in just ten percent of the adult male population. This helped to eliminate some suspects but could not be used for positive identification of the killer. Since Lynda was killed on a secluded path, police believed the murderer was a local man. They had no helpful leads.

On July 31, 1985 another 15 year old, Dawn Ashworth, was raped and murdered on another quiet footpath. Police searched their database for local people with a history of sexual offenses. They identified a young kitchen porter at the Carlton Hayes mental hospital on the outskirts of the village. He was questioned and made a full confession, though it was later retracted. The police took a blood sample and asked Dr. Alec Jeffreys to compare the sample with that found on Lynda Mann’s body. The DNA evidence clearly showed that the kitchen porter was not responsible for either murder, but it also proved beyond all doubt that the same unknown man had killed both girls. The police refocused their investigation and asked for blood samples from potential suspects.

More than 4,500 men provided samples. One of these was Colin Pitchfork, a twenty-seven year old bakery worker who had been questioned earlier in the investigation. The owner of a local pub also made an interesting report. Bakery workers had been heard discussing the fact that Colin had paid a workmate, Ian Kelly, to give a blood sample on his behalf. Police checked the signature of the blood test against Pitchfork’s genuine signature and found the two did not match. He was arrested and forced to provide a blood sample. The sample confirmed that he was the double murderer. He confessed to the crime and in January 1988 was imprisoned for life.

DNA evidence also helped convict a suspect in the World Trade Center bombing of 1993. The suspect had mailed a letter to the *New York Times* claiming credit for the attack in the name of a group called the Fifth liberation Brigade. The FBI obtained a DNA fingerprint from the saliva used to seal the envelope.

Since 1998, some 2,000 suspects in the United States have been cleared using DNA testing. Derrick Coleman, a star basketball player for the New Jersey Nets was accused of raping a woman in a Detroit hotel room on July 15, 1994. All charges against him were dropped after DNA analysis of semen samples taken during the rape investigation failed to match the basketball player's DNA profile.

One of the basic assumptions of forensic science is that a person present at the scene of a crime exchanges traceable evidence with the location in a number of different ways. Traces may be found on the suspect that links him or her to the victim or crime scene, or to the crime itself. Hairs, fibers, soil, plant debris, paint flakes and other microscopic evidence can trap even the most careful criminals and prove their involvement in the most meticulously planned crimes.

Fibers are gathered at a crime scene with tweezers, tape, or a vacuum. They generally come from clothing, drapery, wigs, carpeting, furniture, and blankets. For analysis, they are first determined to be natural, manufactured, or a mix of both. Natural fibers come from plants (cotton) or animals (wool). Manufactured fibers are synthetics like rayon, acetate, and polyester, which are made from long chains of molecules called polymers. To determine the shape and color of fibers from any of these fabrics, a microscopic examination is made. Generally, the analyst gets only a limited number of fibers to work with—sometimes only one. Whatever has been gathered from the crime scene is then compared against fibers from a suspect source, such as a car or home, and the fibers are laid side by side for visual inspection through a microscope.

Cross transfers of fiber often occur in cases in which there is person-to-person contact, and investigators hope that fiber traceable back to the offender can be found at the crime scene, as well as vice versa. Success in solving the crime often hinges on the ability to narrow the sources for the type of fiber found. The problem with fiber evidence is that fibers are not unique. Unlike fingerprints or DNA, they cannot pinpoint an offender in any definitive manner. There must be other factors involved, such as evidence that the fibers can corroborate or something unique to the fibers that set them apart. Fibers can serve as a link to different cases, and can be an integral part in building a case. Fiber evidence was at the center of one of the most controversial murder cases in the last 30 years.

Mathematics can be a very crucial element in solving crimes and proving that the accused is guilty. However it can also be used in a reckless manner, making it appear the accused was much more likely to have committed the crime than they really were. One such case of this is the famous Atlanta Child Murders. Between 1979 and 1981, a series of murders of black children, mostly young boys, terrorized the city of Atlanta. The Atlanta Police Department was slow to react at first, since several of the first victims were poor inner-city boys with possible connections to drugs. Unfortunately, that is a way of life in a big city like Atlanta, so investigations were limited. While the police may have been able to dismiss the first murders as “drug-related”, this was certainly not the case for the next two victims, Milton Harvey and Yusef Bell. Their middle class status garnered some media attention, and the black community was not pleased with the efforts of the police department to protect their children. At the time, the police did not believe that one person was responsible for all the killings. From March 4 until August 20, 1980, seven more boys and 1 girl were murdered.

The FBI was finally brought in, and a task force was formed. Once the official task force was formed, the police had to decide which cases to include in their investigation. Those specially assigned cases, which represented murders that fit particular parameters, were compiled into a list. The "List" took on a life of its own during the media hype and investigation into the murders and is still the source of controversy. Of the many hundreds of murders that occurred during the late 1970's and early 1980's, at least ninety of those shared a similar geographic and/or social connection with one another. During the course of the investigation into the murders, officials chose to ignore these connections in more than sixty of the ninety cases. The Task Force Unit ignored the more than sixty cases mostly because they failed to meet the parameters that police were continuously changing and because they failed to notice the geographic and social connection between the victims, both on and off The List. Some, who had failed to make the List at one point, could have qualified for it at another, after the parameters of the List were changed. Many of the murder cases slipped through the cracks because they failed to make the List.

The course of the investigation changed in February of 1981. The only forensic evidence linking the murders was a particular type of fiber found on the victims' clothing. This fiber had an unusual, triple-lobed cross-section, which appeared to correspond with fibers used in carpets and rugs. When the reference to the fibers appeared in the newspapers, the killer immediately adapted his methods of disposing the bodies. Victims were then dumped in rivers wearing little or no clothing so that the chances of finding any more fiber evidence would be minimal. The killings continued, and the victims began to get older. The first adult to make the List was twenty-one-year old Eddie (Bubba) Duncan. He disappeared on March 20, 1981 and was found dead on April 8, 1981. With

Duncan's death, the parameters of the List changed to encompass older victims. Before this period, other victims who were young adults were left off the List because they were considered "too old." Those earlier young adult victims were never added, even after the parameters changed.

Early on the morning of May 22, 1981, a police patrol staking out the Chattahoochee River, where some of the corpses had been found, heard a splash. They rushed to the bridge where the James Jackson Parkway crossed the river, where they found Wayne Williams standing by his station wagon. Williams, almost twenty-three-years-old, was a freelance photographer and music promoter who said he was traveling across the bridge to find the home of a potential client with whom he had an appointment several hours later. He told the police the woman's name was Cheryl Johnson and that he intended to audition her with the possibility of promoting her as a singer. However, agents did not believe his story, particularly when the phone number was incorrect and the address didn't exist. Williams allowed the authorities to search the car. For over an hour, Williams was questioned about what he was doing on the bridge and his reason for being in the area. Several hours later, officers dragged the Chattahoochee River around the bridge, but they found no evidence of a body. On May 24, the body of twenty-seven year old Nathaniel Carter was dragged from the river.

When police searched William's house and car ten days later, they identified unusual fibers matching those found with the first bodies. In order to use them as evidence, they needed to prove that the fibers were not commonly found. After further tests, they traced the fibers back to a carpet manufacturer in Dalton, Georgia. Over a single twelve-month period the factory had made just 16,397 square yards using that fiber in the color "English Olive", which was found in Williams' home and car, as well as on the clothes of the victims. It was calculated that the probability of finding that shade of that particular carpet in any house in Atlanta at the time was one in 7792. A second significant fiber was found on the shorts of one of the murder victims and also in the carpeting in Williams' station wagon. General Motors had made the carpet, and checks revealed that just six hundred and twenty-eight out of more than 2.4 million cars registered in the Atlanta area at that time were fitted with that type of carpet, so the probability of finding this type and color of fiber in any car was one in 3828. To calculate the likelihood of another individual having those same carpets in his or her house *and* car, you would need to multiply the independent probabilities, which is one in almost *thirty million*. This was enough for the jurors to convict Williams to two life terms in prison, even though there were no eyewitnesses, weapon, motive, confession, or clear placement of Williams with any of the victims prior to their deaths.

Even though the only physical evidence was the fibers present on the victims and also in Williams' house, 30 million to one odds of someone else in the Atlanta area committing the crime had to leave the jury confident that they convicted the right man. Could the prosecution have skewed the data to fit their case? Many people believe that they did. The government ignored the fact that the same carpet was in all but one or two rooms in the house, including the parents' bedroom and the living room. Therefore not only was Wayne Williams exposed to the carpet, but so were the other four people that lived in the Williams' house, and any other regular visitor. They ignored the fact that even in residential applications many of the exact same fibers were dyed the same color and used in rugs which are not the same model number as those used in the Williams' house, not to mention that millions of pounds of the exact same fiber had been sold undyed to other manufacturers for use in applications such as car mats. As far as the probability ratio for the car is concerned, the prosecution used metro Atlanta figures to show how rare this vehicle would be. This means the Williams' vehicle was not even included because it was registered in Muskogee County, which is far from Atlanta. Considering all of these factors would have had an enormous effect on the probability ratio the prosecution used, which would not have been nearly as impressive to the jury.

Although the Supreme Court ruled in *Frye v. United States* (1923) that results were not admissible in court, the polygraph has become another important tool in criminal investigations. The Breathalyzer was introduced in 1954, which gave the police another valuable tool for gathering evidence. In 1977, the FBI introduced the beginnings of its Automated Fingerprint Identification System (AFIS) with the first computerized scans of fingerprints. With the advent of newer, more reliable methods of using forensic evidence, forensic labs have multiplied in number over the last several decades. Modern forensic science still relies heavily on fingerprinting, ballistics, analyzing trace elements and DNA composition.

Objectives

The main objective of this unit is to show students real life applications of mathematics. Students will also see how math and science are related and integral to the practice of forensic science. Some specific skills students will develop during this unit include:

- Using logic and deductive reasoning to determine if a suspect committed a crime.
- Conduct an experiment to determine if evidence samples are blood.
- Compare and contrast fiber samples to find a match to criminal evidence.
- Calculate foot to height ratio for several people.

- Analyze different substances and classify them.

Strategies

The specific strategies employed to carry out the unit include cooperative learning, critical thinking, problem solving, deductive reasoning, and analyzing data. A list of mathematics standards addressed in this unit is found in Appendix D.

Classroom Activities

Lesson 1: Confirming the presence of blood

In this activity, students will conduct an experiment to determine the presence of blood. At a crime scene, investigators often perform simple preliminary tests to determine if a suspicious stain is actually blood. This test confirms the presence of the blood component hemoglobin. Hemoglobin is composed of two parts, heme, the iron-containing part and globin, a protein. It is the heme that is involved in the test. Heme acts as a catalyst to speed up the decomposition of hydrogen peroxide into water and oxygen gas. In the presence of heme, the stain will bubble and sometimes froth on the addition of hydrogen peroxide. Any “red-blooded” creature has heme in its blood. Heme is responsible for the red color.

To conduct the experiment, the teacher should prepare several “suspected” bloodstains. Beef blood can be obtained at the bottom of a ground meat container. A blood substitute can be made using ferric chloride. Use 1 gram of ferric chloride, 30 ml of water and 3 drops of red food coloring. Some non-blood samples could include motor oil, ketchup, food coloring or coffee. Students should collect the dried blood by scraping the samples with a suitable tool and placing them in an evidence container. The samples could also be prepared and tested on a piece of cardboard. Students should place 2-3 drops of hydrogen peroxide onto the stain. Wait 2-3 minutes while observing the stain carefully for the presence of tiny bubbles of gas.

Students should create a chart to record their data. They should include the sample number as well as any observations. Students should report results with a (+) if gas bubbles are observed or a (-) if no gas bubbles are observed.

Lesson 2: Fiber analysis

This activity gives students the opportunity to examine fibers. Forensic analysis of fibers involves visual and physical examination of properties such as

melting point, flame resistance, color, luster, roughness, and resistance to certain chemicals. For this activity, students will look at each fiber under a microscope and perform a simple flame test. Under a microscope, most natural fibers have a distinctive rough appearance. Silk and most synthetic fibers have smooth surfaces. This makes them difficult to distinguish from one another using just a microscope.

A simple flame test can be used to examine the characteristics of different fibers. In a flame test, the fiber is brought into contact with a flame. Different types of fibers may react differently, such as melting or burning, or producing a light or dark colored ash. By using both sets of observations, it should be possible to differentiate between the fibers being examined. To complete this experiment, students should complete the activity called, “The Jewelry Store Robbery.” The teacher should prepare the sample fibers in advance. The evidence fiber should match one of the fibers being tested. As students complete the experiment, they should complete the data sheet for fiber analysis found in Appendix A.

The Jewelry Store Robbery

While closing up at the end of the day, jewelry store owner, Miles Johnson discovered that five very expensive rings were missing from a still-locked display case. Police suspected an “inside job” since the lock on the case did not appear to have been tampered with. All employees had access to the key.

While examining the case, police discovered a small piece of red fiber that had gotten caught on a sharp piece of metal on the framework of the glass display case. Mr. Johnson said that most of the employees wore red clothing that day because a promotional photo for a Valentine’s Day sale was to be taken. Police contacted the photographer who supplied a color print of the photo.

Mr. Johnson identified the employees who were wearing red clothing. Police obtained search warrants and recovered the clothing worn on the day of the theft. Sample fibers were removed from each garment. The manufacturer’s label was used to identify each type of fabric.

Compare the fabric found in the jewelry case to the samples taken from the employees’ clothing. Who is the thief?

Microscopic Examination

1. Using forceps carefully remove a fiber sample from one of the sample bags and place it on a clean microscope slide. Place one drop of water on the sample and cover it with a cover slip. This type of sample preparation

is known as a “wet mount.” Place the slide in position on the microscope stage slide holder.

2. Examine the fiber sample using a magnification of 75X or 150X. Note any unusual characteristics on your data sheet. For example, does the fiber appear to be tightly or loosely braided? Are the fibers smooth or rough looking? Are the strands orderly arranged or very disorganized? Do they have a shiny or dull appearance?

Flame Test

1. Place a candle in a holder that will not be knocked over easily. Light the candle. Using forceps, remove a fiber sample from one of the sample bags.
2. Still using the forceps carefully move the fiber close to the flame. Observe what happens. Does the fiber melt, curl away from the heat, burst into flames, etc.?
3. Now put the fiber into the flame. Does it burn rapidly, slowly, or melt? Does it self-extinguish when removed from the flame or continue to burn? Blow out the burning fiber if necessary. Do not allow it to burn all the way to the forceps.
4. Observe the burned end of the fiber. Did the fiber melt? Did ash form? What color is the ash?
5. Record all of your observations on your data sheet.

Test the fiber sample from the crime scene and those recovered from the employees and compare the results. Does your data reveal who may be the thief?

Lesson 3: Foot to height measurements

The bones of the feet can tell a lot about a person. This simple activity illustrates that a person’s foot is approximately 15% of his or her height. To complete the activity, have students complete the spreadsheet found in Appendix B in which they list the individual’s name, height, and foot length. Have several adults remove their shoes and measure their height. Students should measure the left foot for consistency. Students should divide the length of each person’s left foot by his/her height. Then they should multiply the quotient by 100. The results of the calculations should be about 15, illustrating that the length of a person’s foot is approximately 15% of his or her height. When a forensic scientist has the length of a foot, the forensic scientist will be able to approximate the height of the individual.

Lesson 4: Powder analysis

A forensic scientist may discover powder at a crime scene. In order to determine if it is illegal or not the crime lab will identify the substance using chemistry. For this experiment you will need: a pencil, white paper, measuring spoons, white chalk, magnifying glass, eyedropper, water, sugar, salt, cornstarch, 4 sheets of black construction paper, 4 small jars, iodine solution, dish towel and vinegar.

Students should complete the following activities and fill out the Powder Analysis Chart with their results. The chart can be found in Appendix C.

Procedure:

1. Place one-fourth teaspoon of the four white powders on a sheet of black construction paper. Label the powders with the white chalk.
2. Study the powders with the magnifying glass. Examine what each powder looks like. How would you describe the powder's shape. Does it have large or small grains? Your observations should be written in the appearance column of the chart.
3. Examine the powders further by rubbing each powder between your fingers. Describe how each powder feels in the Texture column of the chart.
4. Determine if there is a smell to any of the powders. Record your findings in the Smell column of the chart.
5. Take the eyedropper and place a drop of water on each individual powder. Examine what happens. Do the powders dissolve? Is there a reaction? Write your observations in the Reaction to Water column.
6. Place one-half teaspoon of each powder in a separate jar. Add 2 drops of iodine to each jar using the eyedropper. Record what happens in the Reaction to Iodine column.

Comparing test results of substances that are known help forensic scientists identify unknown substances. After analyzing and recording results of each substance, have someone leave the room and put a sample of one of the powders on construction paper. See if the person can perform the same tests to determine what the powder is.

Annotated Bibliography/Resources

Evans, Colin. The casebook of forensic detection: How science solved 100 of the world's most baffling crimes. New York: John Wiley and Sons, 1996.

A book that looks at science and how it helped to solve crimes throughout history.

Frollini, Rosemary. Super Sleuths.

A curriculum unit developed by the Department of Chemical Engineering at Carnegie Mellon University.

Owen, David. Hidden Evidence: Forty True Crimes and How Forensic Science Helped Solve Them. Buffalo: Firefly Books, 2000.

A book that explains the application of forensic science in solving real crimes.

<http://www.cyberbee.com/whodunnit/crime.html>

A website that offers various activities for teachers to use in their classrooms.

<http://www.howstuffworks.com/dna-evidence.htm>

A very simple explanation of DNA and its use in solving crimes.

http://www.crimelibrary.com/criminal_mind/forensics/trace/2.html?sect=21

Court TV profiles of famous cases.

<http://www.192.211.16.13/curricular/forensics/Forensics3workshopans.pdf>

Blood typing word problems.

<http://www.forensicdna.com>

Historical timeline of developments in forensic science.

Appendix A

Data Sheet for Fiber Analysis

Sample #	Source	Fiber Type	Near Flame	In Flame	Microscopic Examination
1	Mrs. Robinson	100% cotton			
2	Mr. Bates	nylon			
3	Miss Marpole	Silk			
4	Mr. Rogers	Acrylic			
5	Ms. Hathaway	Rayon			
6	Mr. Dillon	Polyester			
7	Evidence	unknown			

Appendix B

Foot to Height Measurements

Name	Foot length in inches	Multiply By 100	Divide by 15	Approximate Height in Inches	Divide by 12	Height in Feet (decimal)	Height in Feet and Inches

Appendix C

Powder Analysis

Substance	Appearance	Texture	Smell	Reaction to Water	Reaction to Iodine	Reaction to Vinegar
Baking Soda						
Sugar						
Salt						
Cornstarch						

Appendix D

Content Standards Addressed

Mathematics Standards

1. All students use numbers, number systems, and equivalent forms (including numbers, words, objects and graphics) to represent theoretical and practical situations.
2. All students compute, measure, and estimate to solve theoretical and practical problems, using appropriate tools, including modern technology such as calculators and computers.
3. All students apply the concepts of patterns, functions and relations to solve theoretical and practical problems.
4. All students formulate and solve problems and communicate the mathematical processes used and the reasons for using them.
5. All students understand and apply basic concepts of algebra, geometry, probability and statistics to solve theoretical and practical problems.
6. All students evaluate, infer and draw appropriate conclusions from charts, tables and graphs, showing the relationships between data and real-world situations.