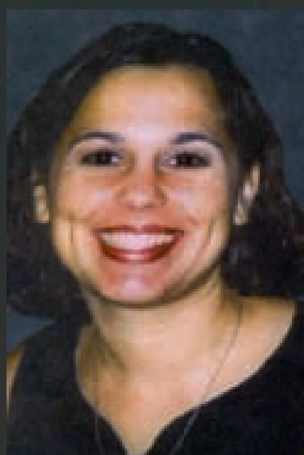
CHAPTER 3

Forensic Laboratory Techniques

WHERE IS LACI?



REUTERS/LOU DEMATTEIS/FILE LD/GN

Figure 3-1. Laci Peterson.

Laci Peterson was 27 years old and in her eighth month of pregnancy when she disappeared from her home in Modesto, California, on December 24, 2002. She was last seen walking her dog that morning at 10:00 a.m. Her husband Scott returned home from a fishing trip and discovered that Laci was gone. Trying to locate her, he contacted friends and family. He reported her missing shortly before 6:00 p.m.

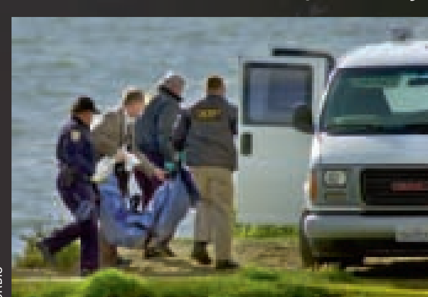
Over the next three days, police, firefighters, and volunteers searched for Laci, but there was no sign of her. A grid-pattern search along Dry Creek revealed no evidence. Three days after her disappearance, the FBI joined in the investigation, and the Peterson home was searched.

Peterson had been a suspect in his wife's disappearance almost from the beginning. When he confessed to having a romantic relationship with another woman, he became a very strong suspect. Peterson maintained that he had told Laci about his indiscretion and that it was not something that would have ended their marriage. At first, Laci's parents supported Peterson. When it was also discovered that he had taken out a $250,000 life insurance policy on Laci, they stopped.

As time passed, evidence against Peterson mounted. A powdery substance found on Peterson's boat was identified as concrete dust. A long, dark hair caught on pliers was found in the same fertilizer warehouse where Scott, a fertilizer salesman, had stored his boat. Forensic scientists used comparison microscopes to compare this hair to hair known to be Laci's. They examined the cuticle, pigmentation, and medulla. Recall from previous coursework that the cuticle is the outer layer of hair. The medulla is the center core. The hair found at the warehouse was consistent with Laci's hair. Scott Peterson had purchased a four-day fishing license on December 20, but he told police he hadn't decided to go fishing until the morning of Laci's disappearance (December 24). His blood was found on the driver's door inside his truck.

On April 13, 2002, the body of a fetus with the umbilical cord still attached washed ashore near Point Isabel in Northern California. The next day, a female's body was discovered in a park near Point Isabel. DNA testing revealed them to be the bodies of Laci and her baby, Conner.

Scott Peterson was convicted of the two murders and sentenced to death by lethal injection.



CHRIS HARDY/SAN FRANCISCO CHRONICLE/ CORBIS

Figure 3-2. Laci's body being loaded into the van.

OBJECTIVES

By the end of this chapter, you will be able to:

3.1 Distinguish between physical and chemical properties.

3.2 Describe presumptive and confirmatory tests.

3.3 Compare and contrast different types of microscopes.

3.4 Explain how qualitative analysis differs from quantitative analysis.

3.5 Differentiate between thin-layer chromatography, gas chromatography, and high-performance liquid chromatography.

3.6 Calculate R_f (retention factor).

3.7 List and describe three types of spectroscopy.

3.8 Compare and contrast techniques for visualizing fingerprints.

3.9 Describe the structure of DNA.

VOCABULARY

chemical property - property of a substance that describes how it reacts in the presence of other substances

chromatography - any of several processes used to separate a mixture into its individual components based on their attraction to a stationary liquid or solid

confirmatory test - test done to establish with certainty the characteristics of a substance

frequency - the number of waves that pass a specific point within a given time; usually expressed in cycles per second or hertz (Hz)

physical property - property of a substance that can be observed or measured without changing the chemical identity of the substance

presumptive test - a test to screen evidence and narrow down the possible type of a substance

R_f value - retention factor; in paper and thin-layer chromatography, ratio of the distance a substance traveled to the distance the solvent traveled

wavelength - the distance between crests, or peaks, of two consecutive waves

Obj. 3.1 INTRODUCTION

Hairs and fibers found at a crime scene can give investigators a great deal of information. Microscopy and other analytical techniques can be used to determine whether the hairs came from a human or another animal. These techniques also help investigators determine whether the fibers came from carpet, clothing, or something else.

In the crime lab, forensic scientists compare samples of evidence from the crime scene to known samples. The evidence samples are called *questioned samples*. The known samples are called *controls*. Ultimately, investigators hope to identify the evidence samples through specific physical and chemical properties.

Physical properties are properties that can be measured without changing the identity of the evidence. For example, when forensic scientists calculate the density of glass, they divide the mass of the glass by its volume. Measuring mass and volume does not affect the chemical makeup of the glass. Therefore, density is a physical property. Other physical properties include color, melting point, boiling point, odor, and viscosity. Changes to substances that do not alter the chemical makeup of the substance—cutting, shredding, melting, or freezing—are physical changes.

CHEMISTRY

Chemical properties determine how a substance behaves in the presence of other substances. For example, iron will react with oxygen in the presence of water to produce rust, or iron oxide. Changes to a substance that alter its chemical identity are chemical changes. Rusting, burning, and decomposing are chemical changes. When chemical testing is done on evidence, the original evidence sample is often destroyed.

Obj. 3.2 PRESUMPTIVE AND CONFIRMATORY TESTS

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Figure 3-3. Presumptive test for blood.

At a crime scene, field investigators must make immediate decisions regarding potential items of evidence. For example, if an investigator finds a red stain at a homicide scene, he or she must conduct initial tests to narrow down the possible identity of the stain. Although it is easy to assume that the red stain is human blood, it could also be paint, ketchup, or blood from an animal. **Presumptive tests** allow a field investigator to screen evidence to reduce the number of possibilities and to get a preliminary identification. If presumptive tests at the scene show that the red stain is blood, investigators will collect additional samples. The tests do not, however, tell crime-scene investigators whether the blood is from a human or another animal. These samples are sent to the lab for **confirmatory tests.** Confirmatory tests are used to make a more specific identification. A confirmatory test would determine whether the blood belonged to a human or some other animal (see Figure 3-3).

Presumptive tests exist for saliva, semen, blood, urine, and vaginal secretions. There are also presumptive tests for many kinds of drugs. Presumptive tests screen for chemicals in each fluid. At the crime scene, investigators might use a

UV (ultraviolet) light, or another alternative light source, to determine whether a stain is a body fluid. If so, a sample will be collected and sent to the lab. At the lab, forensic scientists may perform presumptive tests to determine what kind of body fluid. For example, semen contains the enzyme acid phosphatase. Although this enzyme is found in other fluids, including vaginal secretions, it is found in much higher concentrations in semen. The presumptive test for semen is actually screening for acid phosphatase. To definitively identify the evidence as semen, confirmatory testing would be completed at the crime lab. For example, the fluid may be viewed under a microscope. If sperm is present, the fluid is semen. In this case, microscopy is a confirmatory test. To identify the person who produced the semen, the sample must undergo more specialized confirmatory tests, such as DNA profiling. Presumptive testing reduces costs and aids field investigators in collecting evidence essential to the case. Confirmatory tests are necessary to identify, with certainty, a piece of evidence. Each test plays an integral role in forensic investigations.

BIOLOGY

MICROSCOPY

Obj. 3.3

Prior to the mid-1600s, microscopes could magnify a specimen only about six to ten times its original size. In 1665, Robert Hooke published a book called *Micrographia*. In it, he described cork cells. Hooke was the first to observe cells; he used the term *cells* because the dead cork cells looked like small rooms. In 1676, Antoine van Leeuwenhoek was the first to observe single-celled microscopic organisms. Today, there are several different kinds of microscopes. Some can magnify an object hundreds of thousands of times.

Did You Know?

Some of the earliest microscopes were simply magnifying glasses. Looking at small insects like gnats and fleas was very common. For that reason, microscopes were sometimes referred to as *flea glasses.*

COMPOUND LIGHT MICROSCOPE

The compound light microscope is probably the most widely used microscope today. This microscope has a light source and multiple lenses to obtain high magnification. The compound microscope usually has a magnification between 40× (40 times) and 1,000× (1,000 times). Compound microscopes are powerful enough to view hair, fibers, and cells. Figure 3-4 shows a cross-section of an artery through a compound light microscope at different magnifications.

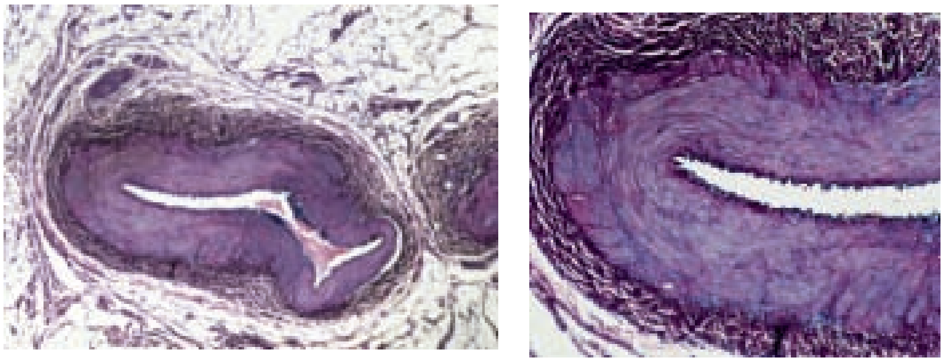

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Figure 3-4. *The image on the left has been magnified 40×. The image on the right has been magnified 100×.*

OMAR TORRES/AFP/GETTY IMAGES

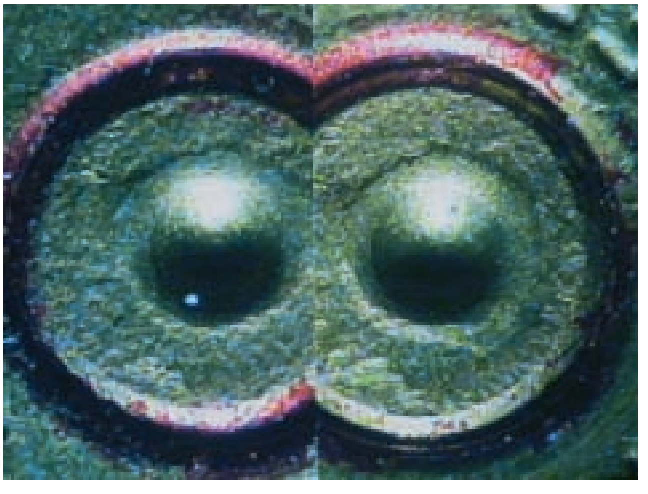
Figure 3-5. *Comparison microscope.*

STEREOMICROSCOPE

A compound microscope works by sending light through the specimen. Sometimes, a specimen is too thick or opaque to be seen through a compound microscope. The light of a stereomicroscope, or dissecting microscope, is reflected from the surface of the specimen. Because the light is reflected, the stereomicroscope produces a three-dimensional image useful for dissecting. Surface details are also more visible with the stereomicroscope. Forensic investigators use a stereomicroscope to examine insect larvae, paint chips, and other small items of evidence.

COMPARISON MICROSCOPE

The comparison microscope is another useful tool (see Figure 3-5). The comparison microscope is actually two microscopes connected to one eyepiece. When the investigator looks through the eyepiece, he or she sees a circular, split-view window. The image on the right is of the specimen under the microscope on the right and can be compared side-by-side to the image on the left. The comparison microscope is particularly useful when comparing bullet striations, fibers, and hair samples. Investigators are able to make comparisons while viewing two samples at the same time (see Figure 3-6). Usually, the investigators will compare a known sample to a questioned sample.



PHILIPPE PSAILA

Figure 3-6. *Images of two bullet casings as seen through a comparison microscope. One casing was found at the crime scene. The other was taken from the suspect's gun.*

ELECTRON MICROSCOPES

Compound microscopes, stereomicroscopes, and comparison microscopes all use light. Electron microscopes, on the other hand, use beams of electrons to form images. These microscopes can magnify materials up to 500,000× with good resolution, but the image is in black and white. The *transmission electron microscope (TEM)* passes a beam of electrons through a thin slice of a specimen. This produces images of internal structures. The *scanning electron microscope (SEM)* passes a beam of electrons over the surface of a sample to produce a three-dimensional image. This image provides details about the surface of the sample. Forensic investigators use electron microscopes to analyze small specimens and to view tiny surface or internal details. SEM is also an important step in the determination of the identity of trace materials, such as gunshot residues.

CHROMATOGRAPHY

Obj. 3.4, 3.5, 3.6

Most analytical techniques can be classified as either quantitative or qualitative. A quantitative analysis will result in a measurable amount—a quantity. Qualitative analysis, on the other hand, will result in a description or identification of the components of a mixture. In chemistry, a *mixture* is the combination of two or more substances. The substances in a mixture do not react chemically. Therefore, they can be separated based on their physical properties.

Qualitative tests are based on the physical and chemical properties of the sample. **Chromatography** separates substances within a mixture based on their physical properties. Different substances will adhere, or stick, to solid surfaces or dissolve in a solvent differently. In paper chromatography, a small amount of a liquid mixture is placed near the bottom of a piece of paper. Usually, a scientist will place a drop of an unknown mixture and a drop of a known mixture several millimeters apart. The known mixture acts as the control. The bottom of the paper is placed into a liquid solvent. The solvent must be lower on the paper than the samples. The solvent moves up the paper and is called the *mobile phase*. The paper itself is called the *stationary phase* because it does not move. You have probably seen a liquid move along a piece of paper. If you spill a little water on a paper towel, for example, the water will spread out. In paper chromatography, the liquid solvent spreads across the paper in much the same way. As the liquid solvent moves up the paper, different components of the mixture will adhere to the paper at different places. These components leave marks on the paper.

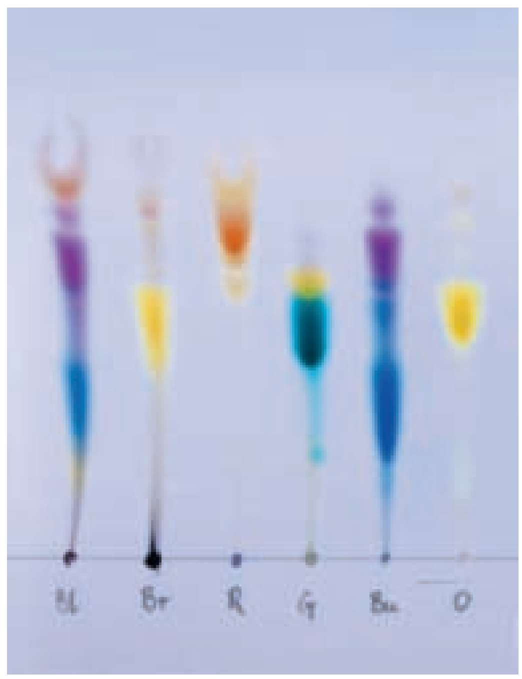


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Figure 3-7. *Chromatogram from paper chromatography.*

The result of any chromatography is a called a *chromatogram* (see Figure 3-7). A chromatogram shows substances that were dissolved in the original mixture. The chromatogram also shows how far the solvent traveled. Investigators can identity components of the original

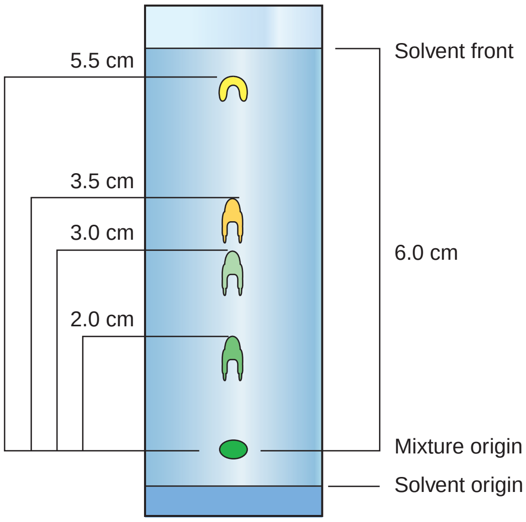


Figure 3-8. *Chromatogram used for calculating R_f.*

mixture by calculating the retention factor, or the R_f value. The R_f value is a qualitative comparison between the length of time the substance is in the mobile phase and in the stationary phase. In paper chromatography, the **R_f value** is the ratio of the distance the substance traveled to the distance the solvent traveled. Chromatography can be done with different solvents to establish the identity of an unknown substance. The R_f value for each substance will depend on the solvent being used. First, the investigator measures how far the solvent traveled. The line that shows where the solvent stopped moving is called the *solvent front*. The investigator then measures how far each dissolved substance traveled. For example, if the substance traveled 3.0 cm and the solvent traveled 6.0 cm, as in Figure 3-8, the R_f is calculated as follows:

$$R_f = \frac{\text{Distance substance traveled}}{\text{Distance solvent traveled}}$$

$$R_f = \frac{3.0 \text{ cm}}{6.0 \text{ cm}}$$

$$R_f = 0.5$$

Chromatography is used in forensic science to analyze dyes in fibers, test for explosives or accelerants, and to check body fluids for the presence of drugs. More sophisticated forms of chromatography have replaced paper chromatography in forensic laboratories in recent years. Most other chromatographic techniques pass liquid or gas through a column or tube packed with a porous solid material. Thin-layer chromatography (TLC), gas chromatography (GC), and high-performance liquid chromatography (HPLC) are commonly used in forensic laboratories. TLC is similar to paper chromatography, but the stationary phase is a thin layer of gel-like material on a glass or plastic plate. TLC is faster and produces clearer separation than paper chromatography. Both paper and thin-layer chromatography are useful for separating dyes and inks. GC is performed at high temperatures and is useful for separating mixtures that contain large molecules, such as the proteins found in blood. HPLC uses high pressure to force mixtures through a column of liquid. Unlike GC, HPLC can take place at room temperature. Therefore, HPLC can be used to test for the presence of flammable materials, such as explosives or accelerants, which may be found during an arson investigation. Figure 3-9 shows a sample of a gas chromatogram.

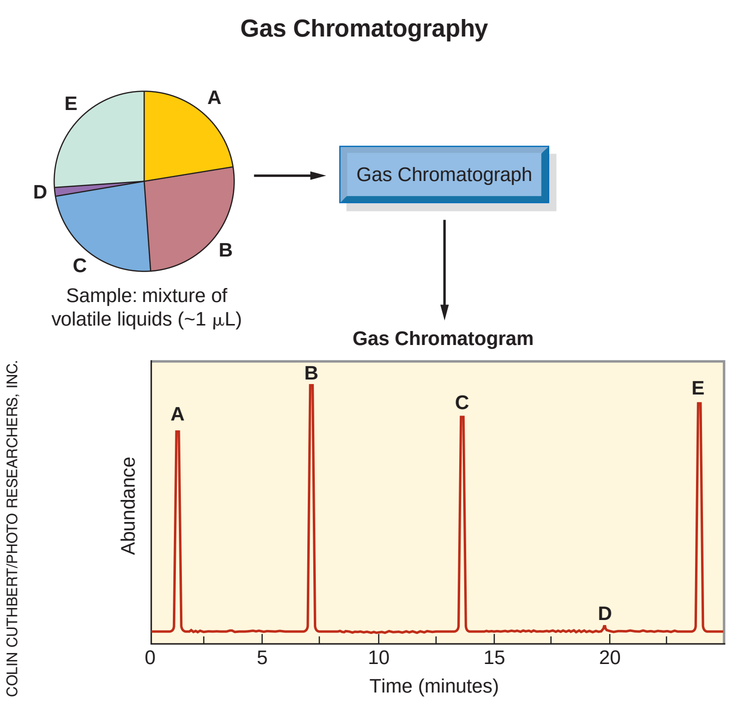
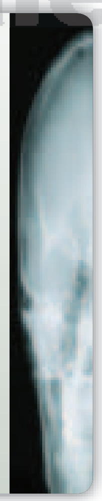


Figure 3-9. *Gas chromatography helps forensic scientists determine the components of a mixture. Each spike represents a different component of the mixture. The relative heights tell the scientist the relative abundance of each component.*

Digging Deeper
with Forensic Science e-Collection

Many people die each year because someone was driving while intoxicated. Alcohol impairs reflexes, which makes driving extremely dangerous. But how much is too much? For people under the age of 21, it is illegal to consume any alcohol. States have laws that define legal blood alcohol levels for drivers over 21. Confirmatory tests for blood alcohol levels use gas chromatography. New presumptive tests are very accurate and can give law-enforcement personnel the information they need much more quickly. Using the Gale Forensic Science eCollection at www.cengage.com/school/forensicscienceadv, research current techniques used to get quicker results for law enforcement.



ELECTROMAGNETIC RADIATION

Light travels in electromagnetic waves. The highest point in the wave is called the *crest*. The distance between two consecutive crests is the **wavelength. Frequency** refers to how many waves pass a specific point within a given time. Therefore, a wave with a high frequency will have a short wavelength (see Figure 3-10). Visible light, X-rays, radio waves, and microwaves are all electromagnetic waves. Electromagnetic waves can be organized into the electromagnetic spectrum, based on their wavelengths and frequencies. Forensic scientists use the electromagnetic spectrum (see Figure 3-11) to search for latent fingerprints, examine articles of clothing for trace evidence, or determine the structure of a molecule.

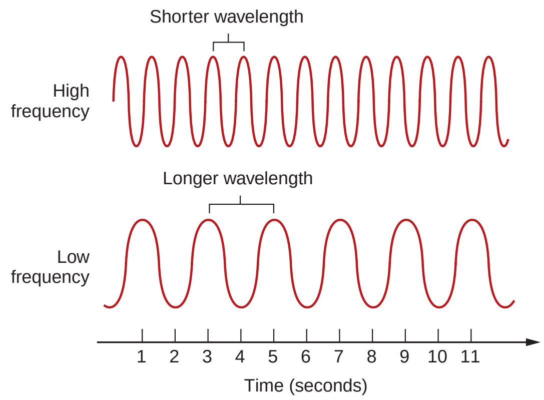


Figure 3-10. *Higher frequency waves have shorter wavelengths.*

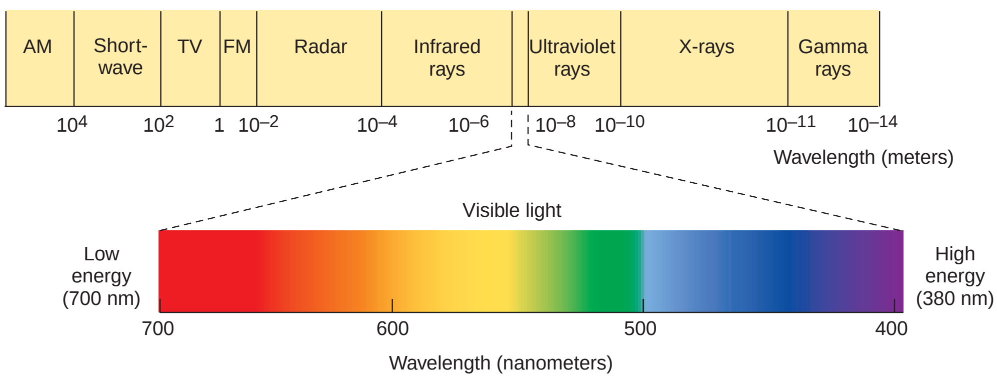


Figure 3-11. *The electromagnetic spectrum is divided into wavelength ranges, or bands. Visible light has a wavelength between 380 and 760 nm (nm = 10^{-9} m).*

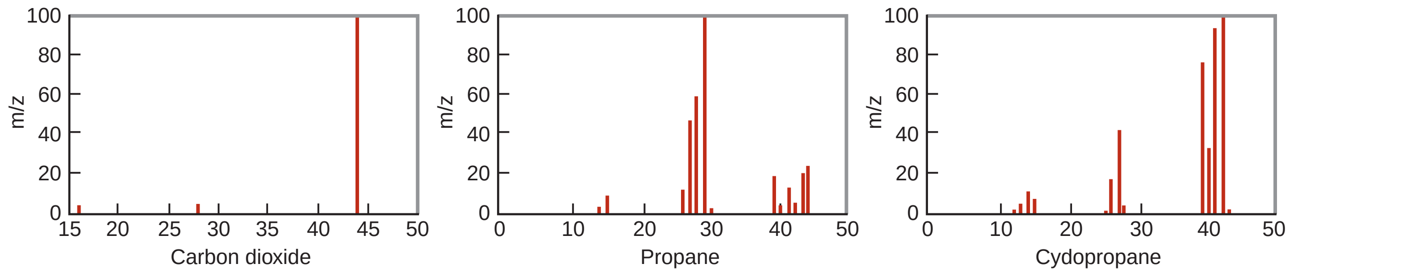


Figure 3-12. *Spectrographs of carbon dioxide, propane, and cyclopropane.*

Obj. 3.7

SPECTROSCOPY

When a substance is heated, it emits light at a specific wavelength. Electromagnetic spectroscopy uses this chemical property to determine what elements are present in a sample. Spectroscopy can be used to identify fibers and other trace evidence. It can also be used to detect contaminants in various materials. Spectroscopy can detect accelerant and explosive residue. An electromagnetic spectrograph measures the wavelengths of light emitted and captures a spectral image on photographic film. The spectral image is a series of lines (see Figure 3-12). Each element produces a unique line in the spectral image. So, the pattern of lines tells the scientists which elements are found within the sample. Spectroscopy also measures the amount of light absorbed, which can be used to determine the concentrations. There are several forms of spectroscopy. Mass spectroscopy is often combined with gas chromatography to identify atoms and molecules by their masses. A sample is loaded into the mass spectrometer and vaporized and ionized, forming charged particles called *ions*. The ions are then sent through a magnetic or electric field. The path of the ion depends on the ratio of its mass to its charge. The results are recorded on a photographic plate. Every chemical has a unique mass spectrum, making mass spectroscopy useful as a confirmatory test.

Atomic absorption spectroscopy (AAS) measures the amount of light of a specific wavelength absorbed by atoms of a particular substance. This technique is especially useful in determining heavy-metal contaminants in air, water, and soil samples. It is also useful when analyzing paint chips. This technique can help forensic scientists determine whether soil or paint at the crime scene can be linked to another location. A link may help connect a suspect or victim to the crime.

Ultraviolet (UV) spectroscopy measures wavelengths of light and can be used to determine the concentration of different elements in a solution. The graph produced by UV spectroscopy is compared to that of known substances as part of a quantitative analysis of the data. UV spectroscopy can be used to detect drugs in blood or urine, analyze components of dyes and food additives, and monitor air and water quality.

Did You Know?

In June 2008, a partial fingerprint on a painting called "Young Girl in Profile in Renaissance Dress" confirmed that the painting was a da Vinci original. The fingerprint was consistent with two other fingerprints found on da Vinci works. In 1995, the painting sold for $19,000. The painting is now worth $160 million.

Obj. 3.8

FINGERPRINT-DEVELOPING TECHNIQUES

Often, crime-scene investigators find objects and surfaces at a crime scene that were touched by the victim or perpetrator of the crime. The person may have left fingerprints behind. These fingerprints can be a very important piece of evidence. Most of the time, the fingerprints are latent, or invisible. Certain chemical and physical properties of fingerprints make it possible for a latent fingerprint examiner to use a variety of techniques to lift and visualize these prints. For example, most body fluids can be seen with a high-intensity UV light. This light helps investigators detect the presence of fingerprints. Another well-known technique for visualizing fingerprints is called *dusting for fingerprints* (see Figure 3-13). Investigators apply finely ground powders to the surface with a soft brush. The powders stick to fingerprint residues, making the print visible. The print can then be lifted with adhesive tape and placed on a labeled card. The powders come in a variety of colors. The color of the object or surface being analyzed for prints determines the color of the powder used.


SEAN JUSTICE/CORBIS

Figure 3-13. *Dusting for fingerprints.*

CYANOACRYLATE FUMING

Dusting works best on fresh fingerprints. Sometimes, however, latent fingerprints are not found right away. To view prints found on nonporous substances, such as glass and many plastics, crime-lab technicians may need to use cyanoacrylate, or Super Glue®. When heated, the cyanoacrylate reacts with traces of proteins and fatty acids in the fingerprint. The technique is called *cyanoacrylate fuming* or *Super Glue fuming*. The item being analyzed is placed or suspended inside an enclosed fuming chamber (an aquarium with a lid will work) along with warmed water. The glue is placed in a small container inside the chamber and heated. The fumes react with the fingerprints, and the fingerprints become whitish in color. Although the technique is not difficult, it is potentially hazardous. The fumes are irritating to mucous membranes and should never be inhaled.

CHEMISTRY

Did You Know?

Super Glue fuming was first used in 1978 by the Criminal Identification Division of the Japanese National Police Agency.

SILVER NITRATE

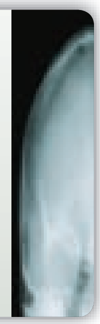
Crime-lab technicians may use silver nitrate ($AgNO_3$) solution instead of cyanoacrylate to detect fingerprints left on nonporous surfaces. The solution reacts with salts in perspiration in the fingerprint to form silver chloride ($AgCl_2$). Under an ultraviolet light source, the silver chloride will appear black.

NINHYDRIN

If the latent prints are found on porous surfaces, such as wood, fabrics, and concrete, technicians may use ninhydrin. Ninhydrin reacts with the amino acids in the fingerprints to produce a purple fingerprint. Ninhydrin may be sprayed on the item or the item may be dipped into the ninhydrin. It takes up to 48 hours to develop fingerprints in this manner. However, heating the surface will increase the rate of the reaction.

Digging Deeper
with Forensic Science e-Collection

DFO is a relatively new method used to enhance fingerprints. Using the Gale Forensic Science eCollection at www.cengage.com/school/forensicscienceadv, research DFO and investigate a case in which DFO was instrumental. Discuss the key elements of the case. Additionally, describe how this case relates to the Frye standard introduced in Chapter 1.



DIAZOFLUOREN

CHEMISTRY

Ninhydrin is often used to develop prints found on paper. However, diazofluoren (DFO) is even more effective than ninhydrin. The paper is dipped into the DFO for 10 seconds and then allowed to dry. DFO reacts with amino acids in the fingerprints. For the best results, the process may need to be repeated. The developed fingerprints may not be visible to the naked eye. However, they will be visible when viewed under a blue-green light.

Did You Know?

Many people who have fingerprint cards on file have never been accused or convicted of a crime. For example, the fingerprints of teachers, military personnel, civil servants, and adoptive parents are included in the database.

VACUUM METAL DEPOSITION

Another technique uses a vacuum metal deposition chamber to evaporate gold and zinc. The gold is attracted to the thin layer of tissue left by the latent fingerprint. The zinc condenses on the gold coating and between the fingerprint ridges. This technique works best on nonmetal surfaces. It has also been somewhat successful in developing fingerprints on finely woven fabrics. Figure 3-14 summarizes some of the fingerprint-developing techniques described here.

FINGERPRINT DATABASES

Once latent fingerprints have been developed, they must be photographed. The photograph is scanned and digitized. Forensic scientists can then compare the print with other prints stored in a database. The database provides a set of potential matches. The scientist compares the potential matches to make the final identification. The FBI maintains the Integrated Automated Fingerprint Identification System (IAFIS). Some state and local agencies maintain databases as well.

Process	Surfaces	Adheres to
Dusting	Nonporous	Residues
Cyanoacrylate fuming	Nonporous	Proteins, fatty acids
Ninhydrin	Porous	Amino acids
Diazofluoren	Porous	Amino acids
Silver nitrate	Nonporous	Salts
Vacuum metal deposition	Nonmetal	Gold is attracted to the tissue; zinc adheres to the gold

Figure 3-14. *Summary of some fingerprint-developing techniques.*

DNA ANALYSIS

Obj. 3.9

Deoxyribonucleic acid (DNA) is found in the cells of all organisms. It can be detected in blood, saliva, semen, tissues, hair, and bones. With the exception of identical twins, each person's DNA is unique. Therefore, DNA samples provide individual evidence to tie a suspect to the crime or to identify a victim. DNA analysis can also be used to determine paternity or to detect genetic disease.

DNA is a very long double-stranded molecule made up of units called *nucleotides*. Each nucleotide is composed of a sugar, a phosphate, and a nitrogenous base. The sugar is called *deoxyribose*. There are four different bases—adenine, guanine, thymine, and cytosine. The structure of DNA is sometimes referred to as a twisted ladder (see Figure 3-15). The sugar and phosphate form the sides of the ladder. The bases make up the rungs of the ladder. Adenine always pairs with thymine; cytosine always pairs with guanine. The uniqueness of each person's DNA comes from the sequence of the base pairings along the ladder.

A *DNA fingerprint* is a DNA pattern that distinguishes one individual from another. A DNA fingerprint can be used to determine whether two samples are from the same person, related people, or unrelated people. Gel electrophoresis is one technique involved in the production of a DNA fingerprint. The process is a form of chromatography. Segments of DNA are separated by size through a gel (the stationary phase) by a mild electric current (the moving phase). Chapter 10 discusses in detail the various techniques for extracting and analyzing DNA.

3DRENDERINGS/SHUTTERTSTOCK

Figure 3-15. *Three-dimensional structure of DNA.*

CHAPTER SUMMARY

- Physical properties are characteristics that can be observed and measured without changing the chemical identity of the substance.
- Chemical properties are characteristics that determine the way a substance interacts with other substances.
- Presumptive tests screen evidence for possible identification. Confirmatory tests determine the identity of evidence.
- The comparison microscope is one of the most useful tools in forensic investigations because it allows for the side-by-side comparison of samples.
- Most analytical techniques can be classified as either quantitative or qualitative. Quantitative analysis will always produce a number or a proportion. Qualitative analysis will always provide a description or statement.
- Chromatography is used to separate a mixture into its individual components.
- Wavelength is the distance between peaks of consecutive waves.

- Frequency is the number of waves that pass a specific point in a given amount of time.
- Electromagnetic spectroscopy measures the wavelength of light emitted when a substance is heated. Mass spectroscopy separates atoms and molecules according to mass.
- Fingerprint-developing techniques include dusting, cyanoacrylate fuming, silver nitrate, and vacuum deposition chambers.
- Repeating patterns of DNA base pairs are used to produce a DNA fingerprint. A DNA fingerprint can be used to determine whether two DNA samples are from the same person or related people.

CASE STUDIES

Gerald Fit Mason

On July 21, 1957, four teenagers were parked near oil fields in Hawthorne, California. A man walked up to the car and pointed a gun at the driver. He robbed the teens and raped one of the girls. He then stole the car. About 30 minutes later, he was pulled over for running a red light. As the two officers were walking away, he shot them. Both officers were killed. Several hours later, an abandoned 1949 Ford was found. The crime-scene unit took photos of the vehicle and dusted for fingerprints. Two partial latent prints of a thumb were found on the steering wheel, but investigators were unable to find a match. Unfortunately, the case went cold.

Forty-six years later, the LA County Criminalistics Unit reexamined the two partial prints. Investigators used cutting-edge digital fingerprinting technology to make digital copies of the prints. They stitched together the prints collected from the steering wheel and ran the print through the Integrated Automated Fingerprinting Identification (IAFIS) database. Investigators were able to determine that the print was consistent with the fingerprints of Gerald Fit Mason (see Figure 3-16).

On January 24, 2003, an official complaint was filed. Later, detectives arrested Mason for rape, murder, and robbery. On March 21, 2003, Mason confessed. Forty-six years after he committed these crimes, Mason was sent to jail. He is serving two life sentences.

AP PHOTO/ANNE CUSACK, POOL

Figure 3-16. *Gerald Fit Mason*

Think Critically
1. **Discuss some reasons why you think this case may have gone cold.**
2. **Why do you think a criminalistics department would reopen a case after nearly 50 years?**
3. **Had this crime taken place today, what additional evidence may have been collected and how would it have been processed?**

Roger Reece Kibbe: The I-5 Strangler

Over the course of a decade, several women were murdered along Interstate 5 near Sacramento, California. Each of the victims was strangled and bound in a similar manner. The killer had cut the victims' hair and cut their clothes in unusual patterns. These similarities suggested that the same person had murdered all the victims.

Eventually, Roger Reece Kibbe (see Figure 3-17) was charged with killing Darcie Frackenpohl, a 17-year-old runaway. Extensive microscopic and fiber analysis was presented at trial. Investigators had used a comparison microscope to determine that a rope found in Kibbe's car was the same kind of rope used to strangle Darcie. Electron microscopy showed that the ropes had 10 elements in common. The electron microscope analysis also showed that paint had been sprayed near each rope. Both had traces of the same air contaminants.

On May 10, 1991, Kibbe was sentenced to 25 years to life in prison. He was not eligible for parole for a minimum of 16 years and 8 months.

Figure 3-17. *Roger Reece Kibbe*

Think Critically 1. **Was the analysis described in this case study quantitative or qualitative? Explain.**

2. **Hair that was consistent with Kibbe's two cats was found on the clothing of one of the victims. Was this class or individual evidence? What is the relevance of the fact that the hair was from two different cats?**

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CAREERS IN FORENSICS

Science, Technology, Engineering & Mathematics

Gene Cushing: Latent Fingerprint Expert

Gene Cushing (see Figure 3-18) has been a crime-scene investigator for the Lake County, Florida, Sheriff's Office (LCSO) since November 1996. He is a court-certified expert in processing scenes and items of evidence for latent fingerprints. He is also the bloodstains expert for the LCSO and is often called in to document and interpret bloodstains at crime scenes. He has taken extensive training in basic crime-scene procedures, forensic science, tire and shoe documentation and recovery, evidentiary photography, medicolegal investigation of deaths, and blood pattern analysis.

Figure 3-18. *Gene Cushing.*

Currently, the LCSO requires only that applicants for crime-scene investigator positions have a high-school diploma. Cushing points out, however, that most recently hired investigators have four-year college degrees in Forensic Science or in Criminal Justice and Forensic Justice.

Cushing says that most people think that what they see on popular television crime dramas is a portrayal of what he does every day. For example, jurors often expect crime and evidence to be handled precisely and expertly in an hour. Additionally, these televisions shows misrepresent automated fingerprint identification systems. These systems do not give a person's name, address, or place of employment, and they do not determine matches. Actual confirmation is achieved manually.

Gene's typical day involves processing crime scenes, following up on pending cases, and processing evidence for latent prints. He usually receives subpoenas for latent print evidence about twice a month, but he rarely appears in court. Because fingerprints are individual evidence, defendants often settle the case without going to trial.

Gene's favorite part of his job is that LCSO has had the good fortune to receive some of the best equipment available. The sophisticated equipment lessens the likelihood of closing cases without prosecution. To him, the most challenging part of the job is having cases with more questions than answers. One such case would be Gene's investigation into the disappearance of still-missing two-year-old Trenton Duckett from his Lake County home in 2007.

Learn More About It

To learn more about forensic science careers, go to www.cengage.com/school/forensicscienceadv.

CHAPTER 3 REVIEW

Matching

1. the distance between peaks of consecutive waves *Obj. 3.7*
2. property described by behavior in the presence of another substance *Obj. 3.1*
3. the number of waves that pass a specific point within a given amount of time *Obj. 3.7*
4. property of substance that can be observed or measured without changing the composition of the substance *Obj. 3.1*

a. frequency
b. wavelength
c. physical property
d. chemical property

Multiple Choice

5. Which of the following is a physical property? *Obj. 3.1*
   a. density
   b. mass
   c. melting point
   d. all of the above

6. A fiber found at a crime scene is burned during a burn test. The investigator observes several things, including the rate of the burn, the color of the flame and ashes, and the smell released, to determine the identity of the fiber. What kind of change is taking place during a burn test? *Obj. 3.1*
   a. physical
   b. chemical
   c. complete
   d. none of the above

7. Which of the following microscopes shines light through the specimen, allowing observation of cells? *Obj. 3.3*
   a. comparison microscope
   b. dissecting microscope
   c. compound light microscope
   d. electron microscope

Short Answer

8. Distinguish between physical properties and chemical properties. Give examples of each. *Obj. 3.1*

9. Why is it important to reserve some of the evidence sample when completing chemical tests? *Obj. 3.1*

10. Differentiate between presumptive and confirmatory tests. *Obj. 3.2*

11. Why is a comparison microscope a useful tool in forensic investigations? *Obj. 3.3*

12. Compare and contrast the scanning electron microscope and the transmission electron microscope. *Obj. 3.3*

13. What types of materials can be analyzed using chromatography? Be specific about which type of chromatography is best for each substance. *Obj. 3.5*

14. List and describe two forms of spectroscopy. *Obj. 3.7*

15. Distinguish between the six kinds of fingerprint-developing techniques described in this chapter. *Obj. 3.8*

16. In a paper chromatography experiment, the solvent traveled 5.0 cm. Substance A traveled 3.0 cm. What is the R_f value of substance A? *Obj. 3.6*

17. Describe the structure of DNA. *Obj. 3.9*

18. Explain the difference between quantitative and qualitative analysis. Give an example of a technique that aids in each. *Obj. 3.4*

Think Critically

19. A woman was found dead in her office one Saturday morning. She had been shot in the back of the head. It was clear that the perpetrator had opened the metal drawers of the woman's desk and searched through several files. Which fingerprint-development techniques would the latent fingerprint expert be most likely to use to visualize any fingerprints found at the scene? Obj. 3.8

20. In the scene described in question 19, the investigators found a bullet lodged into the window frame above the woman's desk. What kinds of equipment are forensic scientists most likely to use when examining the bullet? Obj. 3.3

A Tale of Two Brothers

By: **Meagan Gallant and Corey Stillwaggon**

Tavares High School
Tavares, Florida

John Calabash, a tall, handsome 21-year-old, was eating lunch with his beautiful girlfriend, Casey Perez, a 20-year-old social butterfly with blue eyes and dark curly hair. They began to talk about their relationship and about his business. Casey wanted to be more involved with the business, but John, knowing what was at stake, told her "no." John and his older brother, Carl, were always competing for the top spot in the family business.

John and Casey had a serious relationship, but marriage was never discussed between them. John, however, had been talking to Carl a lot and was going to ask Casey to marry him soon. Carl was envious of his brother's relationship with Casey. Above everything, though, he wanted to be in charge of the family business. Their father had recently died and, if anything ever happened to John, and John and Casey were married, the business would go to Casey, not Carl. The family business was the largest known drug business throughout the United States.

Figure 3-19. *Evidence collected at the home of John Calabash.*

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Later that night, John and Carl got together at John's house to talk about a big business deal coming up in a couple of weeks. Casey was reading in the other room, but she was also listening to the deal. At 9:42 p.m., as Carl was getting ready to leave, he heard a muffled scream coming from the direction of the kitchen. He didn't think much of it and left the house. Later, Carl returned to John's house, planning to pretend that he had forgotten his wallet. His intention, though, was to put a plan into action to discredit Casey. However, when he arrived at 10:33 p.m., he found his brother dead in the kitchen; John had been stabbed twice in the chest. Carl went to look for Casey and found her dozing in a recliner with the book still open on her lap. After being told that her boyfriend was dead, she and Carl called 911.

When the police arrived, the crime scene was secured, and close-up and long-shot photos of the body and evidence were taken. Police began to collect the evidence, including a large butcher knife found in the kitchen. They also found evidence of a drug-related business, including weapons, large amounts of cash, and drug paraphernalia (see Figure 3-19). They found hair resembling Casey's and blood. All of the evidence was sent to the lab for further analysis. They dusted for fingerprints and found some footprints that were cast and photographed. There was no sign of a break-in—no sign of tool marks or broken glass at entry points. As the police began to investigate an open window, they also began questioning Casey and Carl.

Casey stated that she had been talking with John when Carl came over to visit, but that she had gone into the study to leave them alone to discuss business. She had been reading a book, but eventually fell asleep in the chair. When she awoke, Carl told her that he had forgotten something and had returned to find John, stabbed to death, lying in the kitchen.

Carl claimed that he left the house at about 9:45 p.m., and returned at about 10:30 p.m., to pick up his wallet. When asked how he got into the house, he admitted he had a key. He said he walked into the kitchen, where he believed he had left his wallet, and that was when he saw John lying on the floor. He instantly ran to find Casey.

Activity:

Answer the following questions based on information in the Crime Scene S.P. O.T..

1. Identify the evidence in the story and classify it as class or individual.
2. What motives did Carl and Casey have for killing John?
3. Hair that resembled Casey's was found at the crime scene. Is that important to the case? Why or why not?

WRITING

4. Write your own ending to this mystery. Be sure to include details about the analysis that would be done in the lab. You can be creative, but be sure that your ending is logical and that you demonstrate an understanding of various analysis techniques. Your ending should be 500 words or less.

Preventing Adolescent Crime Together™ (P.A.C.T)

Introduction:

Each person—even an identical twin—has unique fingerprints. However, the pattern of fingerprints is a class characteristic because there are only loops, whorls, and arches. The minute detail of the ridges within the patterns gives fingerprints their individual characteristics. When comparing fingerprints, investigators look at the number and location of ridge endings, bifurcations, and several other specific details. Some law-enforcement departments use fingerprint cards and child identification kits to record individuals' fingerprints.

Materials:

wet wipes
ink (strips or pads)
fingerprint 10-card

Procedure:

1. Wash hands and use a wet wipe to make sure all residues and dirt are removed from hands and fingers.
2. Place the ink pad or strip on the table. Stand at a comfortable distance from the table.
3. Grasp the hand of the person being fingerprinted carefully but firmly. Be sure not to touch your partner's fingertips.
4. Place the index finger on the ink pad or strip. Roll the bulb of the finger from one edge of the fingernail to the other edge. Make sure the ink is on the finger from the tip to just below the first crease (see Figure 3-20). **Note:** Using too much ink will make the ridge characteristics indistinguishable. Using too little ink will cause the print to be too light to see detail.
5. Roll the index finger from nail to nail on the designated area of the labeled card. Lift the finger after rolling to avoid smearing the print detail.
6. Repeat steps 2–5 until you have printed each finger on both hands.

ISTOCKPHOTO

Figure 3-20. *Proper inking for fingerpriniting.*

7. Wash hands thoroughly to remove all traces of the ink.
8. Trade roles with your partner, and repeat steps 1–7.
9. Complete the card with as much detail as possible. If necessary, use the notations described in Figure 3-21 on your card.

Abnormality	Acceptable Notations
One or more fingers, thumbs, or hands are missing.	AMP (for an amputation) MAB (missing at birth) XX
An individual has a bandage or cast on a finger, thumb, or hand.	Unable to Print UP
Permanent tissue damage exists to a finger, thumb, or hand.	Take the prints as they exist; you may include the notation “scarred,” but it is not necessary.
Injury, birth defect, or disease has caused abnormal structure of a finger, thumb, or hand.	Special equipment may be needed, but every attempt should be made to utilize techniques previously mentioned.
Individual has more than five fingers on one or both hands.	Print the thumb and the next four fingers.
Two or more fingers are grown together.	Roll as completely as possible and make a note on the fingerprint card.

Figure 3-21. *The FBI-recognized notations above should be made to describe abnormalities of the fingers, thumbs, or hands. All notations should be made in the corresponding block of the fingerprint card.*

ACTIVITY 3-1 *Ch. Obj: 3.1, 3.4*
SEPARATING MIXTURES

Objectives:

By the end of this activity, you will be able to:

1. Determine physical properties of various materials.
2. Design an experiment to separate a mixture.
3. Evaluate the success of the experiment.

Materials:

(per group of three or four students)

bag of sand (A)
bag of poppy seeds (B)
bag of salt (C)
bag of iron filings (D)
bag of mixture (E)
aluminum foil
filter paper
forceps
funnels
hot plate
magnets
paper plates
paper towels
rubber band
sifter
spoons
stirring rod
tissue paper
variety of glassware
water

Safety Precautions:

Wear safety goggles when handling glassware.
Wear apron.
Be careful when handling hot plate.
Do not handle heated glassware with bare hands.

Procedure:

1. Examine each of the samples (A–E). Note that sample E is a mixture of the other four.
2. Using the equipment and materials available to you, determine any properties that distinguish one sample from the others. Record your observations in your data table.

Data Table. Properties of samples.

Sand	Iron Filings	Salt	Poppy Seeds

3. Based on your observations, design an experimental procedure for separating sample E into its individual components. Be sure to include:
    a. The hypothesis and materials you used
    b. The steps of your procedure
    c. Qualitative and quantitative data
    d. An analysis of the data
    e. A conclusion

Questions:

1. Were you successful in separating the components of the mixture? Explain.
2. If you had done the steps of your procedure in a different order, would the outcome have been the same? Why or why not?
3. Are there supplies that were not provided but that might have made the task easier? Explain.
4. What would you do differently if you were given an opportunity to do this lab again?

Bonus:

1. The mixture in Sample E included iron filings. How would your experimental procedure have changed if the iron filings had been replaced by aluminum filings?
2. The mixture in Sample E included salt. How would your experimental procedure and results have changed if the salt had been replaced by sugar?

ACTIVITY 3-2 *Ch. Obj: 3.3*
MICROSCOPY

Objectives:

By the end of this activity, you will be able to:

1. Operate a compound microscope and a stereomicroscope.
2. Sketch samples in the field of view.

Materials:

(per group of two or three students)
prepared slides
compound microscope
stereomicroscope
protective gloves (optional)

Safety Precautions:

Always carry the microscope with both hands.
If you are allergic to latex, alert your teacher so that you may use alternative gloves.

Procedure:

1. Review the parts of the microscope with your teacher.
2. Place a prepared slide on the stage of the compound microscope.
3. Beginning with the lowest magnification, focus on the sample.
4. Once the field of view is in focus, rotate the nosepiece to a higher magnification.
5. Continue until you get the best image.
6. Draw what you see. Pay attention to detail.
7. View the slide under the stereomicroscope. Draw what you see, paying attention to detail.
8. Repeat with each of the additional slides provided.

Questions:

1. To get the best image, was the magnification the same for every slide? Why or why not?
2. Were some slides better viewed under one microscope than under the other? Explain.
3. If you had several samples of the same thing but from different sources (example: cat hair, dog hair, and human hair or dyed fibers and bloody fibers), how were you able to distinguish between the samples?
4. Based on the samples provided by your teacher, from what types of crime scenes could you expect to find those items of evidence?
5. Determine whether each item is class or individual evidence. Explain.

ACTIVITY 3-3 *Ch. Obj: 3.5*
PAPER CHROMATOGRAPHY

Objectives:

By the end of this activity, you will be able to:

1. Perform paper chromatography.
2. Determine whether the document had been altered.

Materials:

(per group of two students)
4 prepared chromatography strips
scissors
50 mL beakers (2)
10 mL distilled water
10 mL isopropanol
paper towels
stapler or tape

Safety Precautions:

Wear safety goggles, an apron, and gloves.
Consult MSDS sheets for specific instructions for handling and disposal of alcohol.
If you are allergic to latex, alert your teacher so that you may use alternative gloves.

Background:

Bill Evans owns a construction company. He has become very successful in the last several years. To save money, Bill and his wife have been keeping their own books rather than hiring an accountant. The business-related receipts and invoices are useful when they fill out their tax forms each year.

Last week, Bill was told that his business would be audited. The IRS wants to see business records for the last four years. The purpose of the audit is to make sure that Bill and his wife have been paying the taxes they owe. The auditor has asked Bill to bring all of his business-related receipts and invoices to the auditor's office.

Bill and his wife panicked and began collecting every piece of paper they could find. They found some of the receipts from the purchase of computer equipment for the new business, most of the invoices, the payroll records, and the majority of the receipts for materials purchased. However, they could not find all of the receipts. Bill was not sure he had all the documents he needed to support the numbers written in the business records books. He considered changing the amounts on several of the receipts. He thought, "I'll use this black pen and change some of those 3s to 8s. No one will ever know the difference."

Procedure:

1. Your teacher will give you four pieces of chromatography paper. Each of the papers will have an ink sample cut from different areas of Bill's receipts.
2. Trim the bottom corners of each strip to form a V. Be sure you do not cut the ink sample.
3. Add about 0.5 cm of water to one beaker and 0.5 cm of isopropanol to the other. Label each beaker.
4. Place paper strips 1 and 2 into the beaker labeled "water." Be sure the ink dots stay above the water, as shown in the following figure.

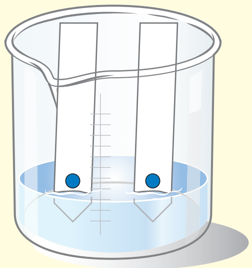


Figure 1. *Experiment set-up.*

5. Place paper strips 3 and 4 into the beaker labeled "isopropanol." Be sure the ink dots stay above the isopropanol.
6. Leave the beakers and strips undisturbed until the solvent (water or isopropanol) has dampened most of the length of the strip.
7. Carefully remove the strips from the beakers. Place them on a paper towel to dry. Do not allow the strips to touch each other.
8. Staple or tape the dry strips to your post-laboratory answers.

Questions:

1. Based on your chromatography results, do you think that Bill changed his receipts? Support your answer.
2. Is water always a good solvent for separating inks? Explain.
3. How could a teacher use chromatography to determine whether a student's answers have been changed after a test has been graded and returned?

ACTIVITY 3-4 *Ch. Obj: 3.4, 3.5, 3.6*

SMOOCH!

Objectives:

By the end of this activity, you will be able to:

1. Use chromatography to distinguish between the four similar shades of lipstick.
2. Calculate R_f values.
3. Differentiate between the lip patterns.

Materials:

(per group of two or three students)
chromatography paper
pencil
metric ruler
scissors
cotton swabs (5)
lipstick samples, labeled 1–5 and E
solvent
beaker
aluminum foil or plastic wrap
evidence envelope
suspect envelope
hand lens

Safety Precautions:

Wear safety goggles, an apron, and gloves.
Consult MSDS sheet for the proper handling and disposal of the solvent.
If you are allergic to latex, alert your teacher so that you may use alternative gloves.

Background:

The president of your school's student government needs your help. He has received several notes from a secret admirer and would like to know more about her. All of the notes are in envelopes with a lip print—a smooch—on the outside. The student president was able to get lipstick and lip-print samples from each of the girls he suspects. Your task is to determine which of the girls wrote the notes.

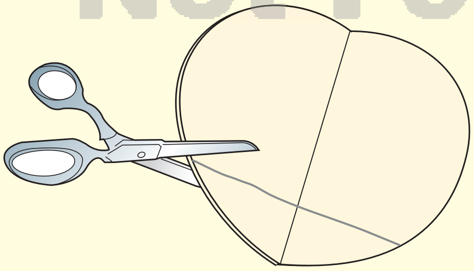


Figure 1. *Cut the chromatography paper along the pencil line.*

Procedure:

1. Gently fold the chromatography paper in half vertically. Open the paper, and use a pencil to draw a dot in the fold about 2.5 cm from the edge of the paper.
2. Using a pencil, draw a line through the dot perpendicular to the fold. Cut the paper along this line, as shown in Figure 1.
3. With your pencil, mark two points that are 1 cm from the cut edge of your paper. Draw a line through these points, all of the way across the page.
4. Label the paper across the top (in pencil) with your group number.
5. Write the number or letter for each lipstick sample across the top of your chromatography paper, as shown in Figure 2.
6. Use a cotton swab to place a small dot of lipstick sample 1 on the line below the number 1.
7. Repeat step 6 for each of the samples provided. Use a clean cotton swab for each sample.

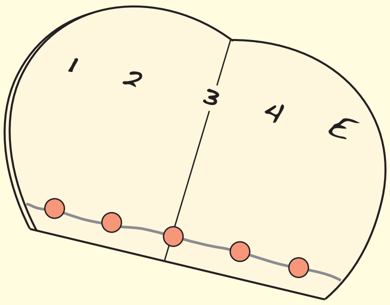


Figure 2. *Place a small dot of each lipstick sample along the pencil line near the bottom of your chromatography paper.*

8. Pour a small amount of solvent into the bottom of the beaker. The solvent should just cover the bottom of the beaker. Measure and record the depth of the solvent.

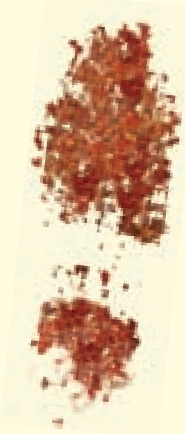
Data Table 1. Lip-print observations.

Sample	Lip-Print Sketches	Observations
Evidence		
1		
2		
3		
4		

9. Carefully place the prepared chromatography paper into the beaker with the flat side resting on the bottom. Make sure the solvent does not touch the lipstick dots. It may help to fold the paper slightly along the crease so it will stand alone in the beaker.
10. Cover the beaker with aluminum foil or plastic wrap. Leave the beaker undisturbed for approximately 30 minutes or until the solvent reaches the top of the chromatography paper.
11. While you are waiting, obtain the suspect and evidence lip prints from your teacher. Record the numbers and corresponding samples in Data Table 1.
12. Using a hand lens, compare the suspect prints with the one on the evidence envelope. Divide each lip print into quadrants and sketch the pattern one quadrant at a time. You may also take notes on your sketches.
13. When the chromatograms are finished separating, remove the paper from the beaker and mark with pencil the solvent front (the farthest distance traveled). Allow the chromatogram to dry completely.
14. Calculate the R_f value for each of the samples. Record your data in Data Table 2.
    a. Measure the distance in millimeters from the line of origin (pencil line) to the sample front. Record the distance.
    b. Measure the distance of the solvent front from the original depth of the solvent. Record.
    c. Calculate the R_f value using the following equation:

$$R_f = \frac{\text{Distance traveled by the sample (in cm)}}{\text{Distance traveled by the solvent (in cm)}}$$

    d. Repeat for all of the samples.



Data Table 2. Chromatography data.

Sample	Distance Solvent Traveled	Distance Sample Traveled	R_f Calculations
Evidence			
1			
2			
3			
4			

Questions:

1. Which suspect wrote the notes? How do you know?
2. If you were called in as an expert witness, what types of qualitative and quantitative data could you offer to identify the secret admirer?
3. Do you think a lip print could be used to convict or exonerate a suspect?
4. If the chromatography paper were doubled in size and the solvent were allowed to travel twice as long, would the R_f values change?

ACTIVITY 3-5 *Ch. Obj: 3.8*
FINGERPRINTING

Objective:

By the end of this activity, you will be able to:
Develop fingerprints using silver nitrate.

Materials:

(per group of three or four students)
3 pieces of paper
newspaper
small spray bottle
silver nitrate solution
watch or clock
UV light (optional)
stereoscope or hand lens

Safety Precautions:

Wear goggles, gloves, and an apron when working with silver nitrate.
If you are allergic to latex, alert your teacher so that you may use alternative gloves.
Silver nitrate will stain clothing. It will also leave skin discolored for several days.

Procedures:

1. Before putting on your gloves, pass three pieces of paper around your group. Be sure that at least one person places his or her fingers firmly in the center of the paper. These papers will now be your samples.
2. Cover your work space with newspaper and put the three samples on top of the newspaper. Put on your gloves.
3. Dampen all three samples with the silver nitrate solution. The samples should be damp but not completely wet.
4. Allow the samples to dry for 20 minutes.
5. Place the samples in direct sunlight or under an ultraviolet light. Check the development of your prints every few minutes until they turn dark gray or black. Record how long it took for the prints to develop.
6. Observe the prints under the stereoscope or magnifying lens. Note the differences among the different prints. Draw two different prints from each sample.

Questions:

1. How long did it take for the fingerprints to develop?
2. What characteristics of the prints were visible? What characteristics might have helped you determine which prints belonged to each person in your group?

Extension:

Design an experimental procedure for identifying an unknown fingerprint. Be sure to include a list of the materials, the steps of your procedure, and the qualitative and quantitative data you would collect. Your experimental procedure should include a questioned sample and three or four known samples.