Chapter 15 Firearms, Toolmarks, and Impressions

Objectives

After reading this chapter, you will understand:

- How class and individual evidence can answer different questions.
- How impression analysis is used in forensic science.
- The impact of firearms in the United States.
- The importance of microscopic examination in forensic science.

You will be able to:

- Distinguish types of firearms.
- Measure individual features of bullets and cartridge cases.
- Describe how a handgun works.
- Use color tests to find gunshot residue.
- Describe the procedure for estimating the distance between muzzle blast and target.
- Make casts of different types of impressions.
- Evaluate and present scientific data.
- Communicate and defend a scientific argument.

“Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and are not clothed.”

—Dwight D. Eisenhower (1890–1969), U.S. general and 34th president

Firearms

Teacher Note

The TRCD for this chapter includes a PowerPoint presentation, which is an overview of the chapter. It can be used as introductory material or at the end as a review.

The TRCD also contains a Word Search puzzle that can be used after students have learned the vocabulary from this chapter.

In 2004 there were 29,569 gun deaths in the United States. Suicides accounted for 56 percent; homicides, 40 percent.

In 1998, handguns killed:

373 people in Germany
151 people in Canada
57 people in Australia
54 people in England and Wales
19 people in Japan
11,789 people in the United States

That is 4.4 deaths per 100,000 people in the United States, compared to Germany with 0.45 and Japan with 0.015 deaths per 100,000 people.

> The vast majority of U.S. homicides involve guns. And they are more powerful than ever.
>
> —Lansing State Journal, *July 2007*

Forensic analysis is vital in order to solve a crime involving a gun.

Firearms came about as the result of the invention of gunpowder in China in the second century AD. The development of modern weapons was not just the refinement of a propellant; it required progress in metallurgy, physics, chemistry, and armaments, and most important, unfortunately, the continual need to kill.

Types of Firearms

Modern firearms that are legal in our society generally consist of:

Figure 15.1 A revolver

1. Handguns or pistols. These are designed to be held in one hand so they are easy to carry and conceal. They are not as accurate as other firearms and are limited to the number of bullets that can be loaded.
   - **a.** *Revolver:* This handgun has a cylinder that holds the bullets, usually six ("six-shooter"). It must be reloaded by hand, and does not eject a spent shell.
   - **b.** *Semiautomatic:* This type of handgun shoots one cartridge each time the trigger is pulled, ejects the empty cartridge case, and reloads

Figure 15.2 A semiautomatic handgun

Figure 15.3 A rifle

automatically. It can hold between five and 19 rounds in the magazine or clip. Note that a fully automatic weapon keeps firing as long as the trigger is held back. Machine guns are automatic weapons.

2. Rifles. These have a longer barrel than a handgun and a butt stock that fits to the shoulder to steady the firearm and minimize kickback (Newton's third law: Every force has an equal and opposite force). Rifles can shoot more powerful cartridges than handguns; therefore, they have a greater range and better accuracy.
3. Shotguns. These are similar to rifles, but are usually used to shoot a packet of shot or spherical pellets. The inside of the barrel is not rifled.
4. Air guns or BB guns. Shot or pellets are propelled by pressurized air, spring compression, or a carbon dioxide cartridge.

Figure 15.4 A shotgun

Figure 15.5 An air rifle

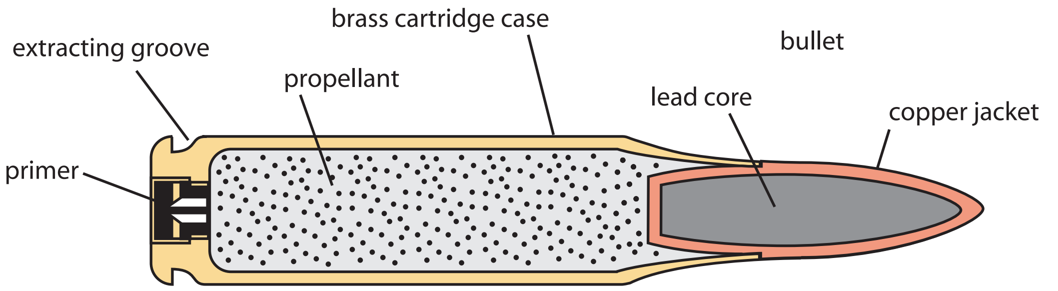


Figure 15.6 Rifle ammunition

Types of Ammunition

Modern ammunition consists of a cartridge case, primer, propellant, and a projectile (Figure 15.6); each can vary depending upon the weapon and the intended results. In all ammunition, a primer in the base of the cartridge is struck by the firing pin of the gun. The primer is ignited, which, in turn, ignites the gunpowder in the cartridge case. This action creates gases that push the projectile out of the cartridge case, along the barrel, and out of the weapon.

> Ballistics is the scientific study of the motion of projectiles in flight.

There are many different kinds of ammunition—over 300 just for handguns!

Various parts and pieces of the ammunition are the evidence that is used to investigate a shooting. As with other types of evidence you have studied, there are class and individual characteristics.

The Bullet

Most bullets are made of lead which may be jacketed with brass, copper, or steel. Armor-piercing bullets are made from steel or tungsten alloys covered with a thin coating of the softer metals of lead or copper/brass in order to prevent barrel wear.

Bullet size is a measure of the diameter and, expressed in inches, is called the **caliber**; thus, a .22-caliber bullet measures 22/100 of an inch, or 0.22 inches across. Caliber also corresponds to the inside diameter of the firearm's barrel or **bore**. Bullet size may also be measured in metric units, so a 9-mm bullet is approximately the same size as a .38-caliber. The size of a shotgun is described by **gauge**, which is related to the weight of the lead pellets or **shot** in a shotgun shell. A single pellet is called a **slug**. The larger the diameter of a shotgun bore, the smaller the gauge. Twelve-gauge is larger than 20-gauge, for example.

caliber: the diameter of the bore of a firearm or the cartridge that it fires, expressed in hundredths of an inch

bore: the interior diameter of a gun barrel

gauge: the interior diameter of a shotgun barrel as determined by the number of lead balls of a size exactly fitting the barrel that are required to make one pound

shot: lead spheres in a shotgun shell

slug: a single shot or bullet in a shotgun shell

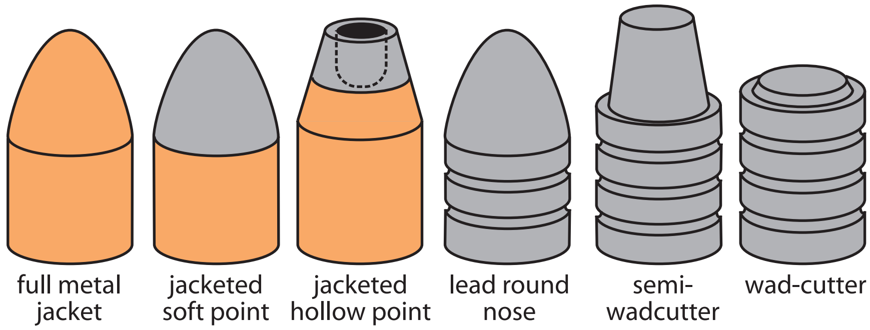


Figure 15.7 Bullet types

The exception is a .410 shotgun which is measured in inches (caliber).

Bullets can have different shapes (Figure 15.7). Some have a hole in the cone (hollow point) that causes them to deform upon impact in order to decrease penetration and cause greater bodily harm. (It must be remembered that the whole point of producing weapons is to injure and kill.) Flat-nosed lead bullets are commonly used for target practice.

The weight, dimensions, shape, and type of bullet are class evidence, but can be used to help determine the type of ammunition used, and from there, the type of weapon. For example, a .38 Colt (manufacturer) "short" bullet weighs 135 **grains**, or 8.7 grams (1 gram = 15.4 grains); a .38 Colt "long" weighs 9.7 grams; a .38 S & W (Smith & Wesson) weighs 10.2 grams; a standard 9-mm weighs 6.5 grams; a .357 Magnum weighs 10.2 grams.

In order to increase the accuracy of shooting, handgun and rifle barrels are **rifled**, that is, the cylinder is machined to form a grooved spiral inside the barrel (see Figure 15.8). These grooves impart a spin to the projectile, decreasing wobbling in flight; the same principle applies when passing a football. The rifling in a barrel produces **lands** and **grooves** on a bullet that twist to either the left or the right. (Figure 15.9)

Lands and grooves are class characteristics, but may be used to identify the make and model of a weapon. For example, a .32-caliber S & W handgun has five lands and grooves with a right-hand (clockwise) twist; a .32-caliber Colt has six lands and grooves with a left-hand twist; Browning firearms also have six lands and grooves but with a right-hand twist.

The expression "bite the bullet" originated in the days before effective anesthetics. Soldiers were given bullets to bite on to help them endure pain; hence its meaning, "endure pain with fortitude."

grains: basic units of weight in the British system, originally based on the weight of a grain of barley. Grains are still used as a unit of weight for precious metals, gunpowder and bullets, and gemstones.

rifled: the bore of a gun barrel that has been machined to form a grooved spiral, much like a helix

lands: the raised areas between two grooves in the rifling of a gun barrel that impart grooves on the bullet

grooves: spiral cuts into the bore of a barrel that give the bullet its spin or rotation as it moves down the barrel

Figure 15.8 Rifling inside a gun barrel

Figure 15.9 Right-twist lands and grooves in brass-clad bullet

The width of the lands and grooves can also be used in identification.

Individual evidence can often be found on bullets. Each gun barrel has unique machining marks as well as wear patterns that can cause scratches or **striae** on a bullet, a kind of "fingerprint" that looks much like a barcode (Figure 15.10). Often these can be matched to a particular weapon, or to bullets from other crimes. A comparison microscope is the instrument required to identify these marks (see Figure 15.11).

Often, however, bullets are so badly deformed or fragmented that not enough area remains on which to find striations. Figure 15.12 shows increasing fragmentation of a .22-caliber bullet fired into loose soil, packed dirt, and wood, in that order. Note the rings in the unfired bullet; these are called **cannelures**, and their function is to aid in securely fastening the bullet to the cartridge case.

striae: parallel sets of scratches on a bullet caused by unique markings in the bore of a rifled weapon

cannelures: grooves around a bullet that provide a means of crimping the cartridge case to the bullet

The Cartridge

The cartridge consists of the bullet and a case or shell that contains the powder and a primer. The case is usually made of brass (70–75 percent copper, 30–25 percent zinc) or nickel-clad brass. The propellant is smokeless powder consisting primarily of nitrocellulose or nitrocellulose and nitroglycerine. The primer is composed mostly of lead styphnate, barium nitrate, and antimony sulfide.

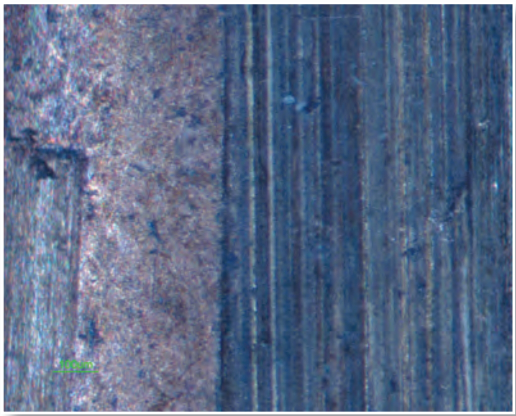


Figure 15.10 Striae on .38-caliber copper-clad bullet

Figure 15.11 Comparison of striae (simulated comparison microscope view, slightly offset)

Figure 15.12 Bullet fragmentation

The combustion products of these chemicals are expelled from the ejection port; thus the presence of lead, barium, and antimony confirm the discharge of a firearm. Most cartridges have the primer in the center of the base (centerfire); some .22-caliber ammunition uses a primer on the circumference of the brass base (rimfire).

head stamp: numerals, letters, and symbols on the base of a cartridge showing the manufacturer, caliber, and code

The cartridge found at the scene of a shooting may provide both class and individual evidence. The dimension of the shell casing, the imprint on the base or **head stamp** (see Figure 15.13), and whether it is rim- or centerfire are all class characteristics. Individual characteristics may result from the

Figure 15.13 Centerfire (left) and rimfire (right) cartridges

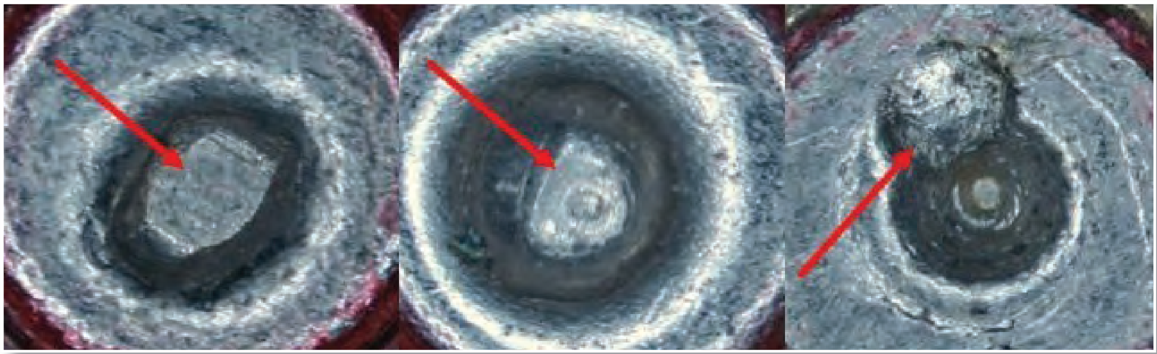


Figure 15.14 Firing pin marks

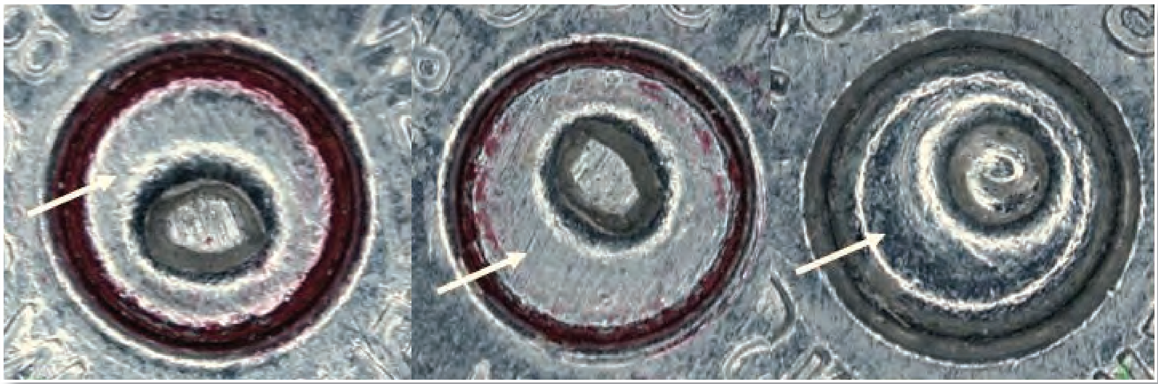


Figure 15.15 Breech marks

breech: portion of the gun that contains the firing mechanism

extractor: hooked or crescent-shaped part attached to the breechblock which withdraws the spent casing from the chamber when the breechblock separates from the barrel after firing

impression of the firing pin when it strikes the primer case (Figure 15.14). **Breech** marks (Figure 15.15) are imparted to the central area of the casing at the primer when the cartridge case is slammed backward as the weapon is fired. When the cartridge is automatically ejected, it is pulled out of the firing chamber by a hooked **extractor** and thrown clear of the chamber by the **ejector**. Both objects may leave identifying marks particular to that weapon (Figures 15.16 and 15.17).

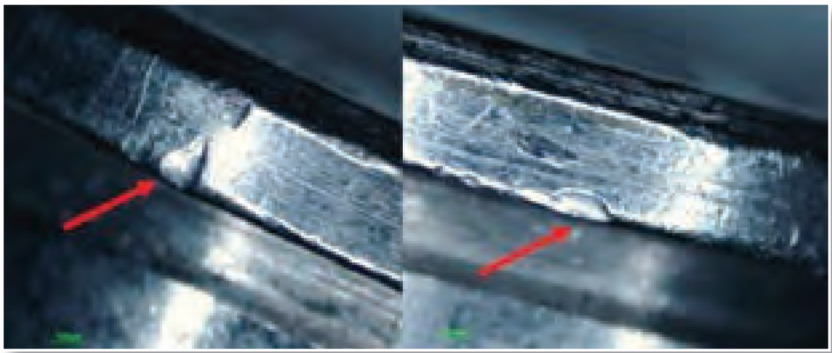


Figure 15.16 Extractor marks

Figure 15.17 Ejector mark

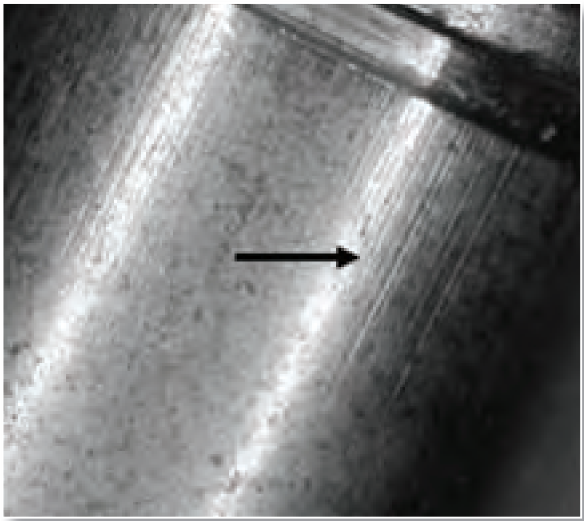


Figure 15.18 Chamber marks

Cartridges may also show scratches imparted by their movement in the **magazine**, and **chamber** marks caused by their movement across rough spots in the chamber during loading and removing (Figure 15.18).

The gross features of each mark are class characteristics, but under higher magnification, the minutiae, so to speak, are unique, and can be compared to other shell cases; see, for example, Figure 15.19 for a match.

ejector: the part on the firearm whose function is to throw a spent casing from the gun after firing

magazine: a container that holds cartridges under spring pressure to be fed into the gun's chamber; also called a clip

chamber: part of the firearm that contains a cartridge for firing

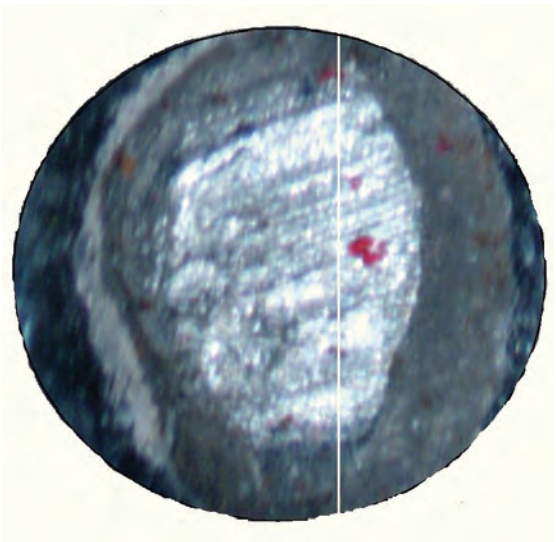


Figure 15.19 Comparison of firing pin marks (simulated comparison microscope view)

Student using a comparison microscope

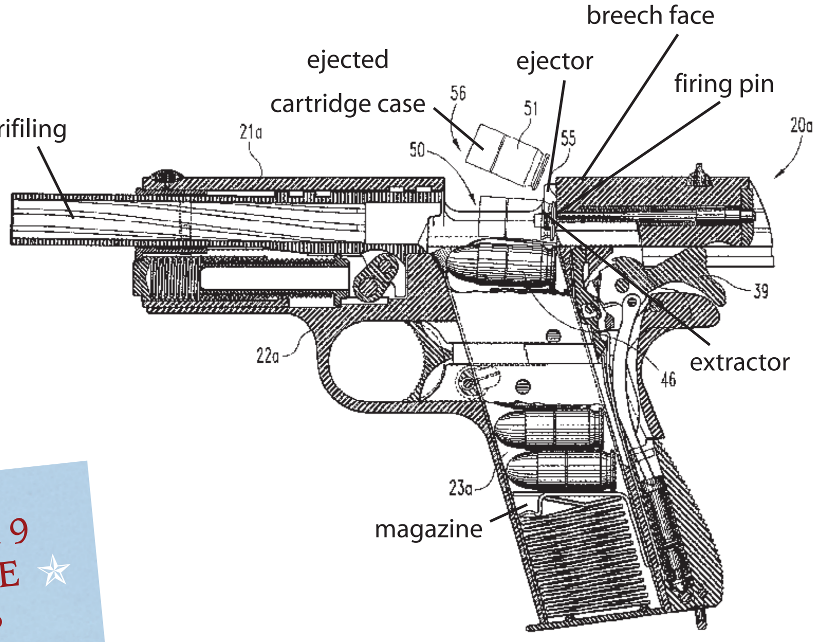


Figure 15.20 Features of a semiautomatic handgun

IN BRIEF

INVESTIGATORS LINK 9 SHOOTINGS TO SAME GUN IN COLUMBUS

COLUMBUS, Ohio—Investigators have linked nine shootings at parked cars, homes and businesses to the same gun in a city with fresh memories of a string of separate shootings that terrorized drivers and killed a woman.

Last week, police said ballistics tests connected eight shootings since Nov. 20 in residential and commercial areas in Columbus. Investigators have since linked a ninth shooting to the same 9-mm gun. . . .

—*from* Lansing State Journal, *2005*

Figure 15.20 is a cutaway drawing showing these features in a semiautomatic handgun.

There are some types of rifling and some types of ammunition that make individualization very difficult, such as polygonal rifling and Teflon-coated bullets.

Laboratory Activity 15.1 Characterization of Bullets and Cartridge Casings

Advance Preparation

Prepare two worksheets for each student from BLM 15.1 and 15.2 from the TRCD.

Advance Preparation

Obtain at least one bullet and cartridge case for each investigative group. They need not match. It is better to have many bullets and shells so you can pick which ones came from the same firearm. Possible sources are your local police department, a local firing range, or acquaintances who

Materials

- magnifying glass
- stereomicroscope
- 15-cm ruler
- dial calipers
- assortment of bullets and cartridge cases
- ink pad
- balance, 0–100 grams, to nearest 0.1 gram

Procedure

Now that you know what you are looking for, examine the bullets and cartridge cases your teacher has given you. The markings can be observed with a good hand lens or, better, a stereomicroscope. Complete each worksheet. Be explicit,

Laboratory Activity 15.1, *continued*

since your data may be compared to others' in order to find a match based on class evidence. You can use an ink pad to show the head stamp. Try rolling a bullet on the ink pad, then on paper to delineate the lands and grooves.

Denote each characteristic that is class evidence with a "C"; if it can be used to individualize evidence, use "C-I." Remember that even with class evidence, the more characteristics that match the known with the unknown, the greater the odds of individualization. Conversely, if there is *not* a match after thorough examinination of each object, then there is *no* link between known and unknown.

Once you find a match using class evidence, can you individualize any of the class evidence to corroborate or negate the match?

Distance from Target

Sometimes it is important to know the distance from muzzle to target in order to reconstruct the event. As the bullet leaves the muzzle of a weapon, it carries along with it some of the unburned particles as well as the combustion products of the propellant, which spread out with distance. The primary combustion products are nitrites (NO_2^-) which can be chemically converted to colored products by the **Greiss test**. Pressing the muzzle against the target causes burns and deposits a lot of soot (see Figure 15.21).

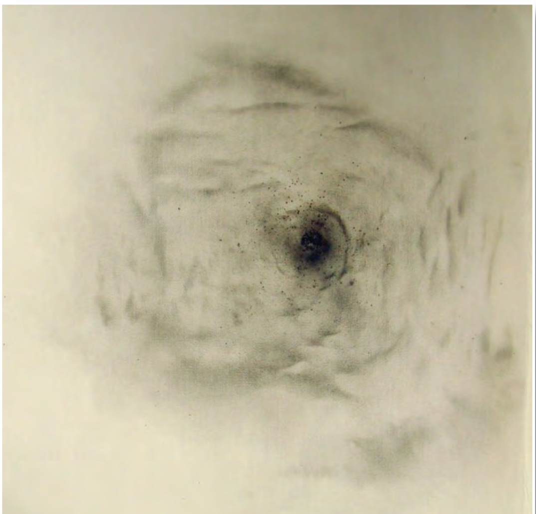


Figure 15.21 Soot from muzzle at a distance of 3 inches

MAN SHOT BY DOG HE WAS TRYING TO KILL

A Florida man could not find a home for a litter of puppies, so he decided to shoot them. As he was holding one, the pup wriggled free and triggered the gun with his paw, shooting his owner in the wrist.

— *from* The Jacksonville News, 2004

Greiss test: a color test for the presence of nitrite in gunpowder residue

Advance Preparation, *continued*

enjoy target shooting. (Hunters can contribute, but they usually do not collect their bullets, and it is better to do this exercise with handgun ammunition.)

Depending on your ammo stash, you may wish to make up a crime story; perhaps multiple robberies with the same MO where the bandits shoot several rounds into the ceiling to intimidate their victims. Is the ammunition consistent with the described firearms and the bullets from the robbery sites? In the case of hunters (if you have sufficient material), determine who actually shot a 12-point buck, since two or three hunters claim to have dropped him and there are several bullets in the carcass.

Matching striae or other microscopic features requires good observation, good drawings, and patience, especially if microphotography is not an option. If you can get a good digital photo, then it can be computer-enlarged and enhanced to make searching and comparing easier.

Precision Forensic Testing, LLC (www.precisionforensictesting.com), has marvelous kits that supply all the necessary materials to investigate firearms.

Laboratory Activity 15.2

The Greiss Test

There is a myth, kept alive by portrayals of shooting victims on television and in films, of victims being hurled backwards or actually being knocked down by the force of a bullet. This is not true.

Advance Preparation

Ask a friendly policeman or target shooter to shoot at your targets, preferably with a handgun, from distances of 0 inches (muzzle next to target), 3 inches, 12 inches, 30 inches, and 60 inches. Actually, prepare two sets of targets so one can be used exclusively for the next activity. If shooting is not possible, you can simulate the targets. Make the bullet hole first. Use a heated iron rod to burn a round hole in the center to simulate the bullet hole (rerod makes a good .38-caliber hole). Drop a few salt crystals on dark fabric to practice your aim and distribution, then repeat on the dampened target with potassium nitrite. Let it dry, undisturbed, and then shake it out. Each investigative group can test one target (removed from the ceiling tile), then combine all their data to make a graph or illustration of powder spread and density with distance.

Figure 15.22 Greiss test at 3 inches from muzzle

Materials

- 15 percent acetic acid
- sulfanilic acid
- 2-naphthol
- potassium nitrite
- methanol
- photo tray or equivalent
- 250-ml beakers
- inkjet photo paper (Epson photo paper works best)
- cotton towel
- cheesecloth
- electric iron
- targets: pieces of white cotton cloth stretched and anchored across 1-foot ceiling tiles

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

SAFETY NOTE *Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals. Also be aware that the iron may be hot.*

Procedure

1. Be sure the target you have been given is labeled.
2. Place the test sheet of paper on a cotton towel, emulsion side up, in a hood or well-ventilated area (the smell of acetic acid can be quite strong).
3. Place the target on top of the paper, with the powder residue in contact with the emulsion side of the paper.
4. Soak a strip of cheesecloth with the 15 percent acetic acid for one minute; wring it out.
5. Place the cheesecloth on the back of the target, cover it with a paper towel to protect the iron, and iron it on medium heat for about 1 minute or until the cheesecloth is dry.
6. Orange-red specks indicate the presence of nitrites.

Examine your target. Note if the density of nitrite particles decreases with distance from the bullet hole. Devise a procedure for estimating the overall density of nitrate particles in your target. This will be useful when examining all the targets.

Gunshot Residue

As the primer ignites the powder charge, the hot gases that propel the bullet from the firing chamber blow out from the ejector port as well as from the muzzle. The *blowback* disperses combustion products of the primer back to the shooter's hand, as well as blanketing the area alongside and behind the weapon. Thus, the presence of lead, barium, and antimony is indicative of the firing of a weapon, but these particles may not necessarily be traceable to the shooter since they spread so readily and are known to be easily transferred. The ejector particles, combustion residues of the powder, and any unburned powder particles are collectively known as gunshot residue (**GSR**). When a bullet enters a target, it may leave behind traces of its constituents, usually lead, or copper from the jacket.

GSR: gunshot residue consisting of burned and unburned powder, vaporized and particulate lead, primer residues of lead, barium, and antimony

Reminder

blowback: material that is scattered backward from the direction of a force or blow. In firearms, it is the backward escape of gases and unburned gunpowder as a gun is fired.

Advance Preparation, *continued*

Solution preparation

1. Add 0.75 g sulfanilic acid to 150 ml distilled water and mix.
2. Add 0.42 g 2-naphthol to 150 ml methanol and mix.
3. Mix both solutions in a clean photo tray.
4. Separately saturate each sheet of photo paper in the solution, placing the paper emulsion side down to prevent curling.
5. Remove the paper after five minutes or so and allow it to dry in a fume hood or well-ventilated area for 15–20 minutes.
6. Confirm the sensitivity of the test paper by dipping a cotton swab in a 0.5 percent solution of KNO_2, drying it, dipping it in 15 percent acetic acid, and touching it to a corner of the paper you have prepared. An orange color should result.

Sulfanilic acid is available from suppliers like Flinn Scientific; 2-naphthol can be obtained from Aldrich Chemical (www.sigmaaldrich.com) at a better price than other suppliers. *2-naphthol is an irritant to skin, eyes, and respiratory tract, so wear gloves and goggles.* The amount of material you are using here can be flushed down the sink with lots of water.

Laboratory Activity 15.3

The Sodium Rhodizonate Test for Lead Residue

sodium rhodizonate test: a color test for the presence of lead in gunshot residue

buffer: a solution containing either a weak acid and its salt or a weak base and its salt, which is resistant to changes in pH

Advance Preparation

As in Laboratory Activity 15.2 , you can simulate GSR distribution as you did for the Greiss test using granular lead acetate. It should be a tighter distribution than the nitrite around the bullet hole, but the density should decrease more with distance. Mix some lead acetate with a small amount of water, dip your finger in it, and press the "bullet hole" so only the rim is wetted. Sprinkle the lead salt as you did in Activity 15.2.

Sodium rhodizonate at a ph of 3 makes a very bright pink in contact with lead metal and purple with the lead ion, so a buffer is required. It is made by adding 2.0 g sodium biphosphate ($NaH_2PO_4 \cdot H_2O$) and 17.8 g citric acid to 1 L of water. Make up a minimum amount of 2 percent sodium rhodizonate in distilled water. This solution does not keep, even in the refrigerator. Figure T15.1 shows a simulated test where the lead acetate was poorly aimed. This image is also provided on the TRCD as Blackline Master 15.3.

Sodium rhodizonate complexes with many metals; spraying with 5 percent HCl turns the color blue, confirming the presence of lead.

Combine the group data as you did with the Greiss test.

The **sodium rhodizonate test**, you may remember, was used in Chapter 8 to test for leaded paint. Here it will be used to detect lead in GSR as a function of distance from muzzle to target. In using these color tests for GSR, the Greiss test should always be performed first because the rhodizonate test interferes with its color development.

Materials

- sodium rhodizonate
- citric acid
- sodium biphosphate
- three spray bottles
- lead acetate or lead nitrate
- 5 percent hydrochloric acid
- targets as described in Laboratory Activity 15.2

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

SAFETY NOTE *Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals.*

Procedure

1. Be sure the target you have been given is labeled.
2. Spray the target area with the sodium rhodizonate solution; record any coloration. *Note: Spray all the reagents in a fume hood or a large cardboard box.*
3. Then spray with the **buffer** solution and note the colors (Figure 15.23).
4. Spray with the hydrochloric acid solution and observe any color change. *Use caution: Even at this strength, the acid can damage your eyes and cause cuts to sting.*

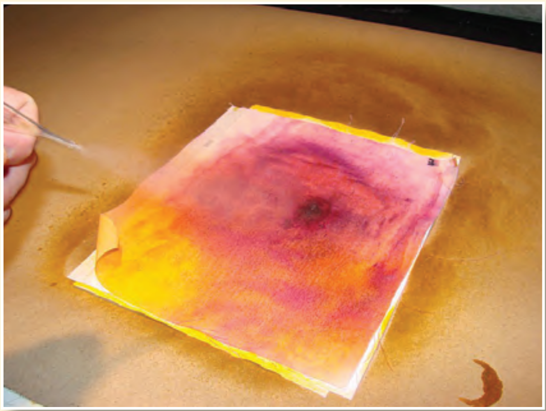


Figure 15.23 Spraying a 3-inch target with buffer solution

Examine your target. Note if the density of lead particles decreases with distance from the bullet hole. Devise a procedure for estimating the overall density of lead particles in your target. This will be useful when examining all the targets.

The Corpse in the Closet

Some kids playing in an abandoned, half-finished house found the badly decomposed remains of a man in a closet. Police noted that it was mostly skeletonized, with just a few beetles working on the remaining skin. The cause of death was not immediately apparent, although the man's rumpled, dark shirt appeared to have a hole in it. The shirt has been directed to your forensic lab to be analyzed for GSR evidence. It is immediately obvious that the color of the shirt will mask any color development from the rhodizonate test. What do you do?

The Greiss test is a transfer, so the color of the shirt will not interfere with the result. Fortunately, you remember from your CSI training class the Bashinski transfer technique for the sodium rhodizonate test. In this technique, filter paper is dampened with 15 percent acetic acid and placed on the suspected area. The paper is covered with several dry paper towels and ironed until the paper is dry. The filter paper is then sprayed with each of the normal reagents, with the standard interpretation of results. Of course, controls and blanks are performed, as usual.

Work up a test protocol for the analysis of the shirt, have it approved by your teacher, and then carry it out. Write a report on what you did and what you found, and state your opinion on cause of death.

SAFETY ALERT! CHEMICALS USED
Always wear goggles and an apron when working in the labaratory

SAFETY NOTE ***Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals.***

A well-equipped crime lab will confirm GSR residues from a shooter's hand using sophisticated and expensive instruments, such as in atomic absorption spectroscopy, neutron activation analysis (NAA), and scanning electron microscopy with an energy-dispersive X-ray analyzer (SEM-EDX).

Advance Preparation, *continued*

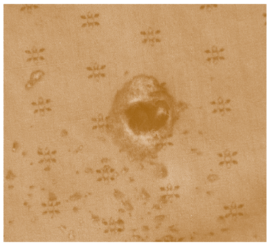


Figure T15.1 Simulated sodium rhodizonate test

Laboratory Activity 15.4

Advance Preparation

A dark, plaid flannel shirt is a good start. Burn a bullet hole. You can make the distribution very close to the hole, or farther away, or even daub a solution of lead ion in the hole itself with no other sprinkles, simulating a lead smear and a shooting from too far to see GSR.

The protocol, you hope, should go like this:

1. Examine shirt, locating questionable hole relative to the torso. Also note any labels indicating brand and size.
2. Examine hole under magnification, looking for burn marks, being careful not to disturb potential particles. Also look for singed fibers and melted tips of synthetic fibers.
3. Perform the modified Greiss test, using a part of the shirt well away from the hole as a control, and a similar fabric known to have GSR as a standard.
4. Carry out the Bashinski transfer and rhodizonite test, using the same type of control and standard as above.
5. Complete chain of custody forms.
6. Interpret results and form an opinion. You may need to use the results of the target distance tests that were performed.
7. Write a report.

Laboratory Activity 15.4, Advance Preparation, *continued*

8. Suggest that the blood unit test for blood on the back of the area of the hole, using luminol.
9. Suggest that a forensic entomologist identify the beetles to estimate a PMI.
10. Suggest that a forensic anthropologist estimate the height and build of the individual as well as potentially identifying characteristics.
11. Suggest that a forensic odontologist look at the teeth for possible matches with those of missing persons.
12. Suggest that the DNA people check teeth, hair, and bone marrow for viable DNA to aid in identification of the corpse.

The problem of blowback contaminating areas other than the shooter's hand still arises, although sampling on the top of the thumb and forefinger and comparing it to the palm should aid in interpretation. Why? Why would there be no GSR on a shooter's palm?

> **POLICE SAY MAN FIRED AT OFFICER**
>
> A Lansing man is being held on $500,000 bond after police say he assaulted his wife, crashed two cars and shot an arrow at a police officer Thursday night.
>
> — *from* The Lansing State Journal, *2007*

In Chapter 9, an additional project involved the use of 8-hydroxyquinoline (quinolinol) to reveal the imprint of a metal object on a person's hand. This technique can be applied to a shooter as well. Spraying the hand with a 2 percent alcoholic solution of this product and then viewing it with a UV light can show an imprint of a pistol grip. The color of the fluorescence can also indicate the finish on the metal or pistol grip.

The Bureau of Alcohol, Tobacco, Firearms and Explosives' National Integrated Ballistic Information Network (NIBIN) maintains a forensic database, the Integrated Ballistics Identification System (IBIS), that contains bullet and cartridge casings that have been retrieved from crime scenes and test-fires of guns found at crime scenes or on a suspect. From NIBIN's inception until 2007, 1,286,500 pieces of evidence and more than 20,300 hits have been registered. A hit is a match of evidence associated with a firearm in the database with other such evidence submitted by a state agency. This match may link a firearm to a crime, an event, and/or a person.

15.1: The Case of *People v. Contreras*

CASE STUDY

On December 29, 1998, Anselmo Vasquez was killed by a single .22-caliber bullet to the chest. His girlfriend, Delia Contreras, was accused and went through three trials before being convicted of murder in September, 2003. There had been a confused confession by her, later recanted, and rumors of another while she was in prison, but both had been discounted.

The bullet, examined at the autopsy, was a copper-clad hollow point with 16 lands and grooves with a right twist, which indicated it was fired from a Marlin-manufactured rifle. The bullet was partially mushroomed and showed strange striations. The bullet hole in Mr. Vasquez's undershirt was larger than expected for a small-caliber weapon such as a .22. Ms. Contreras was taken into custody and found to have GSR on her hands; however, her hands had not been bagged to prevent contamination from the officers' vehicle.

CASE STUDY CONTINUED

A single drop of blood, about ½ inch in diameter, was found in the alley outside the apartment. DNA analysis showed it to be the victim's. Blood spatter analysis suggested that it was a wet drop, not a transfer, from a source moving toward the apartment courtyard.

The state (prosecution) stated that the strange striations on the fatal bullet were caused by its tumbling and rotating through the body after impact. The GSR evidence spoke for itself. The victim's blood came from the accused as she was getting rid of the murder weapon (it was never found). The size of the hole in the undershirt resulted from the type of weave. The scenario the state painted was that Ms. Contreras shot her boyfriend, got rid of the rifle, and then called 911.

Figure 15.24 Test bullet similar to fatal bullet

A defense expert witness meticulously examined the fatal bullet, finding embedded glass in the nose. Test-firing through window glass found that this commonly occurred. The embedded glass was analyzed by SEM-EDX and found to be consistent with window glass. The state's expert countered that the silicon found in the bullet came from the clay mount the defense witness used when examining the bullet, yet analysis of several similar clays found no silicon (the clay that was used was never produced).

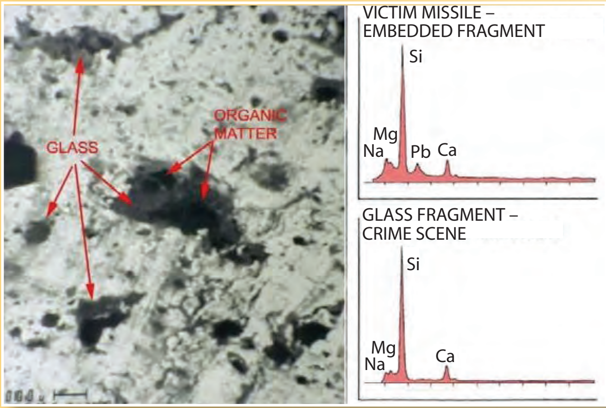


Figure 15.25 Analysis of embedded glass

The defense's expert postulated that the strange features on the fatal bullet were the result of it passing through a cracked bedroom windowpane. Generally, a lead bullet will completely mushroom when passing through window glass. The other bedroom window had apparently just been broken because Mr. Vasquez had been cleaning it up.

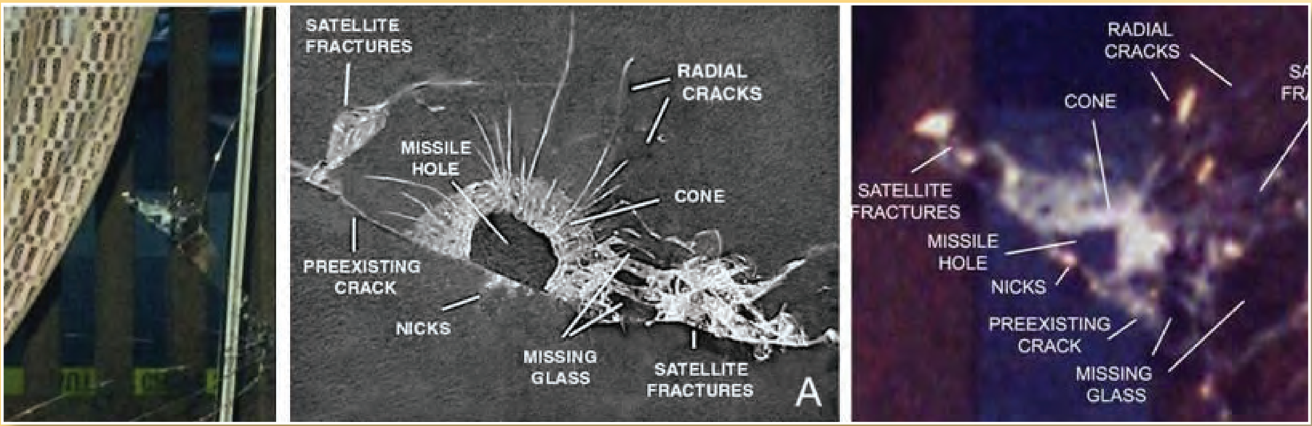


Figure 15.26 (l-r) Broken window in apartment, test window, actual window

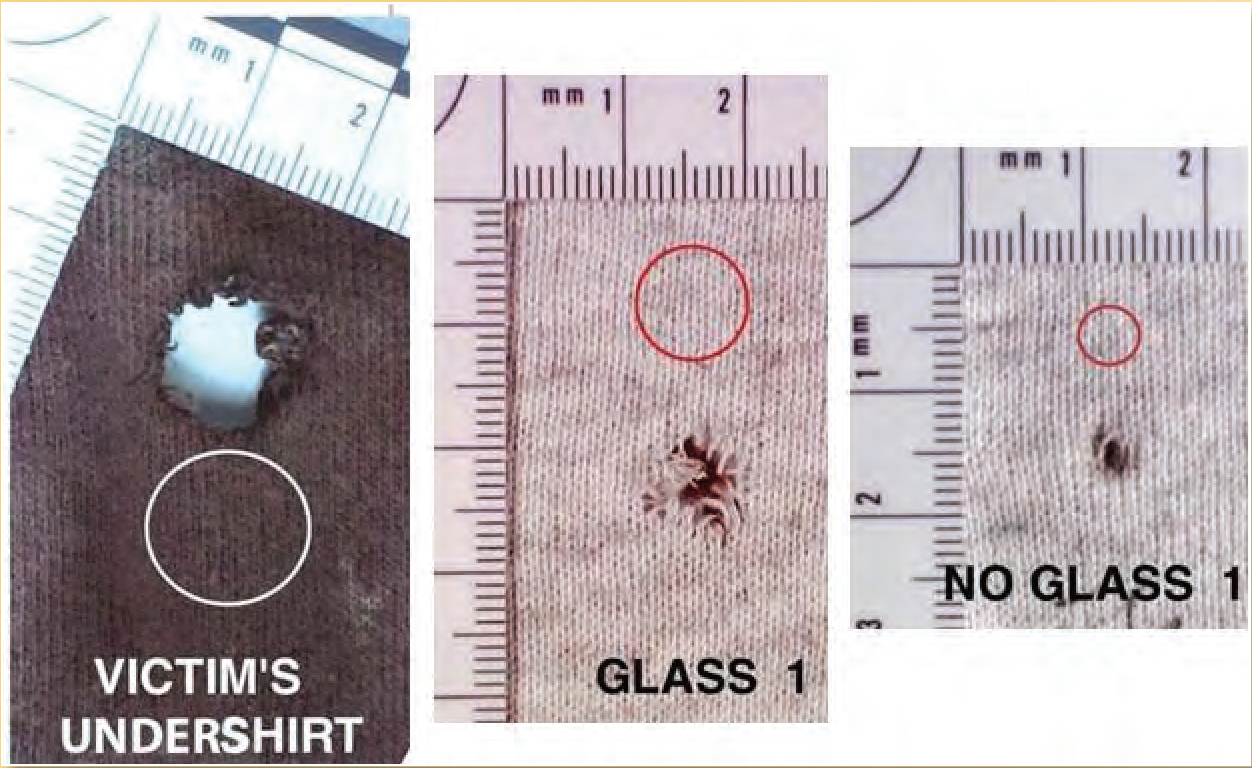


Figure 15.27 Bullet hole in victim's shirt

Many tests were conducted by the defense expert by shooting a .22 at a previously cracked window in an effort to duplicate the glass pattern a bullet might make, and to replicate the extraordinary marks on the bullet itself. Both efforts were mostly successful.

The defense noted that there apparently had been some sort of physical altercation in the alley between Mr. Vasquez and an unknown person. The victim had been wearing short pants; his legs and hands showed abrasions.

The defense reconstructed the shooting based on exhaustive testing, as follows: The altercation in the alley resulted in sufficient damage to draw blood. The GSR on Ms. Contreras's hands was caused by contamination from the police car transporting her to the station.

The glass embedded in the bullet came from it passing through the bedroom window. It entered the windowpane close to the existing crack, which limited mushrooming, imparted a wobble to the bullet that caused the abnormal markings, and made the impact hole in the undershirt larger than a clean shot would have.

—condensed from http://meixatech.com/CONTRERAS.pdf, courtesy Bryan Burnett

What do you think happened? What's missing?

Discussion Questions

Where was the cartridge case? Was it ever looked for? What was Ms. Contreras's state of mind when she called 911? Why did she confess, yet not know what she did with the rifle? Why wasn't GSR tested around the bullet hole to determine the distance of travel? Why didn't the state consider a shot from outside?

The purpose of including this particular case is to show the many different facets of an investigation, the importance of photographs, and the amount of thought, testing, and time (and therefore, money) that goes into a thorough investigation. Further, the case illustrates the logic and deductive reasoning required to advance a hypothesis (reconstruction of events) with justification, and the many unanswered questions that always linger. Some expert witnesses may not do as complete a job or be as forthright as expected or desired, whereas some do exemplary work. Lawyers do not always look for all possible answers, but may follow their own agendas. Justice may not always be served in the real world. And justice and truth may not be synonymous.

Toolmarks

Tools are often used in burglaries to pry open a window or door to gain entry, to open a safe or strongbox or other enclosure, or to steal a car.

Toolmarks are caused by the use of a tool against a usually softer object; for example, a screwdriver used to open a window may be pressed into the softer windowsill, leaving a mark.

Tools can be anything, such as screwdrivers, hammers, pry bars, wire or metal cutters, or saw blades. It is really the purpose for which the object is used, not the object itself, that defines a tool.

Figure 15.28 Tools

As with the marks found in firearms, there are class and individual characteristics of toolmarks. Class characteristics are the features that define the tool—its size and shape. As the tool becomes worn or damaged, it acquires particular markings that can differentiate it from others of its class; it becomes individualized. It is a matter of how closely you look.

Toolmarks associated with a crime are first photographed and/or sketched. Oblique viewing accentuates the details. If possible, the marked item is taken to the crime lab for examination. If this is not possible, the mark is saved by casting with a silicone, plaster, or clay material. From this casting, a three-dimensional replica can be made. The first step in the examination is to identify the class of tool so the police can be notified what to look for among suspects. The features of any tool recovered are then compared to the toolmark evidence. Characteristics that may be unique are compared in the hope of finding a match.

Laboratory Activity 15.5 — Matching Toolmarks

Advance Preparation

Mikrosil casting material is available from Evident Crime Scene Products (www.EvidentCrimeScene.com), for example. They also supply dental stone, gel lifters, and BIO-FOAM impression foam (see "Footwear," next section).

Step 1: Collect an assortment of tools: Hammers, screwdrivers, bolt and/or wire cutters, and pliers are the easiest to use. Apply one hammer stroke to a block of sanded wood; scratch a soft wooden block with a screwdriver hard enough to leave a good impression of scratches; cut a ¼-inch bolt with a bolt cutter and/or a heavy copper or aluminum wire at least ⅛ inch or more in diameter; pinch a block of wood with pliers. Be sure to use as many of the same type of tool as you can—new or used. Label each object with an ID number.

The purpose of this activity is to hone observational techniques with the intent of presenting evidence to a jury.

Materials

- an assortment of hand tools
- an assortment of toolmarks
- examples of toolmarks
- digital camera
- ruler
- dissecting microscope
- magnifying glass
- casting cement or silicone
- wooden blocks
- ink pad
- modeling clay
- lead or aluminum metal
- aluminum foil
- copper or aluminum wire
- Sculpey clay
- oven

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

Caution: *Wear chemical safety goggles to protect your eyes from plaster of paris dust. Work carefully so that plaster dust does not become airborne. Do not inhale plaster dust.*

Procedure

1. Toolmarks
   a. Examine the toolmarks on each object assigned to you. Record the identification number. Take a photograph, if possible; otherwise, sketch it (remember oblique lighting). Measure the dimensions. Include a scale

in any photograph. Make an educated guess as to what tool made the mark.

b. Observe the impression with a good hand lens or a stereomicroscope. Draw what you see. If applicable, make a cast of the impression using a casting cement or silicon. Also make one using a soft modeling clay that can be baked to harden, like Sculpey. These casts can be used as molds to cast a 3-D model of the marks the object made.

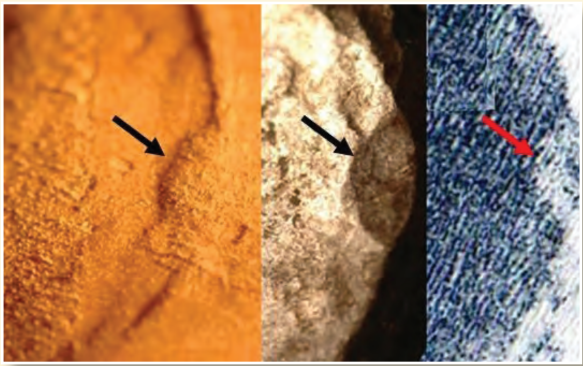


Figure 15.29 Impression of a hammer; (l-r) in wood, photo of hammerhead, inked hammerhead

2. Tools

a. You will now match a tool to the toolmark studied. Select the type of tool you think is applicable. Examine it under magnification to see if it is the particular tool that made the mark. If so, photograph the part that left the toolmark; otherwise, draw it. Record make, model, and dimensions.

b. Duplicate the surface imperfections of the tool itself, using applicable methods such as casting, using an ink pad, molding with modeling clay, etc. For screwdrivers, draw the tip at

Figure 15.30 Comparison of two bolt cutters

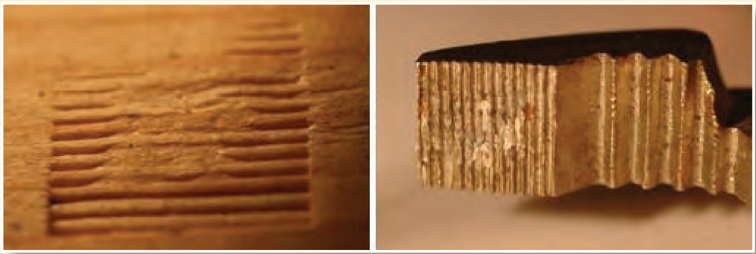


Figure 15.31 Toolmark from pliers

Advance Preparation, *continued*

Step 2: Put out all the tools you used (and maybe some you didn't).

Step 3: Supply fresh wooden blocks, bolts, and/or wire. Let the students label these.

Step 4: Here is where the students must succinctly organize their data to support their conclusions. A digital camera is really important because any photographs can be enlarged and enhanced to illustrate the toolmarks that match the suspected tool, or those that do not match it and thereby exclude the suspect.

A *good* drawing, large enough to show to a jury, will do. Figures 15.29–15.31 show what can be done using a variety of methods—a close-up lens on a digital camera, a good scanner, and Photoshop or Paint.

Laboratory Activity 15.5, *continued*

a 45° angle across a soft, smooth metal strip such as lead or aluminum (try heavy-duty aluminum foil also). There may be other methods you can devise, depending upon the type of tool.

3. Duplication

   Get a fresh wooden block and use the tool you chose to make an indentation or cut. For a snipper or cutter, cut a fresh piece of metal. Compare the marks with those you recorded in step 1. Make a copy with the best method you have found.

4. Conclusions

   Prepare a report detailing any matches found in the toolmarks you studied. To substantiate your opinion, use photos, drawings, and posters to show to the jury.

Figure 15.32 Composite of screwdriver striations; (clockwise) on wood, on aluminum foil, on the screwdriver tip, in clay. The "chicken scratches" are an ink impression of the screwdriver tip (blank areas are depressions).

Answers

Answers depend upon the knowledge and imagination of the student. Examples: (a) a sniper's shoeprint in *soil* at the point of shooting; (b) shoeprints in the *mud* at a construction site where rolls of copper wire were stolen; (c) boot prints in the *snow* at a house that has been vandalized; (d) *bloody* shoeprints at the scene of a vicious crime; (e) the *inked* outsole of a suspect's shoe on white paper; (f) an imprint of dirt, dust, and water left by a sneaker on a *clean* floor.

Impressions

Footwear Marks or Shoeprints

List three circumstances, each with a different medium, where shoeprints could be used as evidence; for example, a burglar walking across a dusty floor.

The word "investigate" is derived from the Latin *vestigium*, which means "footprint."

Footwear marks can provide information about a crime such as:

- Direction of approach and departure
- Point of entry and exit
- Mode of entry
- Sequence of events that took place
- Class and perhaps individual evidence linking suspect to the scene

15.2: Shoeprint Investigation of the Simpson-Goldman Murders

CASE STUDY

Following the murders of Nicole Brown Simpson and Ronald Goldman in the summer of 1994, photographs depicting shoeprint impressions in blood from the Brentwood, California, crime scene were delivered to the FBI Laboratory. The Los Angeles Police Department requested a determination of the brand and size of footwear that made the impressions. The impressions submitted were mainly from a path adjacent to the home of one of the victims, Nicole Brown Simpson. However, other partial impressions were on the victims' clothing.

By examining these impressions and researching the FBI reference and standards files, an FBI examiner was able to positively link some of the crime scene impressions to size 12 Bruno Magli Lorenzo shoes. The examiner issued a report directly to the judge in the case and was subsequently called to testify. Although the shoeprints from the crime scene could be positively linked to a particular brand and size of shoe, at the time of the criminal trial no evidence was available that defendant O. J. Simpson owned such shoes. In the interval between the criminal and civil trials, pictures depicting Mr. Simpson in such shoes were discovered. The shoes became evidence in the civil trial, when the examiner restated his testimony.

—from www.fbi.gov/hq/lab/fsc/current/held

Teacher Note

This case allows the teacher to stress the difference between criminal and civil law (see Chapter 1, page 29, question 15).

The standard method of documenting impression evidence is photography. Oblique-angle viewing can make all the difference in the world; see, for example, Figure 15.33. Collection and preservation can be accomplished by casting in some cases, and by electrostatic or adhesive lifting when the imprint is on a hard surface. Chemical enhancement, such as using a dye on a bloody shoeprint, can sometimes be effective.

Figure 15.33 Oblique and high-angle viewing

Matching shoeprint evidence to a shoe involves class characteristics such as manufacturer, type, model, and size. There are available databases that make searching through thousands of different shoeprints manageable; for example, SoleMate is a commercial database containing manufacturer, date of market release, an image or offset print of the sole, and pictorial images of the shoe itself for more than 12,000 sports, work, and casual shoes. TreadMark is a database that stores and compares imprints from a crime scene. As footwear becomes worn and damaged, the **outsoles** become more individualized, just as with toolmarks.

outsoles: the outer soles of shoes that are the bottom of the shoe, in contact with the ground

Laboratory Activity 15.6

Casting Shoeprints

Teacher Note

Pick out students who are wearing similar footwear. They will be exemplars. Have them make an imprint outside in soft soil or inside in damp soil (a shoebox works well). Do not label them or use a coded ID. The remaining students are the investigators. They will mix up the plaster and make and clean the casts. *Be sure to instruct the exemplars to wear the same footwear to the next class.*

A new product called BIO-FOAM is available to make three-dimensional exemplars. It is a solid block of foam similar to the kind used by florists and hobbyists. Shoes are pressed into the foam, and then sealed with hair spray. Each kit comes in a cardboard box container suitable for storage and protection. This method is easy, takes only seconds, and does not dirty the shoes. Casts can then be made from the imprinted foam blocks.

Another way of recording a shoeprint uses fingerprint powder rather than paint and a self-adhesive, 2-mm-thick, white lined paper mounting board with coated backer. The Lo-Tack version is best for this application. The front of the board has peel-off protective

Materials

- soil, preferably screened to remove large particles and debris
- shoeboxes
- dental stone (preferred over plaster of paris, which needs reinforcing to prevent breaking apart)
- paint stirrer or tongue depressor
- hair spray (a pump spray is better than an aerosol because it will disturb the soil less)
- toothbrush or a bristle brush
- black poster paint
- paintbrush
- white paper, $8\frac{1}{2}'' \times 11''$ or larger

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

Caution: *Wear chemical safety goggles to protect your eyes from plaster of paris dust. Work carefully so that plaster dust does not become airborne. Do not inhale plaster dust.*

Procedure

1. Pour about an inch and a half of soil into a shoebox and smooth it out.
2. Place your foot on the soil with all your weight, being careful not to wiggle.
3. Carefully remove your foot from the box.
4. Spray the impression with hair spray.
5. Mix up a paste of dental stone and water according to the directions. You will probably need about 400 g of powder. You can use a sealable plastic bag. Put the required amount of warm water in first, then add the powder. Mix it by massaging the bag until the material is smooth and has the consistency of pancake batter.

Laboratory Activity 15.6, *continued*

6. Pour the mix into the impression along an inclined paint stirrer or something similar in order to diffuse the flow. Never pour mixture directly into the impression, as this will damage it.
7. Let the cast set for at least 30 minutes, then remove it by prying it up from underneath.
8. Let the cast harden overnight before brushing it clean.
9. Match the cast to the shoe.
10. Use the brush to make a light but thorough coat of poster paint on the base of the cast. Press the cast against white paper until you get a good print. Label it.
11. Repeat this process with the actual shoe, label it to identify it with the cast, and add manufacturer, model, and size.
12. Compare the two prints. How well do they match? How do they differ from other prints made in class? Are there any specific features that could be used to individualize the shoe? If so, note them on the print. Which was easier—comparing the cast to the shoe or comparing the prints? How would you present your findings to a jury?

Teacher Note, *continued*

paper that exposes a smooth, white, adhesive surface. First, cut the mounting board to accommodate the shoe. While wearing the shoe, dust the sole with fingerprint powder, then tap or blow on the sole to remove any loose powder. Remove the protective covering from the board to expose the adhesive side. Place the board adhesive side up on a flat surface. With a second person holding it firmly in place, walk across the board, stepping heel to toe. To protect and preserve the print, the adhesive surface should be covered with fingerprint lifting tape (transparent 2-inch packing tape). This method will give finer detail than poster paint.

Figure 15.34 Casting a shoeprint

Figure 15.35 The cleaned cast

Personal Traits

Can you tell something about a person from his/her footprints? A set of footprints can sometimes tell you about the person or situation. For example, the length of stride and the way the footprint has dug into the ground can suggest running. In a walking **gait**, the length of stride may be related to the height of the individual. Is shoe size related to height?

gait: a manner of walking or moving on foot, said to be as individualized as your personality

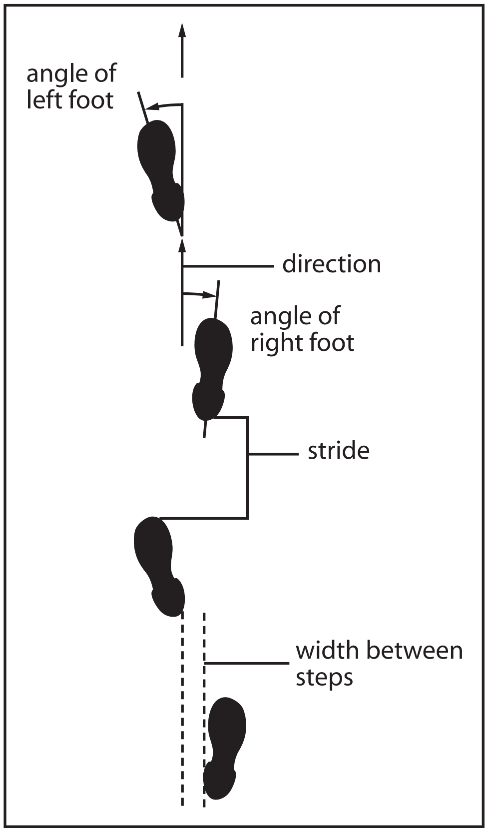


Figure 15.36 Gait pattern

Laboratory Activity 15.7

Relating Shoe Size to Height

This is an exercise in statistical analysis.

Materials

- a 12-inch ruler and a tape measure

Procedure

1. Measure the length of the shoe you are wearing by standing on the ruler.
2. Have someone measure your height.
3. Collect similar data from your classmates.
4. Plot height (*y*-axis) against shoe length (*x*-axis); one set for females, one set for males.
5. Is there a correlation between shoe length and height?

Teacher Note

For advanced classes, Excel can be used to find standard deviation and plot best fit. Error limits can also be drawn in by hand at the points where multiple data are available (see an example using real data from http://staff.imsa.edu/~brazzle/E2Kcurr/Forensic/Tracks/ShoeVsHeightIMSA.htm). Better statistics can be gained by combining data from all your forensic science classes.

6. **Estimate the error limits in your measurements. Will they influence your correlation? How much variation is there in height for the same shoe length? Translate this to error limits on your graph. Is there still a correlation?**
7. **Test the relationship: Obtain the same data from a few of your friends. Estimate their height, with error limits, from their shoe length.**

Tire Treads

Tread marks in tires are treated much the same as footwear marks. Shoes and tires are mass-produced. Class characteristics include design, size, type, and model. Wear and damage cause defects that can lead to individualization.

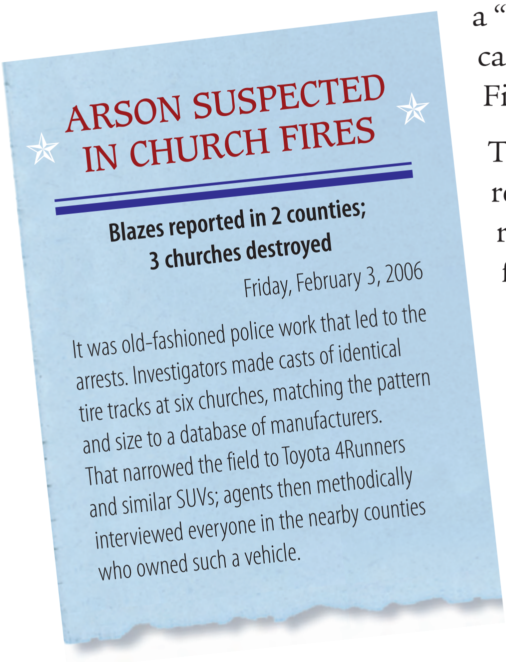
Vehicles are very often involved in crimes. Many times, tire marks are the only way to identify a vehicle. Impressions in mud, dirt, or dust or imprints left on a smooth surface by a moist or dirty tire can be photographed and collected using the same techniques as those used for footwear. One difference lies in the fact that a vehicle weighs at least ten times more than a person, so tire marks may be found on a body.

Figure 15.37 Tire tread; (l-r) tire, impression, imprint

As with footwear, databases contain information on tread designs, manufacturer, date of market release, etc.; for example, TreadMate contains data on more than 5,000 vehicle tires and tread patterns. Other databases consider **wheelbase** and **stance**, both of which can be used to identify a vehicle. Bald spots, marks such as a patch or nail head, cuts, or a split tread can often be seen in a cast impression. Sometimes, caked soil or a rock wedged in a tread can provide a distinctive identifying feature for an important period of time. This is called a "temporary chacteristic." Such characteristics can also be seen in tools; go back and look at Figure 15.27.

wheelbase: distance from center of front wheel hub to center of rear wheel

stance: distance from the centerline of the right tire to the centerline of the left tire



ARSON SUSPECTED IN CHURCH FIRES

Blazes reported in 2 counties; 3 churches destroyed

Friday, February 3, 2006

It was old-fashioned police work that led to the arrests. Investigators made casts of identical tire tracks at six churches, matching the pattern and size to a database of manufacturers. That narrowed the field to Toyota 4Runners and similar SUVs; agents then methodically interviewed everyone in the nearby counties who owned such a vehicle.

Tire marks such as skid marks are used in the reconstruction of accidents, including hit and run. Tire marks can also be used to assess tire failures in moving vehicles.

A recent article in *The Journal of Forensic Science* suggests that pyrolysis gas chromatography–mass spectrometry, PGC-MS (see page 157, Chapter 6), can be used to match the residue left on a road surface from a sudden braking or a spinning wheel to the tire manufacturer. This can assist investigators in tracing vehicles involved in hit-and-run incidents.

Bite Marks

Bite marks may be found in some crime cases, most often involving an assault or sexual attack. Bite mark evidence is common with victims of domestic violence. Everyone has teeth that are of slightly different shapes and slightly different widths, and they're arranged in slightly different ways. As they grow, different things happen; there are chips, fillings, crowns, and caps that make a person's teeth unique. Indeed, it has been estimated that the odds against two persons with a full set of 32 teeth producing identical bite marks are 2.5 billion to 1! Of course, impressions of only a few teeth are usually present on a victim. Bite marks were a prime piece of evidence used to convict serial killer Ted Bundy.

SCILINKS NSTA
GO TO www.scilinks.org
TOPIC bite marks
CODE forensics2E466

Previously, the only way to capture bite mark evidence on a victim was to take a photograph and/or make a drawing, and overlay a transparency of a

Figure 15.38 Bite marks; (l-r) on the skin, impression A, impression B

suspect's tooth pattern. Now, saliva of the perpetrator can be collected and amplified by PCR, and its profile compared to that of a suspect.

In Figure 15.38, which impression matches the bite mark in the skin?

Answer

Impression B

Comparing Bite Marks

Laboratory Activity 15.8

A simple method for acquiring bite marks is presented here.

Materials

- modeling clay or Sculpey clay
- thin plastic sheet such as from a baggie
- camera or scanner
- casting material such as Mikrosil

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

Caution: *Wear chemical safety goggles to protect your eyes from plaster of paris dust. Work carefully so that plaster dust does not become airborne. Do not inhale plaster dust.*

Procedure

1. Form a piece of clay into a rectangular block about 1″ × 2″ × ½″. Push it down on a flat surface with something flat in order to even out the surfaces.
2. Sandwich it between the sides of a thin plastic baggie.
3. Bite down on it, but do not bite through it.
4. Remove the plastic carefully so as not to distort the impressions.
5. Make a mark to identify the top teeth.

Laboratory Activity 15.8, *continued*

6. If using Sculpey, bake the mold according to directions.
7. Pour a casting compound onto one side of the mold, building it up so it will come off in one piece. Allow it to harden.
8. Turn the mold over and repeat for the other side of your bite.
9. Mark the top and bottom and remove the casting from the mold. You now have a replica of your bite.
10. Press the castings into a smoothed piece of dark-colored modeling clay.
11. Scan each side of the clay with a scanner, protecting the glass with a sheet protector. You may be able to manipulate the image to enhance the depressions, and print it out enlarged. A copier may work also. You now have a two-dimensional bite mark that can be easily compared to those of your classmates.

Are the 2-D bite mark impressions all different? What characteristics differentiate the imprints? Mark any specific characteristics in your bite marks, such as a filling, a chip, twisted or crooked tooth, etc.

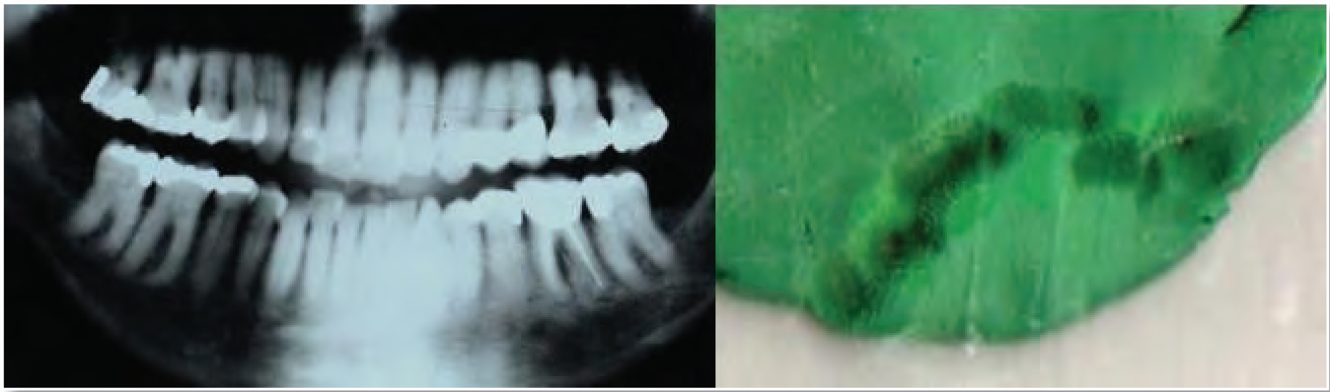


Figure 15.39 Can you relate the coauthor's top bite mark to his X ray?

Laboratory Activity 15.9 The Case of the Bitten Bonbon

Your teacher found her favorite chocolate, half eaten! It was a "Chocopologie" by Knipschildt, which everyone knows is a handmade chocolate with 70 percent Valrhona cocoa powder rolled over a French black truffle. It cost her $250—she was savoring it a little at a time. Fortunately, the churlish chocolatophile left tooth impressions in the top of her treat.

It is your team's job—no, it's your team's *duty*—to find the culprit, who is probably one of your (gasp!) classmates. Your bereft teacher has made several casts of the tooth marks, which will be distributed. Find the cowardly culprit!

Advance Preparation

Surreptitiously select one of your students to be the culprit, sworn to silence. A logical plan for your student investigators would be to initially compare 2-D top bite marks, eliminating the obvious. Then try to match 3-D casts to the culprit's cast. (You may have to buy your culprit's complicity with a chocolate bar,)

Restoration of Serial Numbers

Many items of value have serial numbers stamped into them for identification. People who do not want an item traced—usually those who stole it—attempt to obliterate the identification number, usually by grinding it off. Objects most often found with obliterated serial numbers are motor vehicles (the original vehicle ID number [VIN] on the engine block is missing), motorcycles, bicycles, and firearms.

The Federal Gun Control Act of 1968 mandated that all weapons manufactured or imported show a readily visible serial number.

When a metal is stamped or punched, the crystal structure beneath the impression is deformed. This area reacts to an etching solution more readily than the surrounding area. The chemical processes involved are merely oxidation-reduction reactions. Restoring serial numbers on ferrous metals is usually accomplished by first polishing the area with emery cloth and then repeatedly swabbing it with an acidic cuprous chloride solution. Figure 15.40 shows the effect of HCl-$CuCl_2$ on tool steel.

Restoration of manufacturing information and serial numbers can also be accomplished on wood, plastic, and precious metal articles.

Coauthor John Funkhouser had a case that involved a man falling off a wooden stepladder when it broke apart. He suffered severe injuries. His lawyer felt that the ladder was defective, but the manufacturer's identity that had been stamped into the ladder was unreadable. Wetting the area caused the undisturbed wood around the impression to swell enough so that with oblique lighting, the company name could be read.

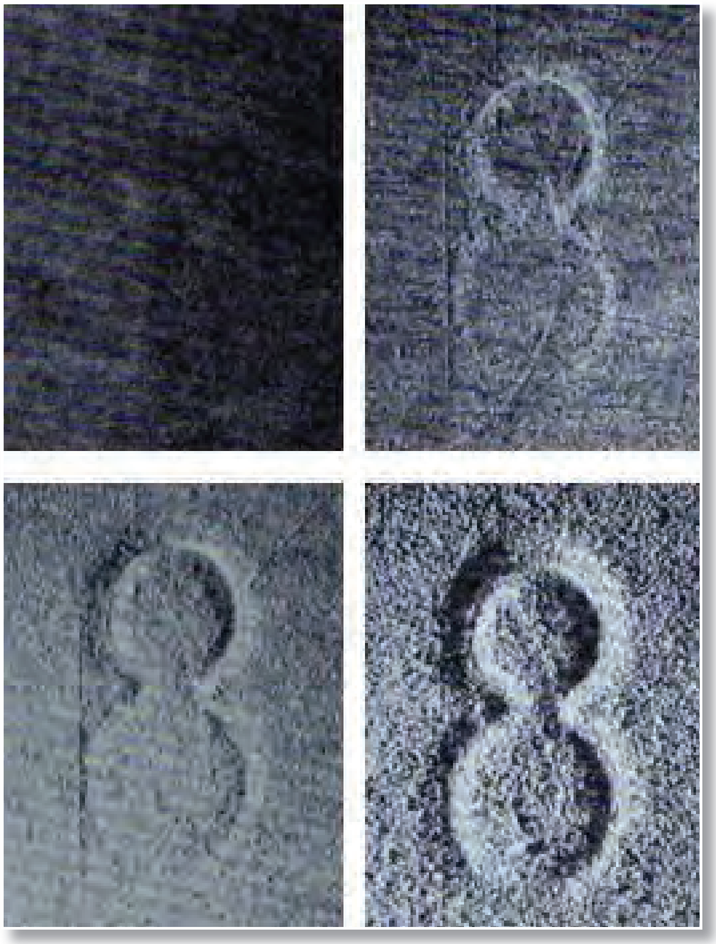


Figure 15.40 Sequential restoration; (l-r, top) 0, 15, (bottom) 30, 120 minutes

Checkpoint Questions

Answer the following questions. Keep the answers in your notebook, to be turned in to your teacher at the end of the unit.

1. An automatic weapon
   a. fires each time the trigger is pulled.
   b. is a revolver.
   c. is a machine gun.
   d. is illegal in the U.S.

2. Could "Dirty Harry" use .38-caliber ammunition in his .357 Magnum?

3. What bullet would you use for target practice? For hunting small game? For maximum damage to your target?

4. Why are lands and grooves important?

5. Name areas of a cartridge case that may yield individual evidence.

6. If the chances of finding a round firing pin in a cartridge are 1 out of 3, parallel breech marks 1 out of 2, and evenly spaced chamber marks 1 mm apart 1 out of 20, what are the odds of finding all three characteristics on a cartridge case? Refer to Chapter 4, pages 82–83. (Be careful, this is a trick question.)

7. What constitutes GSR?

Answers

1. C and D are correct.
2. Yes, the diameter is close enough to fit, but the punch would be less.
3. flat-nose wad-cutter cuts a clean hole in the target; full metal jacket to keep lead out of the meat; a hollow point
4. They are a result of rifling, which increases accuracy of fire; lands and grooves are class characteristics that can be used to identify the weapon's manufacturer and sometimes the type or model.
5. Firing pin in central breech, breech marks in center of base, extractor marks at the rim, ejector marks on or near the rim, chamber marks on the side of the cartridge. Magazine marks on the side of the cartridge perpendicular to its length may also be useful.
6. Apparent answer: $^1/_3 \times {}^1/_2 \times {}^1/_{20} = {}^1/_{120}$ if these were unrelated events. However, one gun can repeatedly produce the same cartridge case with all three features, so they are not independent variables. Be careful with how you use statistics!
7. primarily, primer composition (lead, barium, antimony), burned and unburned powder, nitrites

Answers, *continued*

8. open an unlocked door or window, use a stolen key, make an unforced entry using the threat of violence, use a disguise such as a delivery person
9. the microscope
10. oblique lighting
11. They can provide information about a crime such as direction of approach and departure, point of entry and exit, mode of entry, sequence of events that took place, and class and perhaps individual evidence linking the suspect to the scene. Also, they are always at a crime scene unless someone levitates. However, they are often overlooked or trampled, and even though the Locard principle holds, traces may not be visible.
12. using body measurements as a personal identifier
13. This depends on the plastic color, type, and thickness. A good answer will involve a Web search. If it is a clear plastic, polarized light might show the molecular crystallite deformation. If it is colored plastic, slight heating may create surface imperfections that delineate the original impression. Students should use their imagination and knowledge base; the question is intended more to get them thinking of ways to approach the problem, not to get a "right" answer.
14. B is logical, but contamination is a factor (see Case Study 15.1: The Case of *People v. Contreras*); A is better, but contamination is still a problem. D is probably the best answer, especially if the imprint of a pistol grip is evident.
15. a) gunshot residue, primarily primer composition (lead, barium, antimony), burned and unburned powder, nitrites; b) diameter of cartridge or bore of firearm barrel; c) handgun that fires at each pull of the trigger; d) a color test for nitrite in GSR; e) backward escape of gases and residues as a gun is fired; f) Integrated Ballistics Identification System, a database used to match bullets to firearms; g) a database of tread patterns and tires; h) Bureau of Alcohol, Tobacco and Firearms, a federal government agency

8. Name three circumstances where a burglar could enter a house without leaving a toolmark.

9. What is the most important tool for a firearms and toolmark examiner?

10. How can marks be accentuated for viewing?

11. Why are shoeprints important?

12. What does Laboratory Activity 15.7 have to do with Bertillon?

13. How could an obliterated serial number in plastic be restored?

14. How would one determine if an individual has recently fired a pistol?

a. by smelling the trigger hand

b. by testing with the Greiss reagent

c. by swabbing the hand and analyzing it using SEM-EDX

d. by spraying the gun hand with 8-hydroxyquinoline and observing it in UV light

15. How would you define the following terms to a jury?

a. GSR	e. weapon blowback
b. caliber	f. IBIS
c. semiautomatic handgun	g. TreadMate
d. Greiss test	h. ATF

16. What type of soil would make the best impressions?

17. What kind of shoe would give the least probative imprint?

18. Do any of these shoeprints match?

19. What general types of evidence were found in the Contreras Case Study that have been covered in this textbook?

20. Was the identification of O. J. Simpson's rather uncommon shoes class or individual evidence? Could further investigation have helped?

Answers, *continued*

16. A fine, sifted soil. Stones, sticks, and leaves will mask features.

17. one with a smooth sole, e.g., a woman's high heel, although the heel could be distinctive

18. No; they are all from different shoes.

19. blood, firearms, fabric/fibers, glass

20. Class evidence, although the rarity of the shoes would make such evidence much more probative. If the shoeprints from the crime scene were of sufficient detail, and shoeprints could have been made of Simpson's shoes, perhaps manufacturing imperfections, wear patterns, and damage marks could have individualized the prints.

Teacher Note

The image of the shoe-prints in question 18 can also be found as Blackline Master 15.4 on the Teacher Resource CD.

Optional Website Activity

Have students conduct the virtual autopsy case that can be found in the Chapter 15 student resources area (SCSI tab) on the *Forensics* website. See the teacher resource section on the site for more information.

Project: Both Sides of the Issue; Gun Control Laws

"A well regulated Militia, being necessary to the security of a free State, the right of the people to keep and bear Arms, shall not be infringed."

—U.S. Constitution

Write an analysis paper of the arguments surrounding gun control laws. In order that you gain an understanding of both sides of the issue, and acquire experience in identifying assertions and evidence, structure the paper in the following manner:

TITLE: Should Gun Sales and Ownership Be Subject to Federal Regulation?

AUTHOR: Your name

INTRODUCTION: Write one or two paragraphs briefly explaining current gun control laws. Are they federal laws? Are they state laws? Does your state have both? Are the current laws being enforced? Do we need new laws? Do the current laws need to be revised?

PRO SIDE: Write one sentence stating that gun sales and ownership should be subject to federal regulation.

SUPPORT: Write a short statement of why gun sales and ownership should be subject to federal regulation. Write at least three paragraphs supporting the statement, using at least three difference sources.

CON SIDE: Write one sentence stating that gun sales and ownership should not be subject to federal regulation.

SUPPORT: Write a short statement of why gun sales and ownership should not be subject to federal regulation. Write at least three paragraphs supporting the statement, using at least three different sources.

PERSONAL OPINION: Write your views and conclusions based on the above arguments. You must support one side or the other.

WORKS CITED: List references for all the sources you have used.

Additional Projects

1. If your school has a machine shop, stamp a short identification number into a piece of iron. Take a picture of it. Then have the number ground off. Restore it with Fry's reagent (30 g $CuCl_2$, 60 ml 15 percent HCl) by wiping the reagent in a cotton ball across the area until you get a good impression. Wash it off and take another photograph. *Wear gloves and safety goggles*. Repeat the process with obliterated aluminum using the same reagent, as well as a different one (6 g $FeCl_3 \cdot 6H_2O$ in 94 ml H_2O or 1 M HCl). Which reagent works the best?
2. Developing latent shoeprints. Obtain a square of linoleum, tile, or painted wood. Wipe the bottom of your boot or heavy-soled shoe with a moist cloth. Step on the sample of flooring. Try different methods of developing: Consider sprinkling fingerprint powder or a colored water-soluble powder on it. Try superglue fuming. Think of more ideas and try them. This is what research is all about.
3. You have studied the relationship between foot size and height. Is there a correlation between stride and height?

References

Books and Articles

Innes, B. *Bodies of Evidence*. Pleasantville, NY: The Reader's Digest Association, 2000.

Marriner, B. *On Death's Bloody Trail*. New York: St. Martin's Press, 1991.

Sedotti, M. "The Tell-Tale Bullet," from Mystery Matters in *Chem Matters*, February 1990, pp. 8–9.

Treptow, R. S. *Handbook of Methods for the Restoration of Obliterated Serial Numbers*. NASA, Lewis Research Center, Cleveland, OH, 1978.

Websites

www.precisionforensictesting.com/index.html; a place to get firearms and toolmark kits geared for high school classes

http://library.med.utah.edu/WebPath/TUTORIAL/GUNS/GUNBLST.html; good background information

www.genitron.com/IntPistol.html; interactive handgun firing

http://nfstc.org/projects/firearms/index.htm; detailed description of many aspects of firearms examination

www.forensic-evidence.com/site/ID/bitemark_ID.html; case of erroneous bite mark evidence

www.firearmsid.com; excellent site for identification of firearms

www.firearmsid.com/A_historyoffirearmsID.htm; a very thorough history of firearms

http://members.aol.com/varfee/mastssite/index.html; good site for footwear and tires