CHAPTER 1

BALLISTICS

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INTRODUCTION

Ballistics, in the most general sense, is the study of firearms—"guns" in the vernacular. As a term of art, ballistics technically refers to the study of a bullet's path from the firearm, through the air, and into a target. In criminal investigations, however, ballistics is a shorthand term for firearms identification: the art of matching recovered bullets and their casings to the firearm from which they were fired.

Firearms identification is often treated as a subspeciality of toolmark identification. A toolmark expert attempts to match tools like screwdrivers and crowbars to the marks they make when used on objects. This chapter focuses solely on firearms and the forensic specialists who make these matches. "Ballistics" experts are more than toolmark specialists. They are generally experts in many aspects of firearms and testify about topics ranging from whether a specific object is, legally, a firearm, to intricate reconstructions of crime scene evidence.

The first use of "ballistics" as a synonym for firearms matching was by Calvin Goddard, an early pioneer in the field. Goddard picked the term "Forensic Ballistics" in the 1920s after much consideration, in an effort to employ terms that would be concise and meaningful. He later regretted that decision. Goddard noted in 1953 that "from that day onward, scientific identification of firearms has popularly been known as ballistics, and the more I struggle to correct the trend that I so innocently started, the wider the usage becomes."

However one wishes to name the field, it is an important one. As a lawyer, you are likely to come across firearms in a large number of criminal cases. Guns are subject to a variety of state and federal laws and regulations regarding possession, transportation, and use, the violation of which is often a criminal offense. Firearms are, of course, also used to commit a variety of crimes. A little bit of history, firearms terminology, and some basic physics will help counsel understand firearms evidence when it appears in a case. (See Figure 1-1.)

THE SCIENCE OF BALLISTICS

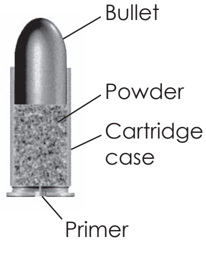
A Brief History of Firearms Identification

Today, it may be set down as a scientific fact, and a postwar discovery now first made public, that no two revolvers or pistols ever leave precisely the same marks upon a bullet, and that it now is possible and practicable to link the bullet to the weapon in virtually every instance.

—W. S. Stout, *Fingerprinting Bullets,*
SATURDAY EVENING POST (1925)

Early firearms such as matchlocks and flintlocks were made one at a time by individual gunsmiths. Each barrel and each bullet mold was unique. The barrel length, width, and the size of the bullets reflected the quirks of its maker. Even the screws that held together early firearms were handmade and often specific in width and pitch of the threads. Those individual quirks made it possible for early investigators to match bullets by

Figure 1-1 Parts of a Cartridge



SOURCE: Jonathan A. Turner.

simple observation. An English investigator, a member of London's Bow Street Runners, was able to match a bullet to its mold in 1835 just by looking at the two items. He also matched a paper patch (used to create a seal between the bullet and gunpowder in the days before cartridges) to a newspaper in the suspect's house.

In the early 19th century, firearms and bullets began to be mass-produced. Rifling, the grooves cut into a barrel to make a bullet more stable as it flies, was standardized by manufacturers. A firearms maker or law enforcement officer could look at a bullet from a crime scene and say whether it was, in general, too large to come from a specific firearm, or whether the major rifling marks on the bullet matched those on the barrel. He could no longer match a bullet to a specific firearm among those made by one manufacturer.

Experts suspected that there might be fine marks and differences unique to each firearm, but invisible to the naked eye, that were made during the manufacturing process and accentuated by use and maintenance. Magnification proved to be the key. Indeed, experts found differences between firearms made by the same manufacturer, even between guns made one right after another on the same machines. A Parisian professor began photographing bullets from crime scenes and those fired from recovered weapons, enlarged them, and tried to compare them. Other experts tried rolling the bullets on inked paper, or on a soft material. Microscopes existed in the late 19th century, but it was hard to compare two enlargements simultaneously to see if the tiny marks on the bullet or cartridge were the same. As long as an investigator could inspect only one bullet at a time with his microscope, and had to keep the picture of it in his memory until he placed the comparison bullet under the microscope, there was a risk the investigator would miss noting key details or see a match that didn't exist.

Charles E. Waite, a legal investigator, became involved as an expert in the Stielow case, a New York homicide conviction in 1915 based on sloppy firearms identification testimony. Charles Stielow, sentenced to death for murder, was exonerated by Waite's investigations, which concluded that Stielow's revolver could not have fired the fatal bullets. Stielow was pardoned and released from prison.

Afterwards, Waite began visiting firearms companies and making notes about how firearms and ammunition were manufactured. Waite joined with Major Calvin Goddard, an officer in the Ordnance Corps; Philip Gravelle, a chemist; and John Fisher, a physicist, to form a private Bureau of Forensic Ballistics in New York City. These four men were among the first experts to study firearms identification.

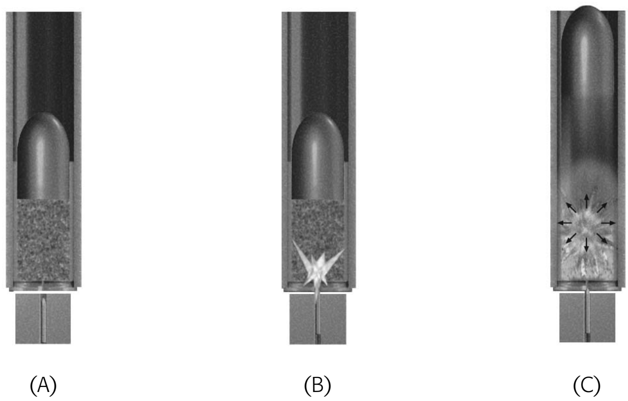
Gravelle wanted to be able to look at both the crime scene evidence and a bullet fired from a recovered weapon at the same time. He developed a comparison microscope (two microscopes with a bridge so that objects can be compared in the same field of view) and a way to mount bullets on the microscope. Modern examiners' equipment and methods are essentially those that Gravelle pioneered.

Matching bullets to their firearms is only part of this history. In an early firearm, the shooter poured gunpowder into the barrel, added the bullet, added paper wadding to create a better gas seal, and tamped it all carefully into place with a rod. This was, of course, slow, imprecise, and dangerous if the powder ignited prematurely. Loose gunpowder was also likely to get damp and fail to ignite, and the shooter might under- or overload the powder charge if rushed. Just before the American Civil War, manufacturers created individual premeasured charges of powder and bullet held in a cylinder of paper or cloth, often coated with wax or grease, called cartridges. The cartridges were bitten or cut, the powder was poured into the barrel before loading the bullet, and the paper was used as wadding. (Some cartridges were soaked in potassium nitrate so that the whole thing, uncut, could be rammed powder end first into the barrel unopened and would likely fire.)

Ammunition makers looked for a way to combine bullet and powder into one durable moisture-resistant unit. The metal cartridge case was introduced in the mid-19th century. The cartridge case contained a percussion cap, or primer, in its base (Figure 1-2A). When the firing pin struck the primer, it in turn ignited the gunpowder (Figure 1-2B). The cartridge case expanded from the explosive gasses and was pressed against the *breech* (the back of the chamber) and the firing pin as the bullet was pushed down the barrel (Figure 1-2C). In rifles, shotguns, and semiautomatic pistols, the cartridge is extracted or ejected from the firearm after each shot so that a new round can be loaded and fired. Often the now-empty case ends up on the ground. In a revolver, several cartridges are loaded into the cylinder, which rotates after firing to place an unfired round between the firing pin and barrel. After all of the shots are fired, the shooter then manually removes the cartridges and can pocket them instead of leaving them for investigators to find.

Early experts suspected the breech marks and firing pin marks impressed into the relatively soft cartridge metal by the force of the shot could be used to match an expended cartridge to a specific firearm. In 1907, experts tried to do just that in the aftermath of a riot by U.S. Army soldiers near Brownsville, Texas. The examiners were able to match most

Figure 1-2 Cartridge Being Fired
(A) Cartridge at rest in firearm; (B) firing pin igniting primer; and (C) primer igniting gunpower and gas pressure forcing bullet from barrel.



SOURCE: Jonathan A. Turner.

of the cartridges to their rifles—their report was a milestone in firearms identification.

Firearms identification came to the public's attention in 1925 when the *Saturday Evening Post* published two articles called "Fingerprinting Bullets" on Waite's work. Goddard became famous for his work identifying firearms used in the Sacco and Vanzetti case in 1927 and in Chicago's St. Valentine's Day Massacre in 1929.

In the Sacco and Vanzetti case, Goddard test-fired a bullet from Sacco's gun into a wad of cotton and then put the ejected bullet on Gravelle's comparison microscope next to bullets found at the crime scene. The first two bullets did not match, but the third one did. (As discussed later, random variation in marking caused by minute differences in expansion, pressure, angles, or even bits of grit can make marks more or less visible.) Even a defense expert agreed that these two bullets had been fired from the same gun. Sacco and Vanzetti were executed.

In the St. Valentine's Day case, Goddard examined various fired bullets, shotgun pellets, and fired cartridge cases and concluded that one 12-gauge shotgun and two Thompson submachine guns were used in the crime. Goddard was later able to match the evidence to guns found in a suspect's home.

Goddard also trained the first firearms identification expert at the FBI laboratory, founded in 1932. The FBI laboratory is now one of the largest employers and trainers of firearms examiners.

With the publication of three major firearms identification treatises in 1934 and 1935, the field had become accepted by the courts and by law enforcement in the United States, the United Kingdom, and Europe. For the most part, the techniques pioneered by Goddard and his contemporaries are still in use by modern firearms examiners. Digital imaging and databases allow firearms examiners to search for potential matches for crime scene evidence more quickly, but a definitive opinion still requires an examiner to compare the evidence on a microscope.

Firearms

One of an examiner's most basic tasks is to explain how firearms and ammunition work. Juries, judges, and lawyers are often unfamiliar with this complex and sometimes arcane topic. Because statutes often distinguish between different kinds of firearms, and between objects that look like a handgun or rifle (like air pistols, paint ball guns, starter pistols, nonworking replicas, or even toys shaped and painted to look like actual firearms) and those that can discharge a bullet, the firearms examiner is often asked to explain whether an object meets a statutory definition.

States, and the federal government, have been regulating the possession, carrying, transportation, and sale of firearms since the early 19th century. These statutes often define the word "firearm" and divide guns into types like rifles, shotguns, and handguns. When a police officer finds something that looks like a firearm at a crime scene or takes it from a suspect, an examiner makes sure that the object is an actual working firearm and not broken, intentionally made permanently unusable or "demilitarized," a nonworking replica, or just a gun-shaped object like a toy. Criminal charges and penalties can vary if, for example, the object is "a weapon from which a shot can be fired" and whether the shot is fired by a gaseous combustion, like gunpowder, or by air pressure or a spring like a BB or pellet gun.

Firearms examiners may also have to answer questions about whether a firearm was broken if a suspect says a shooting was an accident and the firearm "went off" by itself. The firearm may have internal safety devices that failed, or it may be a weapon, such as a replica of a historic handgun, that was not made with such features. Examiners also look for illegal modifications to firearms—such as making a shotgun's barrel shorter than the minimum legal length (generally 18 inches) to improve its concealability, or obscuring the firearm's serial number.

What Kind of Firearm Is It?

If the object is a working firearm, the examiner determines what kind of gun it is. Concealable weapons like handguns and short-barreled shotguns were among the first to be regulated. New York's Sullivan Law, passed in 1911, requires people to acquire a license to possess or carry a firearm small enough to conceal. The federal Mailing of Firearms Act, passed in 1927, prohibits sending firearms that can be concealed on a person through the mail. Since the early 20th century, many other statutes have distinguished between rifles and shotguns, and handguns. Thus, an examiner may have to determine whether a specific firearm meets the definition of a handgun, generally by measuring the length of its barrel, or is legally a rifle or shotgun.

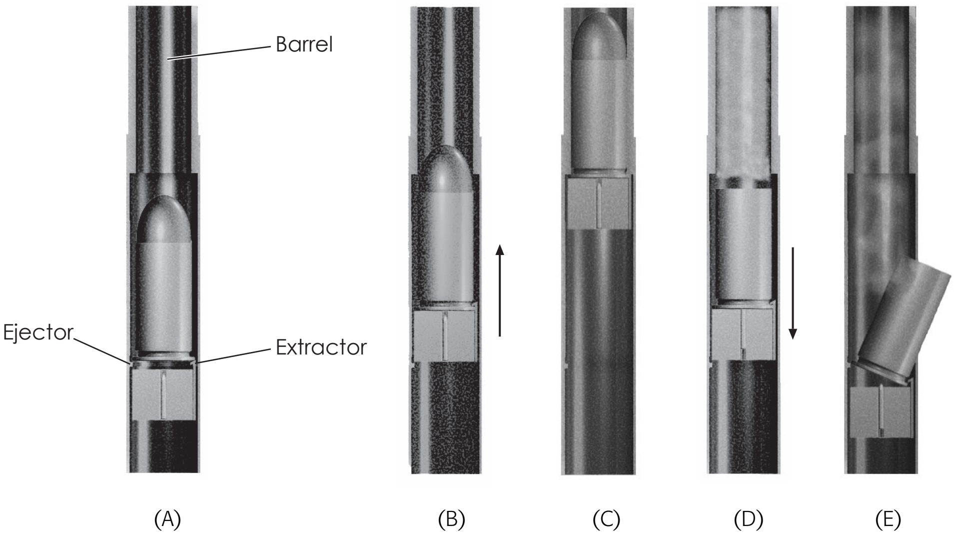
Rifles and shotguns are relatively large firearms. They are designed to shoot targets, often game animals, at long range and so have long barrels to improve the bullet's stability, a heavier barrel and chamber to contain the force of more gunpowder, and a stock to brace the firearm against the user's shoulder for more stability. Because these guns are hard to conceal, and often used for hunting, target shooting, and other sports, they are often less strictly regulated than handguns.

Rifles (and most handguns) have a barrel with grooves cut into it (*rifling*) to make the bullet more stable and accurate. Shotguns have a smooth barrel and often fire one cartridge containing many small round projectiles (*shot*). Rifles and shotguns can be *single shot*—the firearm is loaded, chambered, cocked, and fired, and the spent cartridge is extracted in a series of manual steps. A *semiautomatic* firearm performs all of those steps, except the firing of the next cartridge, automatically. (See Figure 1-3.) In some states, certain semiautomatic rifles and shotguns are defined as *assault weapons*; consequently, they either require specific permits or are prohibited entirely. A *machine gun* is a fully automatic firearm; when the shooter pulls the trigger, the firearm keeps firing until the trigger is released or it runs out of ammunition. Machine guns can be rifles or handguns. Federal and state law restricts transfer and transporting of machine guns.

As noted previously, handguns are designed, in general, as concealable, short range self-defense, target-shooting, and hunting weapons. Normally, the barrel is less than 16 inches long, to make the handgun easier to carry. Often, they are made of light, strong materials to make them more convenient to carry. Typically handguns are divided into revolvers and semiautomatic pistols. ("Pistol" historically refers to any handgun, but it is often used either as a synonym for a semiautomatic handgun or to clarify that the semiautomatic item is a handgun and not a rifle.

Figure 1-3 Sequence of Firing in Semiautomatic Firearm

(A) Cartridge in open chamber; (B) cartridge moving forward as chamber closed (extractor engaged); (C) cartridge at the moment of firing; (D) cartridge at the moment after firing, bullet is being driven out of the barrel and gas pressure forces the cartridge back to open the chamber; and (E) cartridge being ejected from the open chamber by the extractor and ejector, which can both leave marks on the cartridge.



SOURCE: Jonathan A. Turner.

Historically, there was a semiautomatic revolver; it is now a valuable collector's item unlikely to be found at a crime scene.) Some states limit how many cartridges a handgun can hold at one time. For example, Massachusetts requires a specific firearms permit for *large capacity* handguns (those capable of holding more than 10 cartridges at the same time) that is different from the permit for any other handgun.

Single shot "zip guns" are improvised or handmade handguns often made from pipes or, in earlier decades, telescoping car antennas. Any handmade weapon capable of firing a cartridge is often separately prohibited by statute.

Occasionally, an examiner will refer to a handgun colloquially as a "Saturday night special" or a "junk" gun. Unless your jurisdiction uses either of these terms in its statutes or regulations, defense counsel should object if an examiner characterizes a firearm in this manner. These colloquial phrases can be highly prejudicial and are not relevant to most criminal trials. These terms suggests that the handgun is the type of firearm that would only be used by a criminal and is not useful for target-shooting, hunting, or self-defense. Indeed, these handguns generally are not designed for target-shooting or hunting—they are small, very basic, inexpensive handguns that can be carried in a pocket rather than in a special holster and are intended to be accurate at short ranges, such as those typically encountered in a self-defense situation. Thus, they are affordable by people who intend to carry and use them solely for self-defense and who do not want or need the features of a larger multipurpose handgun. Also, some jurors may be aware that there is a racial component to phrases like "Saturday night special." Many statutes banning inexpensive handguns are based on laws passed in Tennessee, Arkansas, Alabama, and other southern states after the Civil War to ban firearms that newly enfranchised black citizens could afford. For example, in the Florida case of *Watson v. Stone* (1941), a concurring opinion noted that "the Act was passed for the purpose of disarming the negro laborers. . . . The statute was never intended to be applied to the white population and in practice has never been so applied."

Not all rifles and handguns use gunpowder, or modern metal ammunition. Compressed-air-powered handguns and rifles are often lightly regulated, if regulated at all. Many states also exempt historic firearms, and working replicas thereof, which cannot use modern ammunition, like muskets, matchlocks, flintlocks, and percussion-cap-based weapons from most regulations. The "black-powder" firearms are primarily owned and used by collectors and hobbyists—they are rarely involved in crimes.

What Kind of Ammunition Is It?

Examiners may also be asked to describe bullets and ammunition to juries explaining different *calibers* (diameters of bullets) and bullet types, such as the difference between a jacketed and unjacketed bullet, or between a round-nosed bullet and a hollow-point bullet. Some kinds of bullets are regulated by federal or state law. Armor-piercing bullets, for example, are regulated by federal law that defines armor-piercing ammunition and limits its sale to law enforcement and the military. In New Jersey, it is illegal for anyone other than military and law enforcement personnel to possess hollow-point ammunition.

Ideally, an examiner will describe ammunition using precise language. The standard cartridge issued to New York City Police Department (NYPD) officers is a CCI-Speer 124-grain Gold Dot +P JHP (a jacketed hollow-point design) for 9mm semiautomatic handguns and a Federal 158-grain +P Nyclad LHP (a lead hollow-point design) for .38 Special revolvers. What does this mean?

The most basic information about a cartridge is its caliber. "Caliber" is a confusing term of art. In theory, the caliber is the diameter of the associated firearm's barrel, not including the depth of the rifling groves. Caliber is usually given in 1/100th of an inch (.22, .45), in millimeters (9mm, 40mm), or in "gauges" (12 gauge, 20 gauge). However, there are many customs and historical variations—".38 Smith & Wesson" ammunition is not the same width as ".38 Special" ammunition, even though one might assume both to be 38/100ths of an inch wide. The .38 Special cartridge is closer to .357 inches in diameter (and indeed can be fired from a handgun designed for .357 ammunition). A .38 Smith & Wesson cartridge will not physically fit into a firearm designed for .38 Special ammunition. Precision, especially where .38 caliber bullets are involved, can be very important.

Revolver and semiautomatic cartridges are not readily interchangeable—the revolver cartridge has a small rim around its base to hold the cartridge in place when it is loaded into the revolver cylinder. The base of a semiautomatic cartridge is flush with the cartridge sides, but there is a small groove cut for the extractor to grip when it ejects the round. It is possible to load a semiautomatic pistol cartridge into a revolver; there are ammunition clips designed for this purpose. If one loads a revolver cartridge into a semiautomatic pistol, the firearm is likely to malfunction in use.

Returning to the example, the first words in the description name the manufacturer. The semiautomatic handgun bullet is made by Cascade Cartridge, Inc. (CCI). The revolver bullet is made by the Federal Cartridge Company. The name of the manufacturer may tell the expert and the jury something about the bullet's construction and quality.

The next piece of information is the bullet's weight. The semiautomatic bullet weights 124 grains; the revolver bullet weights 158 grains. (The weight of bullets and of powder is traditionally given in "*grains*" which are 1/7000 of a pound. In this case, the weight is that of the bullet, plus jacket, if any.) The bullet's weight is important because it affects how much force (kinetic energy) the bullet has when it strikes a target. Doubling the bullet's weight doubles the kinetic energy, assuming that the bullet's velocity is constant.

Next, the style or type of bullet is described. CCI's Gold Dot bullet has a copper jacket, which is electrochemically bonded to the lead core, instead of just pushing or pouring the lead core into the jacket. This makes it less likely that the jacket and core will separate on impact. (Separation can cause the bullet to behave oddly—tumbling or breaking apart, and having less than the expected wounding effect.) The Nyclad bullet has a nylon jacket around the lead bullet. These jackets were not designed to affect damage; jackets were designed for semiautomatic weapons to prevent malfunctions caused when bits of lead from a plain lead bullet are deposited on the ramp and action of the firearm when large numbers of lead bullets are fired. A semiautomatic weapon can fire lead bullets at the risk of malfunctions. Jackets do not affect a revolver's operation, but they can keep down the amount of lead dust released when the bullet is fired—a health concern for officers, especially those using indoor firing ranges for training.

Both bullets are designated as "+P". The firearms industry has a standard for the gas pressure generated by each type of ammunition. A +P cartridge generates higher gas pressure than the standard cartridge, which translates into a higher muzzle velocity, without making the cartridge physically larger. Doubling a bullet's velocity quadruples the amount of kinetic energy it has when it strikes a target. *Magnum* has similar connotations of higher muzzle velocity in the same diameter cartridge. A magnum bullet, such as the .357 Magnum, or Harry Callahan's .44 Magnum, is generally longer than an equivalent round of the same diameter. The longer cartridge holds more gunpowder and can generate a higher muzzle velocity. (Both "+P" and "Magnum" have associated industry standards for gas pressures generated in the chamber.)

Finally, both bullets are hollow-point, which means that they literally have a small hole in their "nose" and are designed to expand when they hit a target. Hollow-point ammunition is commonly used by police officers, federal agents, and citizens for self-defense. By expanding, the bullet increases its drag and tends to remain inside the target—this is believed to increase the chance that the wound will stop an aggressor, although medical examiners have been unable to show any difference in lethality between hollow-point and traditional round-nosed lead bullets. Also, the bullet is less likely to go through standard building materials if it misses the target and more likely to be stopped by police body armor if an officer gets in the way of a round fired by another officer. (Body armor is not commonly used by criminals.)

Occasionally, an examiner will describe a piece of evidence as a "cop killer" bullet. Again, defense counsel should object to this misleading and prejudicial term. The phrase was created by media reports about the Teflon-coated "KTW bullet," named for its three inventors. The KTW bullet has a brass or tungsten core, which helps it penetrate automobile glass instead of being deflected by the angled surface. It also has a Teflon coating, which protects the handgun barrel from excessive wear and makes it better able to penetrate smooth surfaces like automobile glass and metal when it strikes at an oblique angle.

These bullets have not been available for sale to the general public since the 1960s. They were only available to the military and law enforcement. In 1982, NBC television ran a sensational story falsely claiming that the KTW bullet could penetrate police body armor, creating a mythical "cop killer" bullet. The publicity resulted in a federal law which limits the sale of actual armor-piercing ammunition to law enforcement and the military. Winchester's Black Talon bullet was another victim of hysteria about its purported effects.

As an aside, police body armor has to balance comfort and wearability with protection. If the armor is too bulky and uncomfortable, officers will not wear it routinely, which risks their safety. The federal government sets standards for police body armor—the most common type is designed to protect officers from most handgun ammunition. Handguns are the most common weapon faced by police. However, nearly any bullet fired from a rifle will penetrate typical body armor because rifle ammunition is designed to shoot game at a distance and so has a higher muzzle velocity. This does not make rifle bullets armor-piercing or cop killer bullets. Actual armor-piercing ammunition has a solid metal core and is designed to penetrate ceramic and metal armor plates used in tactical (SWAT and military) body armor.

Where Was the Bullet Fired From?

The distance between the muzzle of a firearm and the object or person shot may distinguish between an accident, a self-defense shooting, suicide, and homicide. In some states, examiners perform gunshot residues analysis to estimate the distance between the muzzle of a firearm and whatever the bullet struck. A medical examiner may be responsible for this estimate if the bullet killed a victim.

When the firing pin ignites the gunpowder, most of the gases produced come out of the barrel, along with bits of unburned and burning gunpowder, soot, and sometimes tiny fragments of the bullet as it scrapes along the rifling.

If the firearm's muzzle is directly in contact with an object, all of that material has nowhere else to go but into the object—the gases may tear clothing, or flesh; particles will be found in the bullet hole.

In general, as the distance increases from contact to 2 feet (more or less) from the target, particles of gunshot residue (lead, antimony, and barium), unburned and burned gunpowder, and soot will be found in decreasing amounts. At close range, from 0 to 2 inches, the target may be scorched or seared by hot gasses from the muzzle; blood, tissue, and other materials may be blown back onto the firearm and into the barrel. Burning, burned, and unburned powder may hit and embed into the skin and cause marks called *tattooing*. At a greater distance, roughly 2 to 10 inches, the target will not be scorched, but there will be a black smudge composed of fine particles of metal and bits of burned and unburned gunpowder. From distances greater than 10 inches, only larger grains of powder and metal will be found around the bullet hole. This is, of course, a rough approximation. The exact distances will vary by firearm, ammunition, and environmental conditions.

Finally, at some point, the velocity of all of the particles except the bullet itself is too low for the residue to reach the target. The examiner can only say that the muzzle was more than this distance from the target. It might have been just beyond this distance, or in the next room, or across the street, up to the maximum range of the firearm and the practical limits of the crime scene. There may also have been an intermediate soft object which absorbed the gunshot residue, making it appear that the shot was fired from a longer range.

To make a valid distance determination, the examiner will need to test-fire the recovered firearm, using the same brand, weight, and kind of ammunition. Using a different lot of the same brand of ammunition can sometimes yield a misleading result. Counsel should carefully review the examiner's report to make sure he or she used the correct method for this test.

If police do not recover a firearm, then an examiner may be able to make a rough estimate of the distance between muzzle and target based on the caliber of the bullet, markings on the bullet suggesting what kind of firearm it came from, and the type of particles found around the wound. If a firearm is found and matched, the examiner may test-fire it at various distances to try to match the pattern of residue found at the crime scene.

The cloud of gases also can deposit gunshot residue on the shooter's hands and body. Automatic and semiautomatic handguns use a portion of the gas to eject the now-expended casing and load a new cartridge. Revolvers often have a small gap between the cylinder and the barrel where gases can exit. (Firearms are designed to keep these hot gases from harming the shooter, although they can burn someone holding the firearm improperly, such as during a struggle over the firearm.) If a person's hands are promptly tested after a shooting, an expert may be able to find gunshot residue. However, if the person has washed his or her hands, or normally handled objects over a few hours, any particles will likely be lost.

The paraffin test, occasionally mentioned in older cases or books, is no longer used because it is unreliable. Modern tests swab the target's hands or clothing and analyze the results using a scanning electron microscope (SEM) analysis test.

If an expert finds gunshot residue, this does not necessarily mean that the person fired a firearm. He or she could have held a firearm after it was fired; been near the person who fired the weapon; been contaminated by police officers who recently fired weapons or handled a fired weapon; or been in contact with lead, antimony, and barium through work or hobbies.

Note that for most ammunition all three elements—lead, antimony, and barium—must be present in order for the examiner to testify that gunshot residue is present. Two of the three elements is not enough according to many police laboratories. A few, including the Maryland State Police lab, deem some tests showing only two components adequate to conclude that gunshot residue is present. For example, if .22 caliber ammunition is involved, it may have originally contained only two of the three elements, and thus a finding of those two elements would indicate that gunshot residue is present.

If defense counsel is aware that a gunshot residue test found only one or two elements of gunshot residue, and that all three should have been present, he or she should move to exclude this evidence as irrelevant and as more prejudicial than probative. Many judges will allow testimony about what was found, so long as the examiner also testifies that all three elements are needed for a conclusive result. However, in one recent Minnesota case, *State v. Moua,* the trial court excluded testimony about the results of a gunshot residue test due to concerns about contamination prior to the test samples being taken. The prosecutor may argue that the presence of one or more of the components of gunpowder corroborates other evidence in the case that the client fired a gun, even if those elements are not conclusive in themselves.

Examiners may also try to reconstruct the trajectory (flight path) of the bullet from muzzle to target using rods, lasers, and other devices. When a bullet leaves the muzzle of a firearm, it travels (more or less) in a straight line until it hits something. Over long distances, wind and gravity both affect the bullet; however, most bullets used in crimes are fired at relatively short ranges where these factors can be simplified or ignored. Examiners may carefully place a rod through the holes left by a bullet in objects, or even bodies, to try to figure out where the bullet was fired from. Once the bullet hits an object, however, it may be deflected or deformed by it, and travel in an unpredictable way. An examiner may be able to find scuffs or abrasions on materials produced by the bullet striking an object and being deflected by it.

Often the numbers assigned to multiple wounds by medical examiners, doctors, and firearms experts are arbitrary. It is difficult to determine the order in which bullets hit a target or person. Prosecutors and defense counsel should make sure that the jury or judge understands that the numbering does not indicate order. If an expert has an opinion about the order of shots, carefully review the assumptions underlying the opinion.

Also, a trajectory determination may tell the expert where the shooter and target were at the instant the shot struck. It does not necessarily reveal what happened in the prior instants, during the tenths of seconds it took the person holding the gun to decide to shoot, draw the firearm, and fire it. Studies show that a moderately healthy person can turn his or her torso 180 degrees in 0.53 seconds and can turn his or her entire body 180 degrees in 0.667 seconds. This is very close to the amount of time it takes a trained police officer to fire a drawn handgun upon seeing or hearing a signal. Thus, it is possible that at the moment a police officer or gun owner began to fire at an aggressor, the aggressor was facing him or her. By the time the officer or owner completed firing the handgun, the aggressor had turned around, leading to a shot in the back. Counsel should ask the examiner about the assumptions underlying a trajectory determination and whether the shooter and the person shot may have been in motion during the encounter.

A bullet may not take a straight path through the body. If the person who was shot died, the autopsy report will generally include a description of the bullet's track. If the person who was shot survived, the treating physicians will estimate the wound track based on their examination and treatment. The doctor may be mistaken, even about such basic elements as which wound is the entry wound and which is the exit wound. Ask the testifying physician about his or her training in this area, assumptions, and specific findings, if it is important to your case. (If the bullet has not been removed from the person shot, be wary of caliber estimates based on the size of the wounds or on x-rays.)

A firearms owner who has tried to locate every casing fired after target practice on an outdoor range will be familiar with the perverse ability of semiautomatic cartridge casings to bounce, roll, and disappear in sand, tufts of grass, shadows, crevices in concrete pavement, and depressions. Most semiautomatic firearms eject the casing to the right of the pistol's frame. However, the ejection pattern can change if the firearm is held in the left hand or held sideways. In addition, casings are round and light. They bounce and roll on the ground and can be kicked, crushed, or blown by wind or passing cars. Some are even small enough to get stuck in the treads of a sneaker or boot and be carried away from the scene entirely. If an examiner attempts to estimate the shooter's position, counsel should carefully review the expert's methodology to ensure that the estimate is scientifically defensible.

Firearms Identification

The automatic pistol leaves plenty of evidence of its presence in the form of empty fired cases which the guilty party rarely tarries to recover, his main idea being to get away from there, and these can tell a very revealing story if properly assayed.

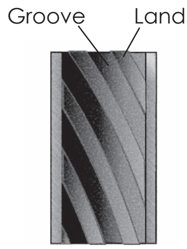
—Calvin Goddard, Address to Southern Police Institute, University of Louisville (May 1953)

When investigators find a bullet at a crime scene, it can tell an examiner the caliber of the gun that fired it, the type of bullet, and possibly the manufacturer and model of the firearm. If police find expended cartridge cases, these also indicate the caliber of the weapon used, its type (rifle/shotgun/revolver/semiautomatic pistol), and possibly the firearm's manufacturer. If police also recover a gun from a suspect, an expert would likely be able to match the bullet and cartridge case to that specific firearm. Experts can do this by looking at the marks the firearm makes on the cartridge and the bullet as it is fired.

When a cartridge is fired, the firing pin strikes the primer. This impresses the firing pin's mark into the soft metal of the primer. The primer contains a tiny bit of explosive, which, when hit, ignites the propellant. The propellant burns rapidly, producing gases that exert pressure in all directions—on the head of the cartridge case, on the walls of the cartridge case, and on the bullet. The bullet is the only part able to move, and is forced out of the barrel, leaving the cartridge case behind.

Most firearms have a rifled barrel. Parallel spiral grooves are cut into the inner surface of the barrel. The space between the grooves is called the *lands* (see Figure 1-4). The grooves twist to the right or left. The number of grooves, their width and depth, and the angle of the twist (pitch) vary by manufacturer. Most American-made firearms use a right twist; Colt uses a left twist. Glock, a popular handgun manufacturer, uses a unique polygonal rifling system. The FBI maintains a database, the General Rifling Characteristics (GRC) file, which is organized by caliber, number of lands and grooves, direction of twist, and width of lands and grooves, to help an examiner figure out the origin of a recovered bullet.

Figure 1-4 Firearm Barrel Showing Rifling

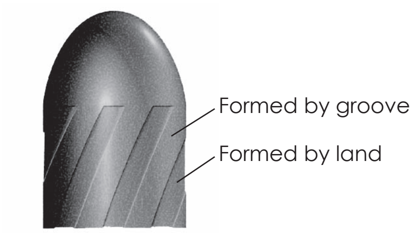


SOURCE: Jonathan A. Turner.

As a bullet passes through the barrel, it engages the lands, forcing the bullet to rotate. The spin acts like a gyroscope to stabilize the bullet and keep its nose pointed in a consistent direction. (This is the same principle behind throwing a football.) The spin makes the bullet more accurate over longer ranges. Because the bullet literally scrapes along the side of the barrel, the land and groove's impressions and other microscopic details are etched into the side of the bullet. These fine microscopic details are called *striations* or *striae.* A cartridge case may also receive striated marks from the extractor and magazine lips in firearms that have these features. (See Figure 1-5.)

Newton's third law requires an equal and opposite reaction to any action. When a bullet is fired, the cartridge is pressed into the breech by the

Figure 1-5 Fired Bullets Showing Rifling Marks



SOURCE: Jonathan A. Turner.

gas pressure. This impresses any marks on the steel breech face onto the back of the softer metal cartridge and the primer. The primer is also pressed back toward the firing pin, which may further impress its mark. The cartridge case may also be marked by the ejector in a firearm, which has this mechanism. These marks are called *impressed marks.*

The marks, which identify the gross properties of the firearm—caliber, number of lands and grooves, and direction of rifling twist—are the firearm's *class* characteristics. The marks are often visible to the naked eye. These will be the same for any bullet fired from any firearm of the same make and model, and often of several different makes and models. Reference works list the class characteristics for each manufacturer, which would enable an examiner to determine what type of firearm was used to fire the recovered bullet.

Trying to match a recovered bullet or cartridge case to a specific firearm is more difficult. Firearm identification assumes that there are *individual* characteristics that are unique and consistent to one specific firearm. In theory, it is not possible to make two machined surfaces that are microscopically identical. Even rifled barrels manufactured consecutively can be distinguished because the cutting and grinding tools are blunted and worn each time they are used, leaving minute variations. Similarly, firing pins and the breech are believed to leave unique markings.

Normal wear and maintenance, corrosion, rust, dirt, and debris will change markings over time, creating both permanent individual characteristics and temporary *accidental* characteristics. These changes can make it easier to tell one firearm from others made by the same manufacturer. On the other hand, the nonpermanence of markings, even from one test-firing to the next, makes a firearms identification match much more difficult than either a DNA or fingerprint comparison. Some studies have compared bullets and cartridge casings from firearms over the course of hundreds, even a few thousand, of fired rounds. The studies' authors report being able to find consistent markings despite wear and other accidental factors.

This examination is complicated by *subclass* characteristics. These are markings caused by temporary conditions in the manufacturing process, such as a chipped or broken tool, and therefore are the same on many firearms in a given production run, though they are not a permanent feature of the class. An examiner must decide whether a mark is, thus, an individual mark unique to a specific firearm or a subclass mark shared by many firearms made at the same time.

If a firearm is recovered, the examiner compares microscopic marks on the cartridge or bullet recovered from the crime scene with test bullets and cartridge cases fired from the recovered weapon into a water tank or bullet trap to see if the markings are consistent. If no weapon has been recovered, the examiner compares the crime scene bullets to each other, and the cartridge cases to each other, to see if the markings are consistent.

According to the AFTE Criteria for Identification Committee, an identification means that "the likelihood another tool could have made the mark is so remote as to be considered a pratical impossibility." When examining evidence, the examiner can come to four conclusions:

1. *Identification*, defined in the Association of Firearms and Toolmark Examiners (AFTE) Glossary as "[a]greement of a combination of individual characteristics and all discernible class characteristics where the extent of agreement exceeds that which can occur in the comparison of toolmarks made by different tools and is consistent with the agreement demonstrated by toolmarks known to have been produced by the same tool."
2. *Elimination*, defined as "[s]ignificant disagreement of discernible class characteristics and/or individual characteristics."
3. *Inconclusive*, defined as either "[s]ome agreement of individual characteristics and all discernible class characteristics, but insufficient for an identification" or "[a]greement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility" or "[a]greement of all discernable class characteristics and disagreement of individual characteristics, but insufficient for an elimination."
4. *Unsuitable* for microscopic comparison.

Note that the examiner's conclusion is all-or-nothing. The recovered evidence can be matched to one, and only one, firearm under this definition. The AFTE definitions are not binding, but most examiners will not offer testimony about statistical probabilities.

In reaching this conclusion, the examiner is looking for a certain quality and quantity of agreement which in turn is mentally compared to the closest known nonmatch the examiner can recall seeing. Some differences always exist between a recovered bullet and a test bullet, even if they come from the same weapon. Similarly, one would expect some differences between cartridges that come from the same weapon.

In 1997, an article by Joseph J. Masson proposed looking for consecutive matching striae (CMS). CMS analyzes the pattern of striated marks to determine how many consecutive matching striae are needed to minimize the likelihood that another firearm was the source of the markings on the recovered evidence. If the examiner is comparing three-dimensional images of the striae, he or she needs to find either one group of six consecutive matching striae or two different groups of at least three consecutive matching striae in the same relative position to claim a match exists. If a two-dimensional image (a mark with minimal discernable depth) is used, the examiner needs to find either one group of eight continuous matching striae or two groups of at least five continuous matching striae in the same relative position to claim a match exists. There is presently a dispute between experts who prefer the CMS method and those who prefer the more subjective approach. They have raised questions about the CMS methodology and about whether CMS should be used to determine whether a match exists or can be used after the examiner has concluded that a match exists to validate that conclusion.

Some firearms are harder to match than others. In .22 caliber firearms—the smallest common handgun caliber—roughly 80 percent of test-fired bullets cannot be matched to each other. This is partly due to the small size of the bullet and plating on some .22 caliber bullets flaking away during firing and damaging the markings. Glock's polygonal rifling is also harder to individually match than more standard rifling patterns.

If police have not recovered a firearm, or if they suspect that the crime might be linked to other crimes, examiners can look for similar evidence in the National Integrated Ballistics Information Network/Integrated Ballistics Identification System (NIBIN/IBIS). The NIBIN is a collection of digital images of markings on bullets and cartridge cases from crime scenes nationwide. An examiner puts the bullet or cartridge case onto a specially designed holder and creates a digital image, which is sent into a Data Acquisition Station (DAS). The NIBIN/IBIS system suggests possible matching bullets and cases based on a complex mathematical algorithm. The examiner will still need to look at the actual bullets or cartridge cases on a comparison microscope to decide whether there is a match. Unfortunately, some studies of the NIBIN/IBIS system have shown that even the top 10 or 15 candidates suggested by the system did not include cartridge cases known to have been fired by the same firearm. Certainly, there is room for improvement both in the image capture system and the comparison algorithms.

Maryland and New York also have a state database that contains images from every handgun sold in those states. Legislative proposals to take *"ballistic fingerprints"* of all handguns have been made in other states; Maryland and New York have spent millions of dollars on their systems and have had few investigative leads, leading some law enforcement officials to oppose these proposals as lacking cost-effectiveness.

BALLISTICS PRACTICE

Training and Qualifications

Of all the various forensic laboratory workers, it can be truthfully said that the firearms examiner is one of the most composite, most varied in his skills, personal traits, and attributes. He is thus because this compositeness comes naturally to him or it is forced upon him. Without it he is not truly a well rounded, "complete" firearms examiner.

—Steve Molnar, *What Is a Firearms Examiner,*
AFTE NEWSLETTER (1970)

An agency hiring a new examiner looks for many traits. Honesty, patience, inquisitiveness, and an interest in firearms are all important. Firearms identification involves a significant amount of work with microscopes and photography, both important skills for the examiner.

Many laboratories look for applicants with a college degree in a scientific major like chemistry or physics. Not all examiners have science degrees. Many current firearms examiners learned their craft based on practical experience, with some classroom study. Here, as in many other forensic disciplines, there are no national standards or licenses. Most states do not license or accredit firearms examiners or many other forensic examiners. The national Association of Firearms and Toolmark Examiners offers certification for its members in Firearm Evidence Examination and Identification and in Gunshot Residue Evidence Examination and Identification. AFTE members are expected to abide by its code of ethics (available on its website at http://afte.org/AssociationInfo/a_codeofethics.htm).

The firearms and toolmark unit of an agency may be accredited by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB). Some states have accreditation programs for crime laboratories as well. The laboratory-based accreditation includes requirements for employee proficiency testing, but it is not a certification of the individual examiner.

Once hired, examiners are often trained by their employer. Some agencies send their trainees to classes taught by larger agencies or laboratories. The FBI and the ATF (Bureau of Alcohol, Tobacco, Firearms and Explosives) offer training for their own agents, and for others, in firearms identification.

In addition to law-enforcement and on-the-job training, many examiners also attend armorer's schools offered by firearms makers. These classes are designed for gunsmiths who repair or adjust the manufacturer's products. Some of these schools teach the examiner to build a firearm from parts; others teach using firearms returned to the manufacturer for repairs. This training teaches the examiner how the firearm was made and helps him or her to recognize when that company's products have been modified in unconventional ways and to diagnose malfunctions.

Experts often tour firearms factories to see how firearms barrels are made; how the breech is milled and finished; how much the cutting equipment is dulled by a single barrel; and how often the equipment is sharpened. This can help the examiner explain to jurors why the marks found on a specific firearm are unique to that gun and why even the firearms made before and after it should have distinctly different marks.

Many examiners are also target-shooters and hunters. Shooting firearms gives an examiner a feel for how firearms are used and handled. It can also help an examiner analyze whether an injury was an accident, negligence, or a deliberate act.

Practical Considerations in a Firearms Case

Safety is a key concern whenever a firearm is introduced into evidence. Normally, police will have ensured that the firearm is not loaded when it is submitted to the trial court; however, a lawyer should still check the firearm before handling it and should have the firearm checked in the judge or jury's presence when the firearm is marked as an exhibit. (If you do not know how to check a specific firearm, research this ahead of time by talking with a firearms dealer, the manufacturer, or an expert.) Although no one has yet been shot in a courtroom by an exhibit assumed to be unloaded, a moment's precaution will maintain that safety record. In addition, checking the firearm in front of the jurors or judge will reassure them that the firearm is safe and that the lawyers are familiar with safe gun-handling.

Firearms instructors teach students that it is unsafe to point the muzzle of even an unloaded firearm at any person or to put a finger inside the trigger guard while handling it. Resist the temptation to point the firearm at anyone or put your finger on the trigger (rest it on or along the frame instead). If someone has a specific reason to manipulate the trigger, make certain the muzzle is pointed in a safe direction (at an object or wall solid enough to absorb an accidental shot) during this process. If both firearms and ammunition are exhibits, think carefully about the pros and cons of sending both into the jury room at the same time.

In general, look at the physical evidence. Is the firearm in good repair? Are the recovered cartridge cases, bullets, and fragments in good condition? How might their condition affect the examiner's results? Is the condition consistent with the prosecution's theory of the case?

What happened at the crime scene between the crime and the police arrival? Could evidence have been removed, moved, or damaged by the victims or bystanders?

What did the police do at the crime scene? Look at the crime scene photographs and sketches to see where evidence was found. Look specifically at the chain of custody documentation for any indication of fabrication or fraud. (Overzealous investigators have falsified evidence in fingerprint cases; it could happen in other cases as well.)

What did the examiner know when the evidence was submitted to him or her? Was this a high-profile case? Was the examiner rushed? Did the examiner have any expectation about the results of his or her tests before making them?

What methods were used to determine the examiner's opinion? Are they the methods recommended in the examiner's training materials and/or laboratory procedures? Are those methods supported by published, peer-reviewed research? Does that research use statistically valid sample sizes and blind testing?

Ask specifically for interim reports, bench notes, and photomicrographs showing any match.

Ask specifically for interim reports, notes, and photographs of any distance determination. Make sure the examiner matched the ammunition type as closely as possible in making this test.

Ask specifically for notes and reports on gunshot residue testing. Check to make sure that proper control samples were taken to identify contamination in the environment. Check to make sure that the officers who arrested and handled the suspect before and during testing did not recently fire a gun or handle a fired gun.

How many comparison bullets did the examiner create? Were they matched by ammunition type? How many bullets had to be compared to find a match?

What is the examiner's criteria for an identification? How did he or she reach that conclusion?

If there is a photomicrograph, is it of the entire circumference, or just the part that matches most closely?

What kind of training does the examiner have? How does that compare with national law enforcement agencies and similar experts in large departments and/or state police agencies in the area? Is the laboratory accredited?

Has the examiner taken proficiency or certification tests? How often? How difficult are the tests in comparison with typical crime scene evidence?

Is it possible that the breech face marks used for the identification are preexisting marks on the ammunition made during its manufacture and not those made by the firearm?

Are there any articles in the forensic identification trade journals discussing this specific firearm or ammunition? Do the articles mention difficulties in making accurate identifications or factors that might produce a false positive result?

Legal Criticisms of Ballistics

We know this guy shot the victim and this is the gun he used. All we want you to do is confirm what we already know so we can get a warrant to get this scumbag off the street. We will wait. How quick can you do it?

—Investigating officers to firearms examiner, as described in Hodge, *Guarding Against Error,* AFTE Journal (1988)

When an examiner reports that your client's firearm has been linked to a crime, defense counsel may have a sinking feeling about the case. As discussed earlier, firearms identification testimony has been accepted by courts since the early 20th century. A prosecutor or defense counsel may feel there's not much that can done but accept the examiner's opinion.

In the past few years, there have been challenges to a variety of longstanding scientific disciplines. In *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (1993), the U.S. Supreme Court set new standards for scientific evidence. Defense attorneys have used *Daubert* to challenge a number of long-accepted forensic techniques, including firearms identification. Attorneys, both prosecutors and defense counsel, should be aware of the concerns raised by the challengers.

There have been a few trial-level challenges to firearms identification under the *Daubert* standards. Firearms identification was challenged, and the examiner's testimony allowed, in *United States v. Moses,* a Maryland federal district court case in 2003, and in *United States v. Prochilo,* a Massachusetts federal district court case in 2002. Firearms examiners' testimony was limited to the examiner's observations of similarities and differences in *United States v. Green* and in *United States v. Monteiro,* two Massachusetts federal district court cases in 2005. The examiner in *Green* was precluded from testifying that the recovered ammunition matched a specific firearm to the exclusion of all others. The *Monteiro* court concluded that the examiner had not followed established standards in his field and was precluded from testifying until he reexamined the evidence and properly documented his findings.

Because firearms and toolmark comparisons are similar to fingerprint comparisons (both visually match patterns and the examiner must account for distortions between the sample and the crime scene evidence), challenges often borrow from the tactics used in fingerprint cases. Some challenges are modeled after the challenge to fingerprint comparisons in *United States v. Plaza*, a Pennsylvania federal district court case from 2002. Other challenges are modeled on the FBI's report on the examiners' errors made in its erroneous fingerprint identification of Brandon Mayfield as a suspect in the Madrid bombing.

In brief, a legal challenge to a firearms expert's methodology and opinion is based on:

1. Whether firearms identification methods have been adequately tested—Are the published studies statistically valid and do they use sufficient blind and double-blind methods? Has there been sufficient testing to determine the error rate in identifications? Is there sufficient study of the statistical likelihood of coincidental matches?
2. Whether the standard used by examiners is too subjective—Examiners determine whether the comparison exceeds the best-known nonmatch agreement the examiner has ever seen in person or in published materials. This standard is both subject and built up in the examiner's "mind's eye" so that it can be difficult to explain.
3. Whether the standard used by examiners is too prone to potential problems of confirmation bias, tunnel vision, and pressures in high-profile cases—The FBI's report on the Mayfield case blamed such human factors for mistakes by three experienced FBI fingerprint examiners.
4. Whether the field has been given sufficient scrutiny by scientists outside the criminal justice community—DNA matching, for example, is used in medical care and research. Fingerprinting is used by some security systems and in identifying disaster victims. Most firearms tests are only used by law enforcement. The *Daubert* and *Plaza* courts both felt that widespread use and acceptance was useful to determining the reliability of a field.
5. Whether training, proficiency, and certification tests are sufficiently rigorous and adequately reflect the difficulties encountered with typical crime scene evidence.

6. Whether the examiner has provided sufficient information (generally photomicrographs of the purported match) to allow the judge or jury to understand the basis for the expert's opinion—If photographs are not introduced, counsel and the fact finder have to take the examiner's word for his or her results, without seeing the underlying data.

Essentially, the *Plaza* challenge is based around memory and perception. People are very good at recognizing patterns, but sometimes one sees what one expects to see, or wants to see, instead of what's really there. If, for example, an examiner tests two bullets known to be fired from consecutively manufactured handguns, he or she expects that the striae will be sufficiently different to show a nonmatch. Thus, if the examiner's results, published in a trade journal, match that preconception, then it is hard to tell whether the examiner truly tested the hypothesis. A scientist in another field would generally perform a *blind* test—the examiner deciding whether the bullet matched or not would not know where it came from. Preferably the test would be *double-blind*, which is when neither the examiner nor the person who provided the samples would know where they came from. (Double-blind testing avoids any subconscious cues passed between the person administering the test and the person taking the test.) A scientist would also test a large number of bullets from the same and from different firearms to create a statistically valid sample and eliminate random chance affecting the results.

The same basic principle applies to the individual examiner. If he or she is given information about the case to cause the examiner to expect the recovered firearm to match the crime scene evidence, then he or she may see a match that doesn't exist. That error occurred in the article quoted at the beginning of this section. The examiner was given information from the detectives suggesting a match was certain, was pressured to have a result quickly, and found the expected match. On later review, the examiner's conclusion proved to be wrong—the evidence did not match the recovered firearm. Expectations, time pressure, and pressure to support a case can all cause mistakes.

A different challenge was raised in *United States v. Kain*, a Pennsylvania federal district court case in 2004. (The case resulted in a plea bargain before the trial court ruled on the defendant's challenge.) The *Kain* challenge focused on statistical issues, specifically the percentage of coincidental matching and nonmatching striations found on firearms evidence. The challenge focused on Biasotti, *A Statistical Study of the Individual Characteristics of Fired Bullets*, 4 J. Forensic Sci. 34 (1959) (still regarded as one of the most exhaustive statistical studies in the field) and Masson, *Confidence Level Variations in Firearms Identification through Computerized Technology,* 29(1) Ass'n Firearms & Tool Mark Examiners J. 42 (1997) (discussing similarities between suspect ammunition found in the IBIS database and false negative results on manual examinations of ammunition known to be fired from the same gun). A lawyer considering a challenge to the statistical likelihood of a random firearm with the same class characteristics as the recovered evidence having sufficiently similar individual characteristics to create a misidentification should look at the *Kain* pleadings.

So far, only three courts have limited or excluded a firearms examiner's testimony based on a *Daubert* challenge. In *Sexton v. State,* 93 S.W.3d 96, 101 (Tex. Crim. App. 2002), the Texas appellate court excluded testimony purporting to match marks on recovered cartridges caused by the lips of the magazine; no magazine was recovered. The *Sexton* holding has not been generalized to other areas of firearms identification.

In *United States v. Green,* the federal district court of Massachusetts limited the testimony of a Boston Police Department firearms examiner to describing his observations. He could not testify that the recovered evidence matched the recovered firearm to the exclusion of all others. The trial court was critical of the examiner's training, of the lack of certification for the examiner or laboratory, and the lack of proficiency testing of the examiner by a neutral testing body. The examiner did not follow the AFTE protocol and provided no notes, recorded observations, or photographs. It also held that there were no peer-reviewed publications, as *Daubert* defined that term, in the firearms identification field. The opinion was also critical of the manner in which firearms evidence is compared, comparing it to a show-up (presumptively suggestive in the eyewitness identification field) rather than a line-up, which would reduce the problems of suggestion and confirmation bias.

In *United States v. Montiero,* another decision by the federal district court of Massachusetts, the trial court criticized a conclusion by a Massachusetts State Police firearms examiner. It also criticized the examiner's training and lack of neutral proficiency testing, although it noted the examiner had taken and passed a proficiency test after making the identification in question. It also criticized the examiner's documentation and adherence to the AFTE procedures and the lack of verification by another examiner. The examiner was precluded from testifying about his opinion until he had met the AFTE standards.

Typically, judges are reluctant to reject evidence that has been accepted without question for decades, even if the lawyer presents compelling evidence that the technique may have problems under the *Daubert* test. Even if the challenge is rejected, it may give the defense lawyer material to impeach the expert at trial or lead to a favorable settlement. The *Kain* case resulted in a favorable plea agreement. The *Prochilo* case resulted in the defendant's acquittal; a vigorous challenge can cause a jury to reject the examiner's opinion if it is not adequately supported. *Green* and *Monteiro* both resulted in limitations on examiners' testimony, which should prove beneficial at trial.

CONCLUSION

Ballistics, or firearms identification, includes many aspects of firearms and ammunition. When a firearms expert is expected to testify in your case, take the time to learn about the firearm and ammunition involved. Know the relevant laws and terms of art. Investigate the examiner's credentials, methods, and conclusions. The investment of time will make you more comfortable with the evidence and help you represent your client more effectively.

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