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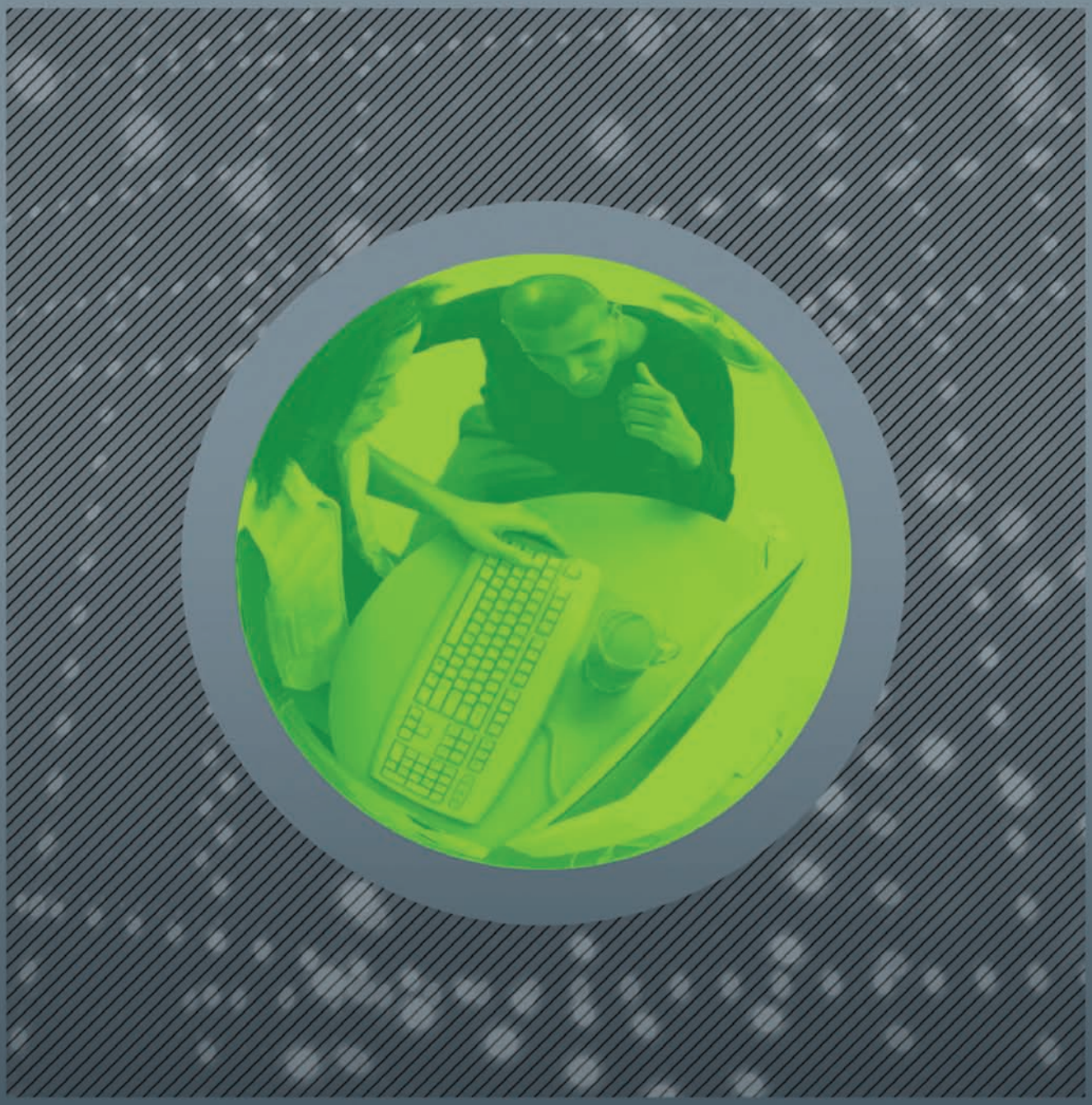

Forensic Science
From the Crime Scene to the Crime Lab
Richard Saferstein
Second Edition

ALWAYS LEARNING™

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Introduction

Joe Burbank/MCT/Newscom

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- **Define *forensic science* and list the major disciplines forensic science encompasses.**
- **Recognize the major contributors to the development of forensic science.**
- **Account for the rapid growth of forensic laboratories in the past forty years.**
- **Describe the services of a typical comprehensive crime laboratory in the criminal justice system.**
- **Compare and contrast the *Frye* and *Daubert* decisions relating to the admissibility of scientific evidence in the courtroom.**
- **Explain the role and responsibilities of the expert witness.**
- **List the specialized forensic services, aside from the crime laboratory, that are generally available to law enforcement personnel.**

CASEY ANTHONY: THE CSI EFFECT?

Few criminal proceedings have captured the attention of the American public or have invoked stronger emotions than the Casey Anthony murder trial. How could a defendant who failed to report her two-year-old child missing for 31 days walk away scot-free from a murder conviction? This case had all the makings of a strong circumstantial case for the state.

The state's theory was that Casey used chloroform to render her daughter unconscious, placed duct tape over Caylee's mouth and nose, and kept the body in the trunk for several days before disposing of it. Caylee's decomposed remains were discovered more than five months after she was reported missing.

Have TV forensic dramas created an environment in the courtroom that necessitates the existence of physical evidence to directly link a defendant to a crime scene? The closest the state came to a direct link was a hair found in the trunk of Casey's car. However, the DNA test on the hair could only link the hair to Caylee's maternal relatives: Casey, Casey's mother (Caylee's maternal grandmother), and Casey's brother (Caylee's uncle). And Caylee herself. No unique characteristics were found to link the duct tape on the body with that found in the Anthony home.

No DNA, no fingerprints, no conviction.

Definition and Scope of Forensic Science

Forensic science, in its broadest definition, is the application of science to law. As our society has grown more complex, it has become more dependent on rules of law to regulate the activities of its members. Forensic science applies the knowledge and technology of science to the definition and enforcement of such laws.

Each year, as government finds it increasingly necessary to regulate the activities that most intimately influence our daily lives, science merges more closely with civil and criminal law. Consider, for example, the laws and agencies that regulate the quality of our food, the nature and potency of drugs, the extent of automobile emissions, the kind of fuel oil we burn, the purity of our drinking water, and the pesticides we use on our crops and plants. It would be difficult to conceive of a food or drug regulation or environmental protection act that could be effectively monitored and enforced without the assistance of scientific technology and the skill of the scientific community.

Laws are continually being broadened and revised to counter the alarming increase in crime rates. In response to public concern, law enforcement agencies have expanded their patrol and investigative functions, hoping to stem the rising tide of crime. At the same time, they are looking more to the scientific community for advice and technical support for their efforts. Can the technology that put astronauts on the moon, split the atom, and eradicated most dreaded diseases be enlisted in this critical battle?

Unfortunately, science cannot offer final and authoritative solutions to problems that stem from a maze of social and psychological factors. However, as the content of this text attests, science occupies an important and unique role in the criminal justice system—a role that relates to the scientist's ability to supply accurate and objective information about the events that have occurred at a crime scene. A good deal of work remains to be done if the full potential of science as applied to criminal investigations is to be realized.

Because of the vast array of civil and criminal laws that regulate society, forensic science, in its broadest sense, has become so comprehensive a subject that a meaningful introductory textbook treating its role and techniques would difficult to create and probably overwhelming to read. For this reason, we have narrowed the scope of the subject according to the most common definition: **Forensic science is the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system.** *Forensic science* is an umbrella term encompassing a myriad of professions that use their skills to aid law enforcement officials in conducting their investigations.

The diversity of professions practicing forensic science is illustrated by the eleven sections of the American Academy of Forensic Science, the largest forensic science organization in the world:

1. Criminalistics
2. Digital and Multimedia Sciences
3. Engineering Science
4. General
5. Jurisprudence
6. Odontology
7. Pathology/Biology
8. Physical Anthropology
9. Psychiatry/ Behavioral Science
10. Questioned Documents
11. Toxicology

Even this list of professions is not exclusive. It does not encompass skills such as fingerprint examination, firearm and tool mark examination, computer and digital data analysis, and photography.

Obviously, to author a book covering all of the major activities of forensic science as they apply to the enforcement of criminal and civil laws by police agencies would be a major undertaking. Thus, this text will further restrict itself to discussions of the subjects of chemistry, biology, physics, geology, and computer technology, which are useful for determining the evidential value of crime-scene and related evidence. Forensic pathology, psychology, anthropology, and odontology also encompass important and relevant areas of knowledge and practice in law enforcement, each being an integral part of the total forensic science service that is provided to any up-to-date criminal justice system. However, these subjects go beyond the intended scope of this text, and except for brief discussions, along with pointing the reader to relevent websites, the reader is referred elsewhere for discussions of their applications and techniques.[1] Instead, this article focuses on the services of what has popularly become known as the crime laboratory, where the principles and techniques of the physical and natural sciences are practiced and applied to the analysis of crime-scene evidence.

For many, the term *criminalistics* seems more descriptive than *forensic science* for describing the services of a crime laboratory. Regardless of his or her title—criminalist or forensic scientist—the trend of events has made the scientist in the crime laboratory an active participant in the criminal justice system.

Prime-time television shows like *CSI: Crime Scene Investigation* have greatly increased the public's awareness of the use of science in criminal and civil investigations (see Figure 1). However, by simplifying scientific procedures to fit the allotted airtime, these shows have created within both the public and the legal community unrealistic expectations of forensic science. In these shows, members of the CSI team collect evidence at the crime scene, process all evidence, question witnesses, interrogate suspects, carry out search warrants, and testify in court. In the real world, these tasks are almost always

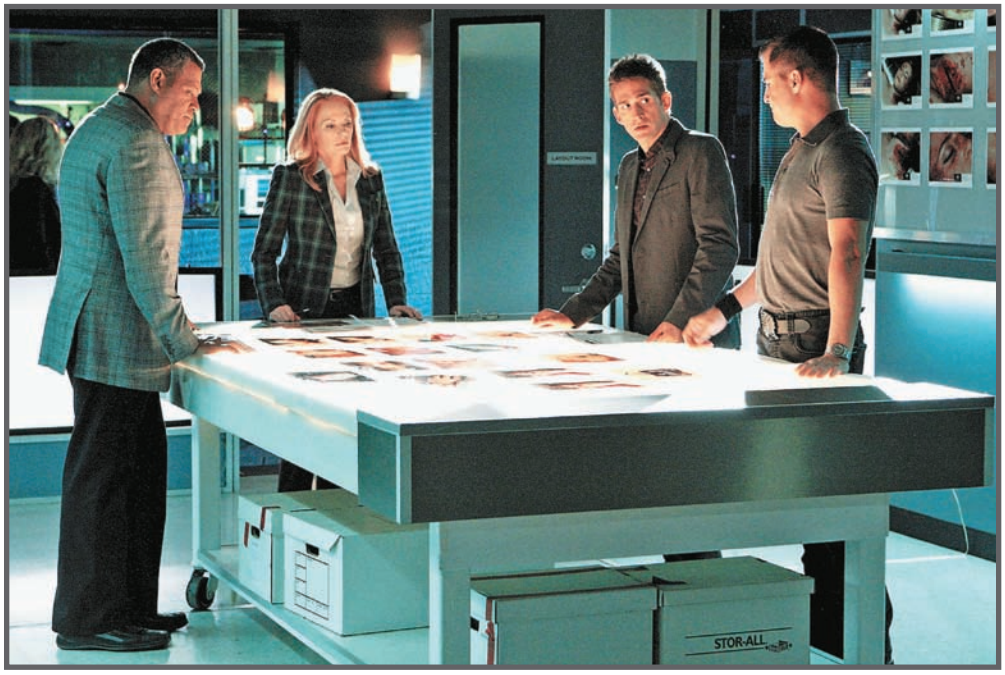

FIGURE 1 A scene from *CSI*, a forensic science television show. *SUN/Newscom*

delegated to different people in different parts of the criminal justice system. Procedures that in reality could take days, weeks, months, or years appear on these shows to take mere minutes. This false image is significantly responsible for the public's high interest in and expectations for DNA evidence.

The dramatization of forensic science on television has led the public to believe that every crime scene will yield forensic evidence, and it produces unrealistic expectations that a prosecutor's case should always be bolstered and supported by forensic evidence. This phenomenon is known as the "CSI effect." Some jurists have come to believe that this phenomenon ultimately detracts from the search for truth and justice in the courtroom.

History and Development of Forensic Science

Forensic science owes its origins, first, to the individuals who developed the principles and techniques needed to identify or compare physical evidence and, second, to those who recognized the need to merge these principles into a coherent discipline that could be practically applied to a criminal justice system.

The roots of forensic science reach back many centuries, and history records a number of instances in which individuals closely observed evidence and applied basic scientific principles to solve crimes. Not until relatively recently, however, did forensic science take on the more careful and systematic approach that characterizes the modern discipline.

EARLY DEVELOPMENTS

One of the earliest records of applying forensics to solve criminal cases comes from third-century China. A manuscript titled *Yi Yu Ji* ("A Collection of Criminal Cases") reports how a coroner solved a case in which a woman was suspected of murdering her husband and burning the body, claiming that he died in an accidental fire. Noticing that the husband's corpse had no ashes in its mouth, the coroner performed an experiment to test the woman's story. He burned two pigs—one alive and one dead—and then checked for ashes inside the mouth of each. He found ashes in the mouth of the pig that was alive before it was burned, but none in the mouth of the pig that was dead beforehand. The coroner thus concluded that the husband, too, was dead before his body was burned. Confronted with this evidence, the woman admitted her guilt. The Chinese were also among the first to recognize the potential of fingerprints as a means of identification.

Although cases such as that of the Chinese coroner are noteworthy, this kind of scientific approach to criminal investigation was for many years the exception rather than the rule. Limited knowledge of anatomy and pathology hampered the development of forensic science until the late seventeenth and early eighteenth centuries. For example, the first recorded notes about fingerprint characteristics were prepared in 1686 by Marcello Malpighi, a professor of anatomy at the University of Bologna in Italy. Malpighi, however, did not acknowledge the value of fingerprints as a method of identification. The first scientific paper about the nature of fingerprints did not appear until more than a century later, but it also did not recognize their potential as a form of identification.

INITIAL SCIENTIFIC ADVANCES

As physicians gained a greater understanding of the workings of the body, the first scientific treatises on forensic science began to appear, such as the 1798 work "A Treatise on Forensic Medicine and Public Health" by the French physician

François-Emanuel Fodéré. Breakthroughs in chemistry at this time also helped forensic science take significant strides forward. In 1775, the Swedish chemist Carl Wilhelm Scheele devised the first successful test for detecting the poison arsenic in corpses. By 1806, the German chemist Valentin Ross had discovered a more precise method for detecting small amounts of arsenic in the walls of a victim's stomach. The most significant early figure in this area was Mathieu Orfila, a Spaniard who is considered the father of forensic toxicology. In 1814, Orfila published the first scientific treatise on the detection of poisons and their effects on animals. This treatise established forensic toxicology as a legitimate scientific endeavor (see Figure 2).

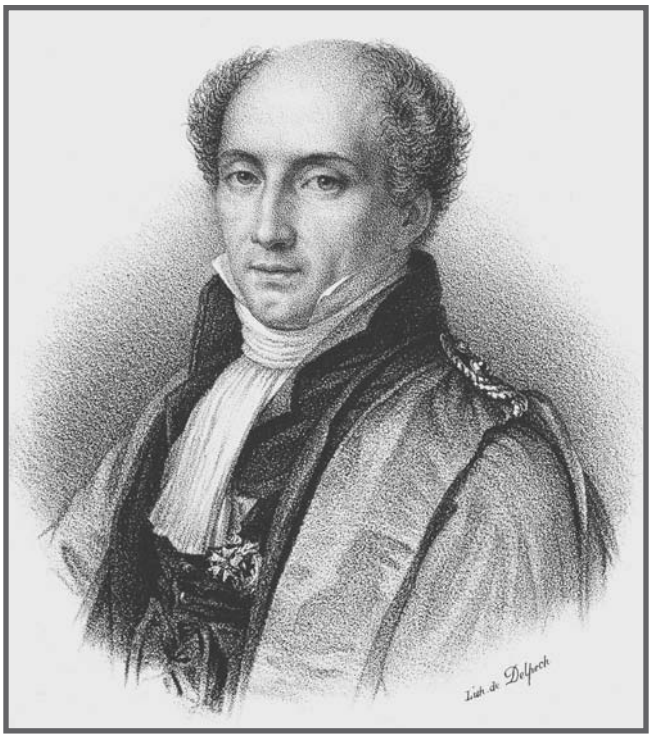

FIGURE 2 Mathieu Orfila.
The Granga Collection, New York

The mid-1800s saw a spate of advances in several scientific disciplines that furthered the field of forensic science. In 1828, William Nichol invented the polarizing microscope. Eleven years later, Henri-Louis Bayard formulated the first procedures for microscopic detection of sperm. Other developments during this time included the first microcrystalline test for hemoglobin (1853) and the first presumptive test for blood (1863). Such tests soon found practical applications in criminal trials. Toxicological evidence at trial was first used in 1839, when a Scottish chemist named James Marsh testified that he had detected arsenic in a victim's body. During the 1850s and 1860s, the new science of photography was also used in forensics to record images of prisoners and crime scenes.

LATE-NINETEENTH-CENTURY PROGRESS

By the late nineteenth century, public officials were beginning to apply knowledge from virtually all scientific disciplines to the study of crime. Anthropology and morphology (the study of the structure of living organisms) were applied to the first system of personal identification, devised by the French scientist Alphonse Bertillon in 1879. Bertillon's system, which he dubbed *anthropometry,* was a procedure that involved taking a series of bodily measurements as a means of distinguishing one individual from another. For nearly two decades, this system was considered the most accurate method of personal identification. Bertillon's early efforts earned him the distinction of being known as the father of criminal identification (see Figure 3).

Bertillon's anthropometry, however, would soon be supplanted by a more reliable method of identification: fingerprinting. Two years before the publication of Bertillon's system, the US microscopist Thomas Taylor had suggested that fingerprints could be used as a means of identification, but his ideas were not immediately followed up. Three years later, the Scottish physician Henry Faulds made a similar assertion in a paper published in the journal *Nature*. However, it was the Englishman Francis Henry Galton who undertook the first definitive study of fingerprints and developed a methodology of classifying them for filing. In 1892, Galton published a book titled *Finger Prints,* which contained the first statistical proof supporting the uniqueness of fingerprints and the effectiveness of his method. His book went on to describe the basic principles that would form our present system of identification by fingerprints.

The first treatise describing the application of scientific disciplines to the field of criminal investigation was written by Hans Gross in 1893. Gross, a public prosecutor and judge in Graz, Austria, spent many years studying and

FIGURE 3 Bertillon's system of bodily measurements used for the identification of an individual. *Courtesy Sirchie Fingerprint Laboratories, Inc., Youngsville, NC, www.sirchie.com*

developing principles of criminal investigation. In his classic book *Handbuch für Untersuchungsrichter als System der Kriminalistik* (later published in English under the title *Criminal Investigation*), he detailed the assistance that investigators could expect from the fields of microscopy, chemistry, physics, mineralogy, zoology, botany, anthropometry, and fingerprinting. He later introduced the forensic journal *Archiv für Kriminal Anthropologie und Kriminalistik,* which still reports improved methods of scientific crime detection.

Ironically, the best-known figure in nineteenth-century forensics is not a real person but a fictional character: the legendary detective Sherlock Holmes (see Figure 4). Many people today believe that Holmes's creator, Sir Arthur Conan Doyle, had a considerable influence on popularizing scientific crime-detection methods. In adventures with his partner and biographer, Dr. John Watson, Holmes was the first to apply the newly developing principles of serology (the study of blood and bodily fluids), fingerprinting, firearms identification, and questioned-document examination long before their value was recognized and accepted by real-life criminal investigators. Holmes's feats excited the imagination of an emerging generation of forensic scientists and criminal investigators. Even in the first Sherlock Holmes novel, *A Study in Scarlet,* published in 1887, we find examples of Doyle's uncanny ability to describe scientific methods of detection years before they were actually discovered and implemented. For instance, here Holmes explains the potential usefulness of forensic serology to criminal investigation:

FIGURE 4 Sir Arthur Conan Doyle's legendary detective Sherlock Holmes applied many of the principles of modern forensic science long before they were adopted widely by real-life police.

> "I've found it. I've found it," he shouted to my companion, running toward us with a test tube in his hand. "I have found a reagent which is precipitated by hemoglobin and by nothing else . . . . Why, man, it is the most practical medico-legal discovery for years. Don't you see that it gives us an infallible test for blood stains? . . . The old guaiacum test was very clumsy and uncertain. So is the microscopic examination for blood corpuscles. The latter is valueless if the stains are a few hours old. Now, this appears to act as well whether the blood is old or new. Had this test been invented, there are hundreds of men now walking the earth who would long ago have paid the penalty of their crimes . . . . Criminal cases are continually hinging upon that one point. A man is suspected of a crime months perhaps after it has been committed. His linen or clothes are examined and brownish stains discovered upon them. Are they blood stains, or rust stains, or fruit stains, or what are they? That is a question which has puzzled many an expert, and why? Because there was no reliable test. Now we have the Sherlock Holmes test, and there will no longer be any difficulty."

TWENTIETH-CENTURY BREAKTHROUGHS

The pace of technological change quickened considerably in the twentieth century, and with it the rate of advancements in forensic science. In 1901, Dr. Karl Landsteiner discovered that blood can be grouped into different categories, now recognized as the blood types A, B, AB, and O. The possibility that blood grouping could be useful in identifying an individual intrigued Dr. Leone Lattes,

a professor at the Institute of Forensic Medicine at the University of Turin in Italy. In 1915, Lattes devised a relatively simple procedure for determining the blood group of the dried blood in a bloodstain, a technique that he immediately applied to criminal investigations.

At around the same time, Albert S. Osborn was conducting pioneering work in document examination. In 1910, Osborn wrote the first significant text in this field, *Questioned Documents*. This book is still a primary reference for document examiners. Osborn's development of fundamental principles of document examination was responsible for the acceptance of documents as scientific evidence by the courts.

One of the most important contributors to the field in the early twentieth century was the Frenchman Edmond Locard. Although Hans Gross was a pioneering advocate for the use of the scientific method in criminal investigations, Locard first demonstrated how the principles enunciated by Gross could be incorporated within a workable crime laboratory. Locard's formal education was in both medicine and law. In 1910, he persuaded the Lyons police department to give him two attic rooms and two assistants to start a police laboratory. During Locard's first years of work, the instruments available to him were a microscope and a rudimentary spectrometer. However, his enthusiasm quickly overcame the technical and budgetary deficiencies he encountered, and from these modest beginnings, Locard conducted research and made discoveries that became known throughout the world by forensic scientists and criminal investigators. Eventually he became the founder and director of the Institute of Criminalistics at the University of Lyons, which quickly developed into a leading international center for study and research in forensic science (see Figure 5).

Locard's exchange principle
Whenever two objects come into contact with one another, materials are exchanged between them.

Locard asserted that when two objects come into contact with each other a cross-transfer of materials occurs (**Locard's exchange principle**). He strongly believed that every criminal can be connected to a crime by dust particles carried from the crime scene. This concept was reinforced by a series of successful and well-publicized investigations. In one case, presented with counterfeit coins and the names of three suspects, Locard urged the police to bring the suspects' clothing to his laboratory. On careful examination, he located small metallic particles in all the garments. Chemical analysis revealed that the particles and coins were composed of exactly the same metallic elements. Confronted with this evidence, the suspects were arrested and soon confessed to the crime. After World War I, Locard's successes inspired the formation of police laboratories in Vienna, Berlin, Sweden, Finland, and Holland.

The microscope came into widespread use in forensic science during the twentieth century, and its applications grew dramatically. Perhaps the leading figure in the field of microscopy was Dr. Walter C. McCrone. During his lifetime, McCrone became the world's preeminent microscopist. Through his books, journal publications, and research institute, he was a tireless advocate for applying microscopy to analytical problems, particularly forensic science cases. McCrone's exceptional communication skills made him a much-sought-after instructor, and he educated thousands of forensic scientists throughout the world in the application of microscopic techniques. Dr. McCrone used microscopy, often in conjunction with other analytical methodologies, to examine evidence in thousands of criminal and civil cases throughout his long and illustrious career.

Another trailblazer in forensic applications of microscopy was U.S. Army Colonel Calvin Goddard, who refined the techniques of firearms examination by using the comparison microscope. Goddard's work allows investigators to determine whether a particular gun has fired a bullet by comparing the bullet with another that is test-fired from the suspect's weapon. His expertise established the comparison microscope as the indispensable tool of the modern firearms examiner.

FIGURE 5 Edmond Locard. *Collection of Roger-Viollet, The Image Works*

MODERN SCIENTIFIC ADVANCES

Since the mid-twentieth century, a revolution in computer technology has made possible a quantum leap forward in human knowledge. The resulting explosion of scientific advances has had a dramatic impact on the field of forensic science by introducing a wide array of sophisticated techniques for analyzing evidence related to a crime. Procedures such as chromatography, spectrophotometry, and electrophoresis (all discussed in later chapters) allow the modern forensic scientist to determine with astounding accuracy the identity of a substance and to connect even tiny fragments of evidence to a particular person and place.

Undoubtedly the most significant modern advance in forensic science has been the discovery and refinement of DNA typing in the late twentieth and early twenty-first centuries. Sir Alec Jeffreys developed the first DNA profiling test in 1984, and two years later he applied it for the first time to solve a crime, identifying Colin Pitchfork as the murderer of two young English girls. The same case also marked the first time DNA profiling established the innocence of a criminal suspect. Made possible by scientific breakthroughs in the 1950s and 1960s, DNA typing offers law enforcement officials a powerful tool for establishing the precise identity of a suspect, even when only a small amount of physical evidence is available. Combined with the modern analytical tools mentioned earlier, DNA typing has revolutionized the practice of forensic science (see Figure 6).

Another significant recent development in forensics is the establishment of computerized databases to store information on physical evidence such as

FIGURE 6 Sir Alec Jeffreys. *Homer Sykes/Alamy Images Royalty Free*

fingerprints, markings on bullets and shell casings, and DNA. These databases have proved to be invaluable, enabling law enforcement officials to compare evidence found at crime scenes to thousands of pieces of similar information. This has significantly reduced the time required to analyze evidence and increased the accuracy of the work done by police and forensic investigators.

Although this brief narrative is by no means a complete summary of historical advances in forensics, it provides an idea of the progress that has been made in the field by dedicated scientists and law enforcement personnel. Even Sherlock Holmes probably couldn't have imagined the extent to which science is applied in the service of criminal investigation today.

Quick Review

- Forensic science is the application of science to criminal and civil laws that are enforced by police agencies in a criminal justice system.
- The first system of personal identification was called anthropometry. It distinguished one individual from another based on a series of bodily measurements.
- Forensic science owes its origins to individuals such as Bertillon, Galton, Lattes, Goddard, Osborn, and Locard, who developed the principles and techniques needed to identify and compare physical evidence.
- Locard's exchange principle states that, when two objects come into contact with each other, a cross-transfer of materials occurs that can connect a criminal suspect to his or her victim.

Crime Laboratories

The steady advance of forensic science technologies during the twentieth century led to the establishment of the first facilities specifically dedicated to forensic analysis of criminal evidence. These crime laboratories are now the centers for both forensic investigation of ongoing criminal cases and research into new techniques and procedures to aid investigators in the future.

HISTORY OF CRIME LABS IN THE UNITED STATES

The oldest forensic laboratory in the United States is that of the Los Angeles Police Department, created in 1923 by August Vollmer, a police chief from Berkeley, California. In the 1930s, Vollmer headed the first U.S. university institute for criminology and criminalistics at the University of California at Berkeley. However, this institute lacked any official status in the university until 1948, when a school of criminology was formed. The famous criminalist Paul Kirk was selected to head the school's criminalistics department. Many graduates of this school have gone on to develop forensic laboratories in other parts of the state and country.

In 1932, the Federal Bureau of Investigation (FBI), under the directorship of J. Edgar Hoover, organized a national laboratory that offered forensic services to all law enforcement agencies in the country. During its formative stages, Hoover consulted extensively with business executives, manufacturers, and scientists, whose knowledge and experience guided the new facility through its infancy. The FBI Laboratory is now the world's largest forensic laboratory, performing more than one million examinations every year (see Figure 7). Its accomplishments have earned it worldwide recognition, and its structure and organization have served as a model for forensic laboratories formed at the state and local levels in the United States as well as in other countries. Furthermore, the opening of the FBI's Forensic Science Research and Training Center in 1981 gave the United States, for the first time, a facility dedicated to conducting research toward new and reliable scientific methods that can be applied to forensic science. This facility is also used to train crime laboratory personnel in the latest forensic science techniques and methods.

Despite the existence of the FBI Laboratory, the United States has no national system of forensic laboratories. Instead, many local law enforcement jurisdictions—city, county, and state—each operate their own independent crime labs. California, for example, has numerous federal, state, county, and city crime laboratories, many of which operate independently. However, in 1972 the California Department of Justice created a network of integrated state-operated crime laboratories consisting of regional and satellite facilities. An informal exchange of information and expertise occurs within California's criminalist community through a regional professional society, the California Association of Criminalists. This organization is the forerunner of a number of regional organizations that have developed throughout the United States to foster cooperation among the nation's growing community of criminalists.

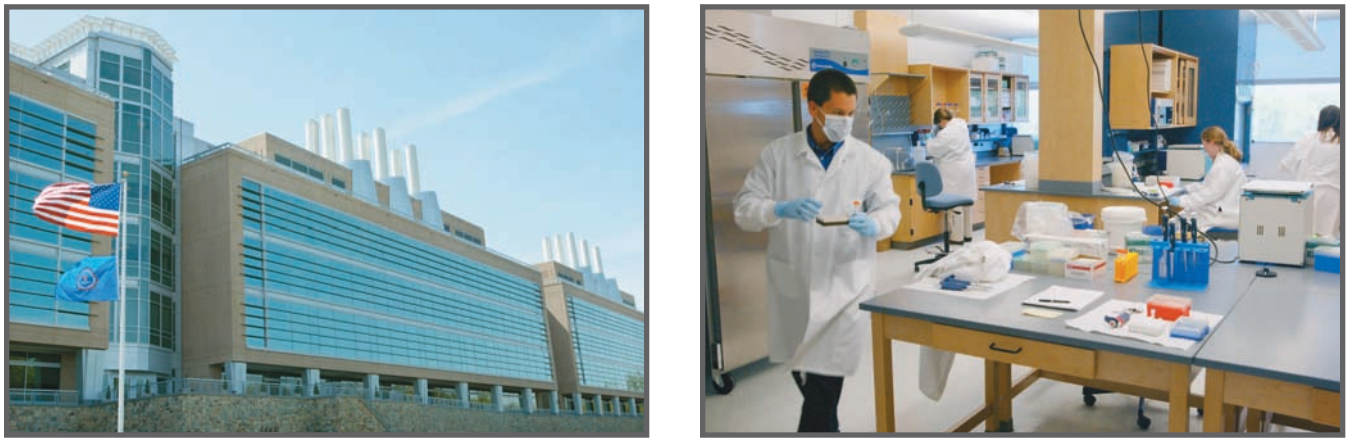

FIGURE 7 (a) Exterior and (b) interior views of the FBI crime laboratory in Quantico, Virginia. *Charles Dharapak/AP Wide World Photos*

ORGANIZATION OF A CRIME LABORATORY

The development of crime laboratories in the United States has been characterized by rapid growth accompanied by an unfortunate lack of national and regional planning and coordination. Approximately four hundred public crime laboratories operate at various levels of government—federal, state, county, and municipal. The size and diversity of crime laboratories make it impossible to select any one model that best describes a typical crime laboratory. Although most of these facilities function as part of a police department, others operate under the direction of the prosecutor's or district attorney's office, and some work with the laboratories of the medical examiner or coroner. Far fewer are affiliated with universities or exist as independent agencies in government. Laboratory staff sizes range from one person to more than one hundred, and services offered may be quite diverse or very specialized, depending on the responsibilities of the agency that houses the laboratory.

THE GROWTH OF CRIME LABORATORIES

Most existing crime laboratories have been organized by agencies that either foresaw their potential application to criminal investigations or were pressed by the increasing demands of casework. Several reasons explain the unparalleled growth of crime laboratories during the past forty years: Supreme Court decisions in the 1960s compelled police to place greater emphasis on securing scientifically evaluated evidence. The requirement to advise criminal suspects of their constitutional rights and their right of immediate access to counsel has all but eliminated confessions as a routine investigative tool; successful prosecution of criminal cases requires a thorough and professional police investigation, frequently incorporating the skills of forensic science experts. Modern technology has provided forensic scientists with many new skills and techniques to meet the challenges accompanying their increased participation in the criminal justice system.

Coinciding with changing judicial requirements has been the staggering increase in crime rates in the United States over the past forty years. Although it seems that this factor alone could account for the increased use of crime laboratory services by police agencies, only a small percentage of police investigations generate evidence requiring scientific examination. There is one important exception, however: drug-related arrests. All illicit-drug seizures must be sent to a forensic laboratory for confirmatory chemical analysis before the case can be adjudicated. Since the mid-1960s, drug abuse has accelerated to nearly uncontrollable levels and has resulted in crime laboratories being inundated with drug specimens.

A more recent contributor to the growth and maturation of crime laboratories has been the advent of DNA profiling. Since the early 1990s, this technology has progressed to the point of individualization or near-individualization of biological evidence. That is, traces of blood, semen stains, hair, and saliva residues left behind on stamps, cups, bite marks, and so on, can be positively linked to a criminal. To meet the demands of DNA technology, crime labs have expanded staff and in many cases modernized their physical plants. The labor-intensive demands and sophisticated requirements of DNA technology have affected the structure of the forensic laboratory as has no other technology in the past fifty years. Likewise, DNA profiling has become the dominant factor in the general public's perception of the workings and capabilities of the modern crime laboratory.

In coming years thousands of forensic scientists will be added to the rolls of both public and private forensic laboratories to process crime-scene evidence for DNA and to acquire DNA profiles, as mandated by state laws, from

the hundreds of thousands of individuals convicted of crimes. This endeavor has already added many new scientists to the field and will eventually more than double the number of scientists employed by forensic laboratories in the United States. A major problem facing the forensic DNA community is the substantial backlog of unanalyzed DNA samples from crime scenes. The number of unanalyzed casework DNA samples reported by state and national agencies varies from month to month but is estimated at around 100,000. In an attempt to eliminate the backlog of convicted offender or arrestee samples to be analyzed and entered into the Combined DNA Index System (CODIS), the federal government has initiated funding for in-house analysis of samples at the crime laboratory and outsourcing samples to private laboratories for analysis.

Beginning in 2008, California began collecting DNA samples from all people arrested on suspicion of a felony, not just the eventual convict. The state's database, with approximately one million DNA profiles, is already the third largest in the world, behind those maintained by the United Kingdom and the FBI. The federal government plans to begin following California's policy.

CRIME LABORATORIES IN THE UNITED STATES Historically, our federal system of government, combined with a desire to retain local control, has produced a variety of independent laboratories in the United States, precluding the creation of a national system. Crime laboratories to a large extent mirror the fragmented law enforcement structure that exists on the national, state, and local levels. The federal government has no single law enforcement or investigative agency with unlimited jurisdiction.

Four major federal crime laboratories have been created to help investigate and enforce criminal laws that extend beyond the jurisdictional boundaries of state and local forces. The FBI (Department of Justice) maintains the largest crime laboratory in the world. An ultramodern facility housing the FBI's forensic science services is located in Quantico, Virginia. Its expertise and technology support its broad investigative powers. The Drug Enforcement Administration laboratories (Department of Justice) analyze drugs seized in violation of federal laws regulating the production, sale, and transportation of drugs. The laboratories of the Bureau of Alcohol, Tobacco, Firearms, and Explosives (Department of Justice) analyze alcoholic beverages and documents relating to alcohol and firearm excise-tax enforcement and examine weapons, explosive devices, and related evidence to enforce the Gun Control Act of 1968 and the Organized Crime Control Act of 1970. The U.S. Postal Inspection Service maintains laboratories concerned with criminal investigations relating to the postal service. Each of these federal facilities offers its expertise to any local agency that requests assistance in relevant investigative matters.

Most state governments maintain a crime laboratory to service state and local law enforcement agencies that do not have ready access to a laboratory. Some states, such as Alabama, California, Illinois, Michigan, New Jersey, Texas, Washington, Oregon, Virginia, and Florida, have developed a comprehensive statewide system of regional or satellite laboratories. These operate under the direction of a central facility and provide forensic services to most areas of the state. Having a regional laboratory that operates as part of a statewide system has increased the accessibility of many local law enforcement agencies to a crime laboratory, while minimizing duplication of services and ensuring maximum interlaboratory cooperation through the sharing of expertise and equipment.

Local laboratories provide services to county and municipal agencies. Generally, these facilities operate independent of the state crime laboratory and are financed directly by local government. However, as costs have risen, some counties have combined resources and created multicounty laboratories to service their jurisdictions. Many of the larger cities in the United States

maintain their own crime laboratories, usually under the direction of the local police department. Frequently, a large population and high crime rates combine to make a municipal facility, such as that of New York City, the largest crime laboratory in the state.

CRIME LABORATORIES ABROAD Like the United States, most countries in the world have created and now maintain forensic facilities. In contrast to the U.S. system of independent local laboratories, Great Britain has developed a national system of regional laboratories under the direction of the government's Home Office. England and Wales are serviced by regional laboratories, including the Metropolitan Police Laboratory (established in 1935), which services London. Recently, the British government announced plans to either privatize or sell off its government-operated forensic laboratories. In the early 1990s, the British Home Office reorganized the country's forensic laboratories into the Forensic Science Service and instituted a system in which police agencies are charged a fee for services rendered by the laboratory. The fees are based on "products," or a set of examinations that are designed to be suitable for particular types of physical evidence and are packaged together. The fee-for-service concept has encouraged the creation of a number of private laboratories that provide services to both police and criminal defense attorneys. LGC is the largest privately owned provider of forensic science services in the UK. With a staff of over 500, LGC delivers forensic services at eight laboratories in the UK. It is expected that under the planned government reorganization of state forensic laboratories, the bulk of forensic services in England and Wales will be carried out by private laboratories such as LGC.

In Canada, forensic services are provided by three government-funded institutes: (1) Royal Canadian Mounted Police regional laboratories, (2) the Centre of Forensic Sciences in Toronto, and (3) the Institute of Legal Medicine and Police Science in Montreal. Altogether, more than one hundred countries throughout the world have at least one laboratory facility offering forensic science services.

SERVICES OF THE CRIME LABORATORY

Bearing in mind the independent development of crime laboratories in the United States, the wide variation in the services offered to different communities is not surprising. There are many reasons for this, including (1) variations in local laws, (2) the different capabilities and functions of the organization to which a laboratory is attached, and (3) budgetary and staffing limitations.

In recent years, many local crime laboratories have been created solely to process drug specimens. Often these facilities were staffed with few personnel and operated under limited budgets. Although many have expanded their forensic services, some still primarily perform drug analyses. Among crime laboratories providing services beyond drug identification, the diversity and quality of services rendered varies significantly. The following forensic science units might be found in a "full-service" crime laboratory.

BASIC SERVICES PROVIDED BY FULL-SERVICE CRIME LABORATORIES

PHYSICAL SCIENCE UNIT The physical science unit applies principles and techniques of chemistry, physics, and geology to the identification and comparison of crime-scene evidence. It is staffed by criminalists who have the expertise to use chemical tests and modern analytical instrumentation to examine items as diverse as drugs, glass, paint, explosives, and soil. In a laboratory that has a staff large enough to permit specialization, the responsibilities

of this unit may be further subdivided into drug identification, soil and mineral analyses, and examination of a variety of trace physical evidence.

BIOLOGY UNIT The biology unit is staffed with biologists and biochemists who identify and perform DNA profiling on bloodstains and other dried body fluids, compare hairs and fibers, and identify and compare botanical materials such as wood and plants (see Figure 8).

FIREARMS UNIT The firearms unit examines firearms, discharged bullets, cartridge cases, shotgun shells, and ammunition of all types. Garments and other objects are also examined to detect firearm discharge residues and to approximate how far from a target a weapon was fired. The basic principles of firearms examination are also applied to comparing marks made by tools (see Figure 9).

DOCUMENT EXAMINATION UNIT The document examination unit studies the handwriting and typewriting on documents in question to ascertain their authenticity and/or source. Related responsibilities include analyzing paper and ink and examining indented writings (i.e., the partially visible depressions that appear on the sheet of paper that was underneath the one that was written on), obliterations, erasures, and burned or charred documents.

FIGURE 8 A forensic scientist performing DNA analysis. *Mauro Fermariello/SPL/Photo Researchers, Inc.*

PHOTOGRAPHY UNIT A complete photographic laboratory examines and records physical evidence. Its procedures may require the use of highly specialized photographic techniques, such as digital imaging and infrared, ultraviolet,

FIGURE 9 A forensic analyst examining a firearm. *mediacolors/Alamy Images*

and X-ray photography, to make invisible information visible to the naked eye. This unit also prepares photographic exhibits for courtroom presentation.

OPTIONAL SERVICES PROVIDED BY FULL-SERVICE CRIME LABORATORIES

TOXICOLOGY UNIT The toxicology group examines body fluids and organs to determine the presence or absence of drugs and poisons. Frequently, such functions are shared with or may be the sole responsibility of a separate laboratory facility placed under the direction of the medical examiner's or coroner's office. In most jurisdictions, field instruments such as the Intoxilyzer are used to determine how much alcohol an individual has consumed. Often the toxicology unit also trains operators of these instruments and maintains and services them.

LATENT FINGERPRINT UNIT The latent fingerprint unit processes and examines evidence for latent fingerprints when they are submitted in conjunction with other laboratory examinations.

POLYGRAPH UNIT The polygraph, or lie detector, has become an essential tool of the criminal investigator rather than the forensic scientist. However, during the formative years of polygraph technology, many police agencies incorporated this unit into the laboratory's administrative structure, where it sometimes remains today. In any case, its functions are handled by people trained in the techniques of criminal investigation and interrogation (see Figure 10).

VOICEPRINT ANALYSIS UNIT In cases involving telephoned threats or tape-recorded messages, investigators may require the skills of the voiceprint analysis unit to tie the voice to a particular suspect. To this end, a good deal of casework has been performed with the sound spectrograph, an instrument that transforms speech into a visual graphic display called a *voiceprint*. The validity of this technique as a means of personal identification rests on the premise that the sound patterns produced in speech are unique to the individual and that the voiceprint displays this uniqueness.

FIGURE 10 An individual undergoing a polygraph test. *Courtesy ZUMA Press, Inc./Alamy*

CRIME-SCENE INVESTIGATION UNIT The concept of incorporating crime-scene evidence collection into the services forensic laboratories offer is slowly gaining ground in the United States. This unit dispatches specially trained personnel (civilian and/or police) to the crime scene to collect and preserve physical evidence that will be processed at the crime laboratory.

Whatever the organizational structure of a forensic science laboratory may be, specialization must not impede the overall coordination of services demanded by today's criminal investigator. Laboratory administrators need to keep open the lines of communication between analysts (civilian and uniformed), crime-scene investigators, and police personnel. Inevitably, forensic investigations require the skills of many individuals. One notoriously high-profile investigation illustrates this process: the search for the source of the anthrax letters mailed shortly after September 11, 2001. Figure 11 shows one of the letters and illustrates the multitude of skills required in the investigation—skills possessed by forensic chemists and biologists, fingerprint examiners, and forensic document examiners.

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Take a Virtual Tour of a Forensic Laboratory
www.mycrimekit.com

OTHER FORENSIC SCIENCE SERVICES

Even though this text is devoted to describing the services normally provided by a crime laboratory, the field of forensic science is by no means limited to the areas covered in this article. A number of specialized forensic science services outside the crime laboratory are routinely available to law enforcement personnel. These services are important aids to a criminal investigation and require the involvement of individuals who have highly specialized skills.

Three specialized forensic services—forensic pathology, forensic anthropology, and forensic entomology—are frequently employed at a murder scene. Other services, such as those discussed next, are used in a wide variety of criminal investigations.

FORENSIC PSYCHIATRY Forensic psychiatry is a specialized area that examines the relationship between human behavior and legal proceedings. Forensic psychiatrists are retained for both civil and criminal litigations. In civil cases, they typically perform tasks such as determining whether an individual is competent to make decisions about preparing a will, settling property, or refusing medical treatment. In criminal cases, forensic psychologists evaluate behavioral disorders and determine whether defendants are competent to stand trial. Forensic psychiatrists also examine behavior patterns of criminals as an aid in developing a suspect's behavioral profile.

FORENSIC ODONTOLOGY Practitioners of forensic odontology help identify victims based on dental evidence when the body is in an unrecognizable state. Teeth are composed of enamel, the hardest substance in the body. Because of enamel's resilience, the teeth outlast tissues and organs during decomposition. The characteristics of teeth, their alignment, and the overall structure of the mouth provide individual evidence for identifying a specific person. Based on dental records such as X-rays and dental casts, even a photograph of the person's smile, a set of dental remains can be matched to a suspected victim. Another application of forensic odontology to criminal investigations is bite mark analysis. Bite marks are sometimes left on a victim of assault. A forensic odontologist can compare the marks left on a victim to the tooth structure of the suspect (see Figure 12).

FORENSIC ENGINEERING Forensic engineers are concerned with failure analysis, accident reconstruction, and causes and origins of fires and explosions. Forensic engineers answer questions such as these: How did an accident or structural failure occur? Were the parties involved responsible? If so, how were they responsible? Accident scenes are examined, photographs are reviewed, and any mechanical objects involved are inspected.

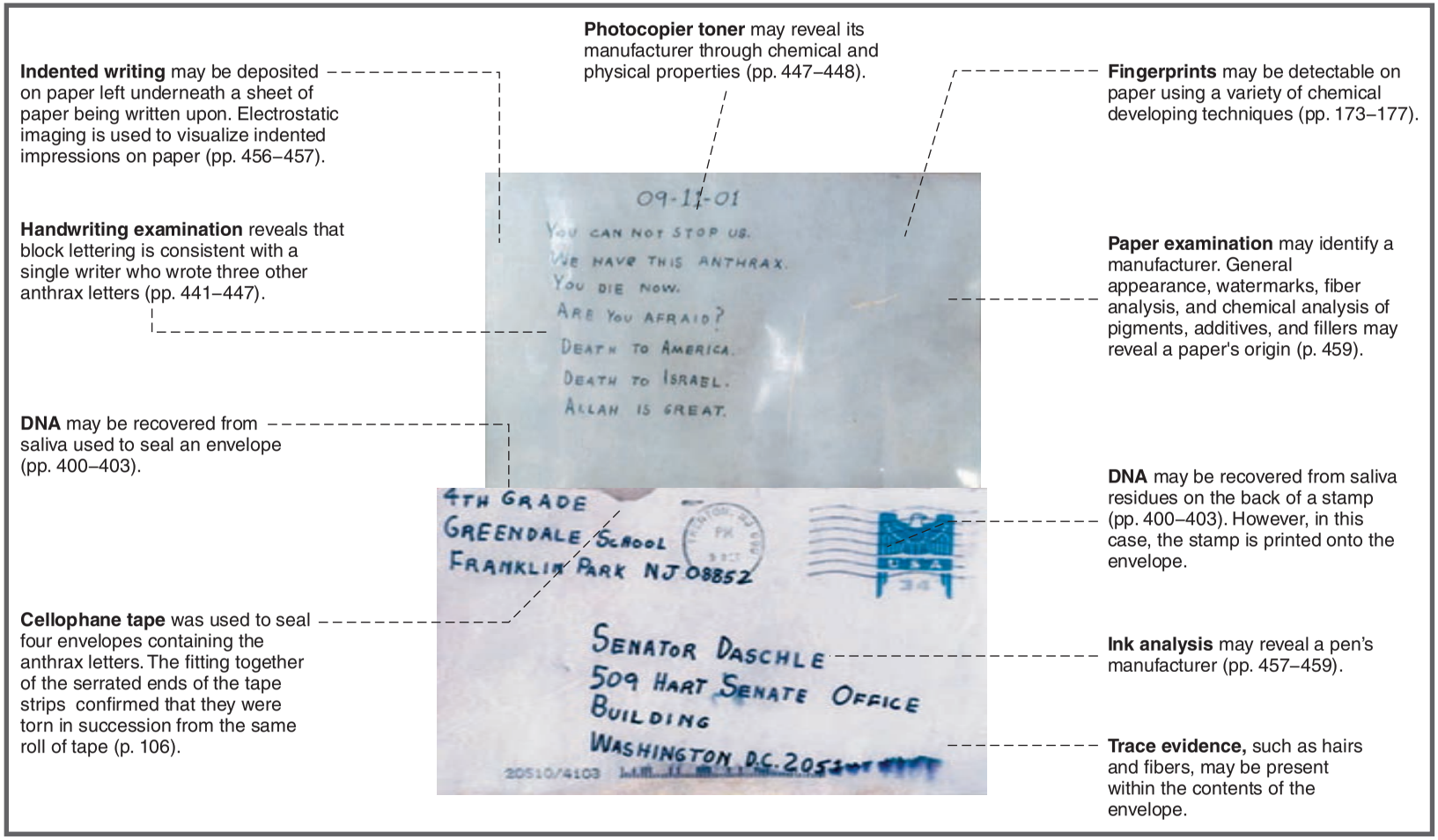

FIGURE 11 An envelope containing anthrax spores along with an anonymous letter was sent to the office of Senator Tom Daschle shortly after the terrorist attacks of September 11, 2001. A variety of forensic skills were used to examine the envelope and letter. Also, bar codes placed on the front and back of the envelope by mail-sorting machines contain address information and information about where the envelope was first processed. *Getty Images, Inc.—Getty News*

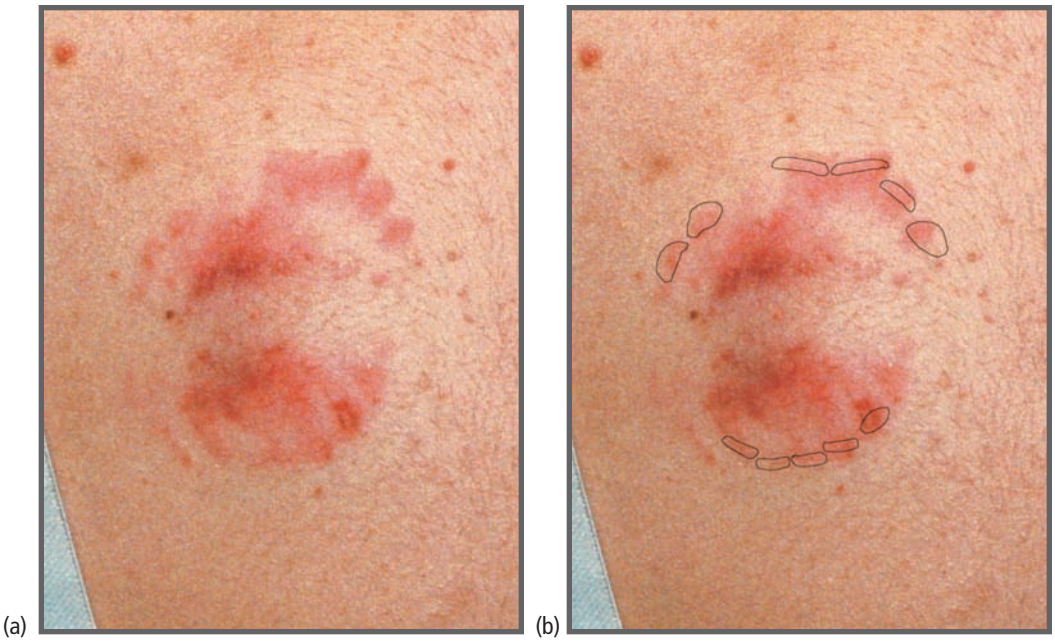

FIGURE 12 (a) A bite mark on a victim's body. (b) Comparison to a suspect's teeth. *David Sweet, DMD, PhD, DABFP, Director BOLD Forensic Laboratory, Vancouver, BC, Canada*

FORENSIC COMPUTER AND DIGITAL ANALYSIS Forensic computer science is a new and fast-growing field that involves identifying, collecting, preserving, and examining information derived from computers and other digital devices, such as cell phones. Law enforcement aspects of this work normally involve recovering deleted or overwritten data from a computer's hard drive and tracking hacking activities within a compromised system.

Quick Review

- The development of crime laboratories in the United States has been characterized by rapid growth accompanied by a lack of national and regional planning and coordination.
- Four major reasons for the increase in the number of crime laboratories in the United States since the 1960s are as follows: (1) The requirement to advise criminal suspects of their constitutional rights and their right of immediate access to counsel has all but eliminated confessions as a routine investigative tool. (2) There has been a staggering increase in crime rates in the United States. (3) All illicit-drug seizures must be sent to a forensic laboratory for confirmatory chemical analysis before the case can be adjudicated in court. (4) DNA profiling was developed and is now often required.
- The technical support provided by crime laboratories can be assigned to five basic services: the physical science unit, the biology unit, the firearms unit, the document examination unit, and the photography unit.
- Some crime laboratories offer optional services such as toxicology, fingerprint analysis, polygraph administration, voiceprint analysis, and crime-scene investigation.
- Special forensic science services available to the law enforcement community include forensic pathology, forensic anthropology, forensic entomology, forensic psychiatry, forensic odontology, forensic engineering, and forensic computer and digital analysis.

Functions of the Forensic Scientist

Although a forensic scientist relies primarily on scientific knowledge and skill, only half of the job is performed in the laboratory. The other half takes place in the courtroom, where the ultimate significance of the evidence is determined. The forensic scientist must not only analyze physical evidence but also persuade a jury to accept the conclusions derived from that analysis.

ANALYZING PHYSICAL EVIDENCE

First and foremost, the forensic scientist must be skilled in applying the principles and techniques of the physical and natural sciences to analyze the many types of physical evidence that may be recovered during a criminal investigation. Of the three major avenues available to police investigators for assistance in solving a crime—confessions, eyewitness accounts by victims or witnesses, and the evaluation of physical evidence retrieved from the crime scene—only physical evidence is free of inherent error or bias.

Criminal cases are replete with examples of individuals who were incorrectly charged with and convicted of committing a crime because of faulty memories or lapses in judgment. For example, investigators may be led astray during their preliminary evaluation of the events and circumstances surrounding the commission of a crime. These errors might be compounded by misleading eyewitness statements and inappropriate confessions. These same concerns don't apply to physical evidence.

What about physical evidence allows investigators to sort out facts as they are and not as they want them to be? The hallmark of physical evidence is that it must undergo scientific inquiry. Science derives its integrity from adherence to strict guidelines that ensure the careful and systematic collection, organization, and analysis of information—a process known as the **scientific method**. The underlying principles of the scientific method provide a safety net to ensure that the outcome of an investigation is not tainted by human emotion or compromised by distorting, belittling, or ignoring contrary evidence.

scientific method
A process that uses strict guidelines to ensure careful and systematic collection, organization, and analysis of information.

The scientific method begins by formulating a question worthy of investigation, such as who committed a particular crime. The investigator next formulates a hypothesis, a reasonable explanation proposed to answer the question. What follows is the basic foundation of scientific inquiry: the testing of the hypothesis through experimentation. The testing process must be thorough and recognized by other scientists as valid. Scientists and investigators must accept the experimental findings even when they wish they were different. Finally, when the hypothesis is validated by experimentation, it becomes suitable as scientific evidence, appropriate for use in a criminal investigation and, ultimately, available for admission in a court of law.

DETERMINING ADMISSIBILITY OF EVIDENCE In rejecting the scientific validity of the lie detector (polygraph), the District of Columbia Circuit Court in 1923 set forth what has since become a standard guideline for determining the judicial admissibility of scientific examinations. In *Frye* v. *United States,*[2] the court ruled that, in order to be admitted as evidence at trial, the questioned procedure, technique, or principles must be "generally accepted" by a meaningful segment of the relevant scientific community. In practice, this approach requires the proponent of a scientific test to present to the court a collection of experts who can testify that the scientific issue before the court is generally accepted by the relevant members of the scientific community. Furthermore, in determining whether a novel technique meets criteria associated with "general acceptance," courts have frequently taken note of books and papers written on the subject, as well as prior judicial decisions relating to the reliability and general acceptance of the technique. In recent years many observers have questioned whether this

approach is flexible enough to deal with new scientific issues that may not have gained widespread support within the scientific community.

The Federal Rules of Evidence offer an alternative to the *Frye* standard, one that some courts believe espouses a more flexible guideline for admitting scientific evidence. Part of the Federal Rules of Evidence governs the admissibility of all evidence, including expert testimony, in federal courts, and many states have adopted codes similar to those of the Federal Rules. Specifically, Rule 702 of the Federal Rules of Evidence sets a different standard from "general acceptance" for admissibility of expert testimony. Under this standard, a witness "qualified as an expert by knowledge, skill, experience, training, or education" may offer expert testimony on a scientific or technical matter if "(1) the testimony is based on sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case."

In a landmark ruling in the 1993 case of *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*,[3] the U.S. Supreme Court (see Figure 13) asserted that "general acceptance," or the *Frye* standard, is not an absolute prerequisite to the admissibility of scientific evidence under the Federal Rules of Evidence. According to the Court, the Rules of Evidence—especially Rule 702—assign to the trial judge the task of ensuring that an expert's testimony rests on a reliable foundation and is relevant to the case. Although this ruling applies only to federal courts, many state courts are expected to use this decision as a guideline in setting standards for the admissibility of scientific evidence.

JUDGING SCIENTIFIC EVIDENCE In *Daubert,* the Court advocates that trial judges assume the ultimate responsibility for acting as a "gatekeeper" who determines the admissibility and reliability of scientific evidence presented in their courts. The Court offered some guidelines as to how a judge can gauge the veracity of scientific evidence, emphasizing that the inquiry should be flexible. Suggested areas of inquiry include the following:

1. Whether the scientific technique or theory can be (and has been) tested
2. Whether the technique or theory has been subject to peer review and publication

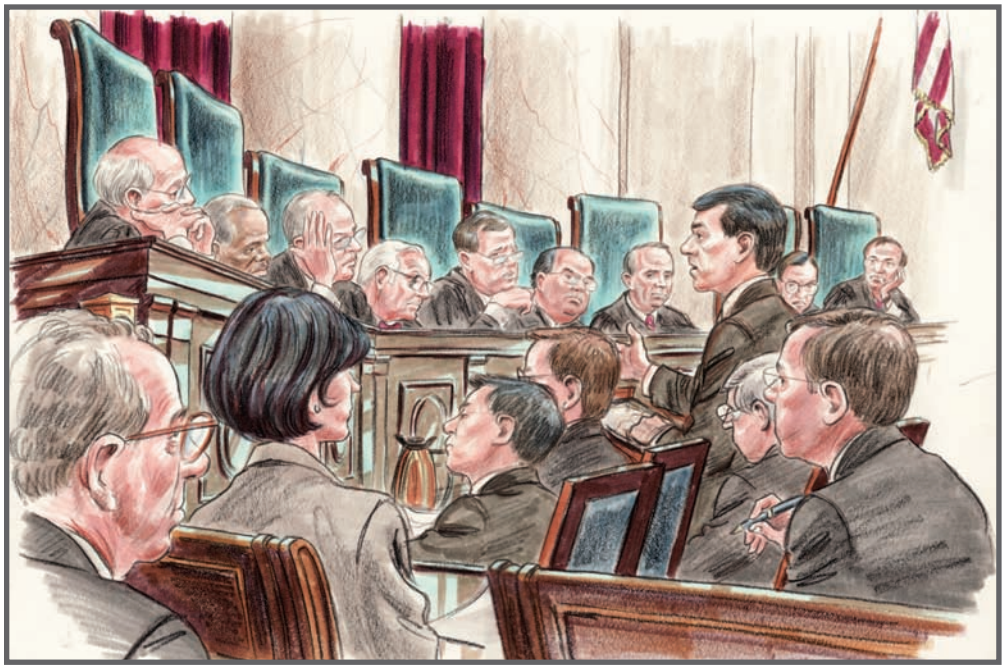

FIGURE 13 A sketch of a U.S. Supreme Court hearing. © *Art Lien, Court Artist*

3. The technique's potential rate of error
4. The existence and maintenance of standards controlling the technique's operation
5. Whether the scientific theory or method has attracted widespread acceptance within a relevant scientific community

Some legal experts have expressed concern that abandoning *Frye*'s general-acceptance test will result in the introduction of absurd and irrational pseudoscientific claims in the courtroom. The Supreme Court rejected these concerns, pointing out the inherent strengths of the US judicial process in identifying unreliable evidence:

> In this regard the respondent seems to us to be overly pessimistic about the capabilities of the jury and of the adversary system generally. Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence.

In a 1999 decision, *Kumho Tire Co., Ltd.* v. *Carmichael,*[4] the Court unanimously ruled that the "gatekeeping" role of the trial judge applied not only to scientific testimony but to all expert testimony:

> We conclude that *Daubert*'s general holding—setting forth the trial judge's general "gatekeeping" obligation—applies not only to testimony based on "scientific" knowledge, but also to testimony based on "technical" and "other specialized" knowledge . . . . We also conclude that a trial court may consider one or more of the more specific factors that *Daubert* mentioned when doing so will help determine that testimony's reliability. But, as the Court stated in *Daubert,* the test of reliability is "flexible," and *Daubert*'s list of specific factors neither necessarily nor exclusively applies to all experts in every case.

The case of *Coppolino* v. *State*[5] (examined more closely in the Case Files feature) exemplifies the flexibility and wide discretion that the *Daubert* ruling, twenty-five years later, apparently gave to trial judges in matters of scientific inquiry. The issue in question was whether the results of a new procedure that has not been widely accepted in the scientific community are necessarily inadmissible as evidence. The court rejected this argument, recognizing that researchers must devise new scientific tests to solve the special problems that continually arise in the forensic laboratory.

The *Coppolino* ruling acknowledged that even well-established scientific procedures were once new and unproved and noted the court's duty to protect the public when weighing the admissibility of a new test. In the words of the concurring opinion, "Society need not tolerate homicide until there develops a body of medical literature about some particular lethal agent." The court emphasized, however, that although these tests may be new and unique, they are admissible only if they are based on scientifically valid principles and techniques.

PROVIDING EXPERT TESTIMONY

Because the results of their work may be a factor in determining a person's ultimate guilt or innocence, forensic scientists may be required to testify about their methods and conclusions at a trial or hearing.

expert witness
An individual whom the court determines to possess knowledge relevant to the trial that is not expected of the average layperson.

Trial courts have broad discretion in accepting an individual as an **expert witness** on any particular subject. Generally, if a witness can establish to the satisfaction of a trial judge that he or she possesses a particular skill or has knowledge in a trade or profession that will aid the court in determining the truth of the matter at issue, that individual will be accepted as an expert witness. Depending on the subject area in question, the court will usually consider knowledge acquired

CASEFILES

DR. COPPOLINO'S DEADLY HOUSE CALLS

A frantic late-night telephone call brought a local physician to the Florida home of Drs. Carl and Carmela Coppolino. The physician arrived to find Carmela beyond help. Carmela Coppolino's body, unexamined by anyone, was then buried in her family's plot in her home state of New Jersey.

A little more than a month later, Carl married a moneyed socialite, Mary Gibson. News of Carl's marriage infuriated Marjorie Farber, a former New Jersey neighbor of Dr. Coppolino who had been a having an affair with the good doctor. Soon Marjorie had an interesting story to recount to investigators: Her husband's death two years before, although ruled to be from natural causes, had actually been murder! Carl, an anesthesiologist, had given Marjorie a syringe containing some medication and told her to inject her husband, William, while he was sleeping. Ultimately, Marjorie claimed, she was unable to inject the full dose and called Carl, who finished the job by suffocating William with a pillow.

Marjorie Farber's astonishing story was supported in part by Carl's having recently increased his wife's life insurance. Carmela's $65,000 policy, along with his new wife's fortune, would keep Dr. Coppolino in high society for the rest of his life. Based on this information, authorities in New Jersey and Florida obtained exhumation orders for both William Farber and Carmela Coppolino. After both bodies were examined, Dr. Coppolino was charged with the murders of William and Carmela.

Officials decided to try Dr. Coppolino first in New Jersey for the murder of William Farber. The Farber autopsy did not reveal any evidence of poisoning but seemed to show strong evidence of strangulation. The absence of toxicological findings left the jury to deliberate the conflicting medical expert testimony versus the sensational story told by a scorned and embittered woman. In the end, Dr. Coppolino was acquitted.

The Florida trial presented another chance to bring Carl Coppolino to justice. Recalling Dr. Coppolino's career as an anesthesiologist, the prosecution theorized that to commit these murders Coppolino had exploited his access to the many potent drugs used during surgery, specifically an injectable paralytic agent called succinylcholine chloride.

Carmela's body was exhumed, and it was found that Carmela had been injected in her left buttock shortly before her death. Ultimately, a completely novel procedure for detecting succinylcholine chloride was devised. With this procedure elevated levels of succinic acid were found in Carmela's brain, which proved that she had received a large dose of the paralytic drug shortly before her death. This evidence, along with evidence of the same drug residues in the injection site on her buttock, was presented in the Florida murder trial of Carl Coppolino, who was convicted of second-degree murder.

through experience, training, education, or a combination of these as sufficient grounds for qualification as an expert witness.

In court, an expert witness may be asked questions intended to demonstrate his or her ability and competence pertaining to the matter at hand. Competency may be established by having the witness cite educational degrees, participation in special courses, membership in professional societies, and any professional articles or books published. Also important is the number of years of occupational experience the witness has had in areas related to the matter before the court.

Unfortunately, few schools confer degrees in forensic science. Most chemists, biologists, geologists, and physicists prepare themselves for careers in forensic science by combining training under an experienced examiner with independent study. Of course, formal education in the physical sciences provides a firm foundation for learning and understanding the principles and techniques of forensic science. Nevertheless, for the most part, courts must rely on training and years of experience as a measurement of the knowledge and ability of the expert.

Before the judge rules on the witness's qualifications, the opposing attorney may cross-examine the witness and point out weaknesses in training and knowledge. Most courts are reluctant to disqualify an individual as an expert even when presented with someone whose background is only remotely associated with the issue at hand. The question of what credentials are suitable for qualification as an expert is ambiguous and highly subjective and one that the courts wisely try to avoid.

The weight that a judge or jury assigns to "expert" testimony in subsequent deliberations is, however, quite another matter. Undoubtedly, education and

experience have considerable bearing on what value should be assigned to the expert's opinions. Just as important may be his or her demeanor and ability to explain scientific data and conclusions clearly, concisely, and logically to a judge and jury composed of nonscientists. The problem of sorting out the strengths and weaknesses of expert testimony falls to prosecution and defense counsel.

The ordinary or lay witness must testify on events or observations that arise from personal knowledge. This testimony must be factual and, with few exceptions, cannot contain the personal opinions of the witness. On the other hand, the expert witness is called on to evaluate evidence when the court lacks the expertise to do so. This expert then expresses an opinion as to the significance of the findings. The views expressed are accepted only as representing the expert's opinion and may later be accepted or ignored in jury deliberations (see Figure 14).

The expert cannot render any view with absolute certainty. At best, he or she may only be able to offer an opinion based on a reasonable scientific certainty derived from training and experience. Obviously, the expert is expected to defend vigorously the techniques and conclusions of the analysis, but at the same time he or she must not be reluctant to discuss impartially any findings that could minimize the significance of the analysis. The forensic scientist should not be an advocate of one party's cause but an advocate of truth only. An adversary system of justice must give the prosecutor and defense ample opportunity to offer expert opinions and to argue the merits of such testimony. Ultimately, the duty of the judge or jury is to weigh the pros and cons of all the information presented when deciding guilt or innocence.

The necessity for the forensic scientist to appear in court has been imposed on the criminal justice system by a 2009 U.S. Supreme Court case, *Melendez-Diaz* v. *Massachusetts*.[6] The *Melendez-Diaz* decision addressed the practice of using evidence affidavits or laboratory certificates in lieu of in-person testimony by forensic analysts. In its reasoning, the Court relied on a previous ruling, *Crawford* v. *Washington*[7] where it explored the meaning of the Confrontation Clause of the Sixth Amendment. In the *Crawford* case, a recorded statement by a spouse was used against her husband in his prosecution. Crawford argued that this was a violation of his right to confront witnesses against him under the Sixth Amendment, and the Court agreed. Using

FIGURE 14 An expert witness testifying in court. *Taylor Jones/ZUMA Press/Newscom*

the same logic in *Melendez-Diaz,* the Court reasoned that introducing forensic science evidence via an affidavit or a certificate denied a defendant the opportunity to cross-examine the analyst. In 2011, the Supreme Court reaffirmed the *Melendez-Diaz* decision in the case of *Bullcoming v. New Mexico*[8] by rejecting a substitute expert witness in lieu of the original analyst:

> The question presented is whether the Confrontation Clause permits the prosecution to introduce a forensic laboratory report containing a testimonial certification—made for the purpose of proving a particular fact—through the in-court testimony of a scientist who did not sign the certification or perform or observe the test reported in the certification. We hold that surrogate testimony of that order does not meet the constitutional requirement. The accused's right is to be confronted with the analyst who made the certification, unless that analyst is unavailable at trial, and the accused had an opportunity, pretrial, to cross-examine that particular scientist.

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MyCrimeKit WebExtra 3

Watch a Forensic Expert Witness Testify—II
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FURNISHING TRAINING IN THE PROPER RECOGNITION, COLLECTION, AND PRESERVATION OF PHYSICAL EVIDENCE

The competence of a laboratory staff and the sophistication of its analytical equipment have little or no value if relevant evidence cannot be properly recognized, collected, and preserved at the site of a crime. For this reason, the forensic staff must have responsibilities that will influence the conduct of the crime-scene investigation.

The most direct and effective response to this problem has been to dispatch specially trained evidence-collection technicians to the crime scene. A growing number of crime laboratories and the police agencies they service keep trained "evidence technicians" on 24-hour call to help criminal investigators retrieve evidence. These technicians are trained by the laboratory staff to recognize and gather pertinent physical evidence at the crime scene. They are assigned to the laboratory full-time for continued exposure to forensic techniques and procedures. They have at their disposal all the proper tools and supplies for proper collection and packaging of evidence for future scientific examination.

Unfortunately, many police forces still have not adopted this approach. Often a patrol officer or detective collects the evidence. The individual's effectiveness in this role depends on the extent of his or her training and working relationship with the laboratory. For maximum use of the skills of the crime laboratory, training of the crime-scene investigator must go beyond superficial classroom lectures to involve extensive personal contact with the forensic scientist. Each must become aware of the other's problems, techniques, and limitations.

The training of police officers in evidence collection and their familiarization with the capabilities of a crime laboratory should not be restricted to a select group of personnel on the force. Every officer engaged in fieldwork, whether it be traffic, patrol, investigation, or juvenile control, often must process evidence for laboratory examination. Obviously, it would be difficult and time consuming to give everyone the in-depth training and attention that a qualified criminal investigator requires. However, familiarity with crime laboratory services and capabilities can be gained through periodic lectures, laboratory tours, and dissemination of manuals prepared by the laboratory staff that outline the proper methods for collecting and submitting physical evidence to the laboratory (see Figure 15).

FIGURE 15 Representative evidence-collection guides prepared by various governmental agencies.

Quick Review

- A forensic scientist must be skilled in applying the principles and techniques of the physical and natural sciences to analyzing evidence that may be recovered during a criminal investigation.
- The cases *Frye* v. *United States* and *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.* set guidelines for determining the admissibility of scientific evidence into the courtroom.
- An expert witness evaluates evidence based on specialized training and experience.
- Forensic scientists participate in training law enforcement personnel in the proper recognition, collection, and preservation of physical evidence.

EXPLORING FORENSIC SCIENCE ON THE INTERNET

There are no limits to the amount or type of information that can be found on the Internet. The fields of law enforcement and forensic science have not been left behind by advancing computer technology. Extensive information about forensic science is available on the Internet. The types of information available on websites range from simple explanations of the various fields of forensics to intricate details of crime-scene reconstruction. People can also find information on which colleges offer degree programs in forensics and webpages posted by law enforcement agencies that detail their activities as well as employment opportunities.

GENERAL FORENSICS SITES

Reddy's Forensic Home Page (www.forensicpage.com) is a valuable starting point. This site is a collection of forensic webpages in categories such as new links in forensics; general forensic information sources; associations, colleges,

and societies; literature and journals; forensic laboratories; general webpages; forensic-related mailing lists and newsgroups; universities; conferences; and various forensic fields of expertise.

Another website offering a multitude of information related to forensic science is Zeno's Forensic Site (www.forensic.to/forensic.html). Here users can find links related to forensic education and expert consultation, as well as a wealth of information concerning specific fields of forensic science.

A comprehensive and useful website for those interested in law enforcement is Officer.com (www.officer.com). This comprehensive collection of criminal justice resources is organized into easy-to-read subdirectories that relate to topics such as law enforcement agencies, police association and organization sites, criminal justice organizations, law research pages, and police mailing-list directories.

WEBSITES ON SPECIFIC TOPICS

AN INTRODUCTION TO FORENSIC FIREARM IDENTIFICATION This website contains an extensive collection of information relating to the identification of firearms. An individual can explore in detail how to examine bullets, cartridge cases, and clothing for gunshot residues and suspect shooters' hands for primer residues. Information on the latest technology involving the automated firearms search system IBIS can also be found on this site.

MyCrimeKit WebExtra 4

An Introduction to Forensic Firearm Identification
www.mycrimekit.com

CARPENTER'S FORENSIC SCIENCE RESOURCES This site provides a bibliography involving forensic evidence. For example, the user can find references about DNA, fingerprints, hairs, fibers, and questioned documents as they relate to crime scenes and assist investigations. This website is an excellent place to start a research project in forensic science.

MyCrimeKit WebExtra 5

Carpenter's Forensic Science Resources
www.mycrimekit.com

CRIME SCENE INVESTIGATOR NETWORK For those who are interested in learning the process of crime-scene investigation, this site provides detailed guidelines and information regarding crime-scene response and the collection and preservation of evidence. For example, information concerning the packaging and analysis of bloodstains, seminal fluids, hairs, fibers, paint, glass, firearms, documents, and fingerprints can be found through this website. It explains the importance of inspecting the crime scene and the impact forensic evidence has on the investigation.

MyCrimeKit WebExtra 6

Crime Scene Investigator Network
www.mycrimekit.com

CRIMES AND CLUES Users interested in learning about the forensic aspects of fingerprinting will find this to be a useful and informative website. The site covers the history of fingerprints, as well as subjects pertaining to the development of latent fingerprints. The user will also find links to other websites covering a variety of subjects pertaining to crime-scene investigation, documentation of the crime scene, and expert testimony.

MyCrimeKit WebExtra 7

Crimes and Clues
www.mycrimekit.com

INTERACTIVE INVESTIGATOR—DÉTECTIVE INTERACTIF At this outstanding site, visitors can obtain general information and an introduction to the main aspects of forensic science from a database on the subject. They can also explore actual evidence gathered from notorious crime scenes. Users will be able to employ deductive skills and forensic knowledge while playing an interactive game in which they must help Detective Wilson and Detective Marlow solve a gruesome murder.

MyCrimeKit WebExtra 8

Interactive Investigator
www.mycrimekit.com

THE CHEMICAL DETECTIVE This site offers descriptions of relevant forensic science disciplines. Topics such as fingerprints, fire and arson, and DNA analysis are described in informative layperson's terms. Case histories describe the application of forensic evidence to criminal investigations. Emphasis is placed

MyCrimeKit WebExtra 9

The Chemical Detective
www.mycrimekit.com

MyCrimeKit WebExtra 10

Questioned-Document Examination
www.mycrimekit.com

on securing and documenting the crime scene. The site directs the reader to other important forensic links.

QUESTIONED-DOCUMENT EXAMINATION This basic, informative webpage answers frequently asked questions concerning document examination, explains the application of typical document examinations, and details the basic facts and theory of handwriting and signatures. There are also links to noted document examination cases that present the user with real-life applications of forensic document examination.

CHAPTER REVIEW

- Forensic science is the application of science to criminal and civil laws that are enforced by police agencies in a criminal justice system.
- The first system of personal identification was called anthropometry. It distinguished one individual from another based on a series of bodily measurements.
- Forensic science owes its origins to individuals such as Bertillon, Galton, Lattes, Goddard, Osborn, and Locard, who developed the principles and techniques needed to identify and compare physical evidence.
- Locard's exchange principle states that, when two objects come into contact with each other, a cross-transfer of materials occurs that can connect a criminal suspect to his or her victim.
- The development of crime laboratories in the United States has been characterized by rapid growth accompanied by a lack of national and regional planning and coordination.
- Four major reasons for the increase in the number of crime laboratories in the United States since the 1960s are as follows: (1) The requirement to advise criminal suspects of their constitutional rights and their right of immediate access to counsel has all but eliminated confessions as a routine investigative tool. (2) There has been a staggering increase in crime rates in the United States. (3) All illicit-drug seizures must be sent to a forensic laboratory for confirmatory chemical analysis before the case can be adjudicated in court. (4) DNA profiling was developed and is now often required.
- The technical support provided by crime laboratories can be assigned to five basic services: the physical science unit, the biology unit, the firearms unit, the document examination unit, and the photography unit.
- Some crime laboratories offer optional services such as toxicology, fingerprint analysis, polygraph administration, voiceprint analysis, and crime-scene investigation.
- Special forensic science services available to the law enforcement community include forensic pathology, forensic anthropology, forensic entomology, forensic psychiatry, forensic odontology, forensic engineering, and forensic computer and digital analysis.
- A forensic scientist must be skilled in applying the principles and techniques of the physical and natural sciences to analyzing evidence that may be recovered during a criminal investigation.
- The cases *Frye* v. *United States* and *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.* set guidelines for determining the admissibility of scientific evidence into the courtroom.
- An expert witness evaluates evidence based on specialized training and experience.
- Forensic scientists participate in training law enforcement personnel in the proper recognition, collection, and preservation of physical evidence.

KEY TERMS

expert witness Locard's exchange principle scientific method

REVIEW QUESTIONS

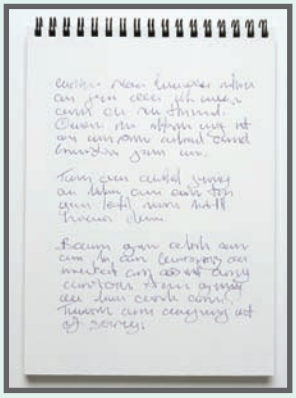
1. The application of science to law describes _____.
2. The Spaniard _____ published the first writings about the detection of poisons and the effects of poisons on animals, and he is considered the father of forensic toxicology.
3. A system of personal identification using a series of bodily measurements was first devised by _____, and he called it _____.

4. The fictional exploits of _____ excited the imagination of an emerging generation of forensic scientists and criminal investigators.
5. One of the first functional crime laboratories was formed in Lyons, France, in 1910 under the direction of _____, who developed _____, a theory stating that there is mutual transfer of material when two objects make contact with each other.
6. The application of science to criminal investigation was advocated by the Austrian magistrate _____.
7. True or False: The important advancement in the fields of blood typing and document examination were made in the early part of the twentieth century. _____
8. The Italian scientist _____ devised the first workable procedure for typing dried bloodstains.
9. Early efforts at applying scientific principles to document examination are associated with _____.
10. The first DNA profiling test was developed by _____ in 1984, and it was first used in 1986 to identify the murderer of two young English girls.
11. True or False: Computerized databases exist for fingerprints, bullets, cartridge cases, and DNA. _____
12. The first forensic laboratory in the United States was created in 1923 by the _____ Police Department.
13. Although no national system of forensic laboratories exists in the United States, the state of _____ is an excellent example of a geographical area in the United States that has created a system of integrated regional and satellite laboratories.
14. A decentralized system of crime laboratories currently exists in the United States under the auspices of various governmental agencies at the _____, _____, _____, and _____ levels of government.
15. In contrast to the United States, Britain has a crime laboratory system characterized by a national system of _____ laboratories.
16. Four important federal agencies offering forensic services are _____, _____, _____, and _____.
17. The application of chemistry, physics, and geology to the identification and comparison of crime-scene evidence is the function of the _____ unit of a crime laboratory.
18. The examination of blood, hairs, fibers, and botanical materials is conducted in the _____ unit of a crime laboratory.
19. The examination of bullets, cartridge cases, shotgun shells, and ammunition of all types is the responsibility of the _____ unit.
20. The study of handwriting and typewriting on questioned documents is carried out by the _____ unit to ascertain authenticity and/or source.
21. The examination of body fluids and organs for drugs and poisons is a function of the _____ unit.
22. The _____ unit dispatches trained personnel to the scene of a crime to retrieve evidence for laboratory examination.
23. True or False: Special forensic science services available to the law enforcement community include forensic pathology, forensic anthropology, and forensic astronomy. _____
24. The "general acceptance" principle, which serves as a criterion for the judicial admissibility of scientific evidence, was set forth in the case of _____.
25. In the case of _____, the Supreme Court ruled that, in assessing the admissibility of new and unique scientific tests, the trial judge did not have to rely solely on the concept of "general acceptance."
26. True or False: The U.S. Supreme Court decision in *Kumho Tire Co., Ltd.* v. *Carmichael* restricted the "gatekeeping" role of a trial judge to scientific testimony only. _____
27. A Florida case that exemplifies the flexibility and wide discretion that the trial judge has in matters of scientific inquiry is _____.
28. A(n) _____ is a person who can demonstrate a particular skill or has knowledge in a trade or profession that will help the court determine the truth of the matter at issue.
29. True or False: The expert witness's courtroom demeanor may play an important role in deciding what weight the court will assign to his or her testimony. _____
30. True or False: The testimony of an expert witness incorporates his or her personal opinion relating to a matter he or she has either studied or examined. _____
31. True or False: In 2004, the U.S. Supreme Court addressed issues relating to the Confrontation Clause of the Sixth Amendment in the case of *Crawford* v. *Washington*. _____
32. The 2009 U.S. Supreme Court decision _____ addressed the practice of using affidavits in lieu of in-person testimony by forensic examiners.
33. The ability of the investigator to recognize and collect crime-scene evidence properly depends on the amount of _____ received from the crime laboratory.

APPLICATION AND CRITICAL THINKING

1. Most crime labs in the United States are funded and operated by the government and provide services free to police and prosecutors. Great Britain, however, relies on private laboratories that charge fees for their services and keep any profits they make. Suggest potential strengths and weaknesses of each system.
2. Police investigating an apparent suicide collect the following items at the scene: a note purportedly written by the victim, a revolver bearing very faint fingerprints, and traces of skin and blood under the victim's fingernails. What units of the crime laboratory will examine each piece of evidence?
3. List at least three advantages of having an evidence-collection unit process a crime scene instead of a patrol officer or detective.
4. What legal issue was raised on appeal by the defense in Carl Coppolino's Florida murder trial? What court ruling is most relevant to the decision to reject the appeal? Explain your answer.
5. **A Timeline of Forensic Science** The following images depict different types of evidence or techniques for analyzing evidence. Place the images in order pertaining to the time in history (least recent to most recent) at which each type of evidence or technique was first introduced. Do this using the letters assigned to the images.

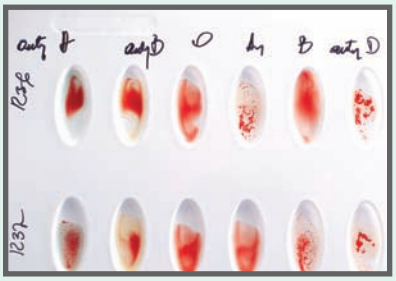
(A)



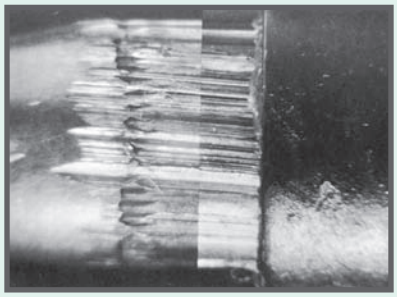
(B)

(C)

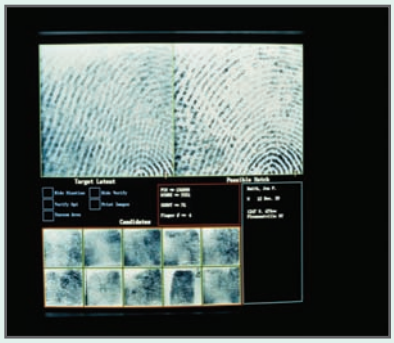
(D)



(E)



(F)



(G)

(A), (B) Dorling Kindersley Media Library; (D) Photolibrary.com; (E) Ikordela/Shutterstock; (F) Getty Images, Inc. - Hulton Archive Photos; (G) Getty Images Inc. - PhotoDisc

6. **Evidence Processing at the Crime Laboratory** You are the evidence technician at the front desk of the state crime lab. You receive the following items of evidence to check in on a very busy day. You must indicate which unit each piece of evidence must be sent to for analysis. Your crime lab has a criminalistics (physical science) unit, a drug unit, a biology unit, a firearms unit, a document examination unit, a toxicology unit, a latent fingerprinting unit, an anthropology unit, and a forensic computer and digital analysis unit.

A.

B.

C.

D.

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H.

I.

J.

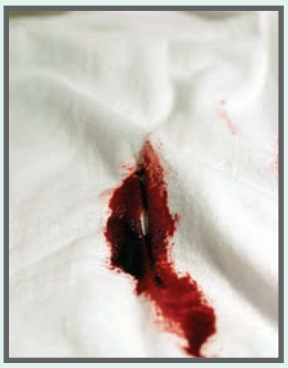
K.

L.

M.


(A)


(B)


(C)

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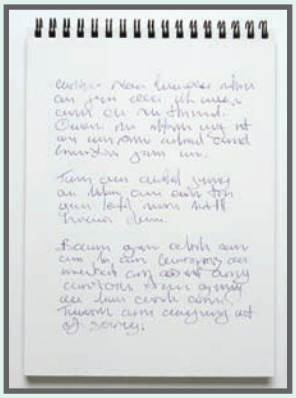
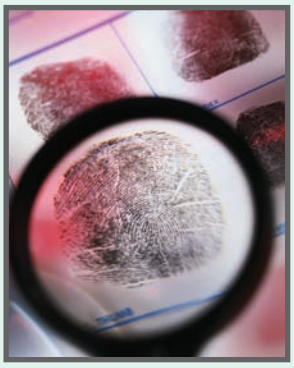

(H)


(I)

(J)


(K)


(L)


(M)

(A) and (E) Getty Images Inc. - Stone Allstock; (B) Michael P. Gadomski/Photo Researchers Inc.; (C) Mikael Karlsson/Arresting Images; (D) German Meneses Photography; (F) Getty Images Inc. - Photodisc/Royalty Free; (G) CORBIS - NY; (H), (J), (M) Dorling Kindersley Media Library; (L) Frank Bean/Getty Images; (I) Alamy Images; (K) Corbis RF

ENDNOTES

1. Two excellent references are André A. Moenssens, Carol E. Henderson, and Sharon Gross Portwood, *Scientific Evidence in Civil and Criminal Cases,* 5th ed. (New York: Foundation Press, 2007); and Werner U. Spitz, ed., *Medicolegal Investigation of Death,* 4th ed. (Springfield, Ill.: Charles C. Thomas, 2006).
2. 293 Fed. 1013 (D.C. Cir. 1923).
3. 509 U.S. 579 (1993).
4. 526 U.S. 137 (1999).
5. 223 So. 2d 68 (Fla. App. 1968), *app. dismissed,* 234 So. 2d (Fla. 1969), *cert. denied,* 399 U.S. 927 (1970).
6. 129 S. Ct. 2527 U.S. Mass., (2009).
7. 541 U.S. 36, 124 S. Ct. 1354, 158 L.Ed. 2d 177 (2004).
8. 564 U.S. 131 S. Ct. 2705, 180 L.Ed. 2d 610 (2011).

Securing and Searching the Crime Scene

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- **Discuss the responsibilities of the first police officer who arrives at the crime scene.**
- **Comprehend the role of the lead investigator in coordinating the crime-scene search.**
- **Describe the conditions at the crime scene that should be given particular notice.**
- **Understand the various search patterns investigators can use to systematically search the crime scene for evidence.**
- **Appreciate the necessity of documenting all initial observations and evidence collected.**

JONBENET RAMSEY: WHO DID IT?

Patsy and John Ramsey were in the upper crust of Boulder, Colorado, society. In the span of five short years, John had built his computer company into a billion-dollar corporation. In addition to financial success, the Ramseys also had a beautiful 6-year-old daughter, JonBenet.

Just after five a.m. on December 26, 1996, Patsy Ramsey awoke and walked downstairs to her kitchen. At the foot of the staircase, she found a two-and-a-half-page note saying that JonBenet had been kidnapped. The note contained a ransom demand of $118,000. When the police arrived to investigate, it was quite apparent that JonBenet was missing.

In retrospect, some serious mistakes were made in securing the crime scene, the Ramsey household. Initially, the police conducted a cursory search of the house but failed to find JonBenet. They did not seal the house off; in fact, four of the Ramseys' friends along with their pastor were let into the home and allowed to move about at will. John was permitted to leave the premises unattended for one and a half hours. One hour after his return, John and two of his friends searched the house again. This time John went down into the basement, where he discovered JonBenet's body. He removed a white blanket from JonBenet and carried her upstairs, placing the body on the living room floor.

The murder of JonBenet Ramsey remains as baffling a mystery today as it was on the first day of its investigation. Ample physical evidence supports both the theory that the crime was committed by an outsider and the competing theory that JonBenet was murdered by someone who resided in the Ramsey household. Perhaps better care at securing and processing the crime scene would have resolved some of the crime's outstanding questions.

Forensic science begins at the crime scene. To be useful to investigators, evidence at a crime scene must be preserved and recorded in its original condition as much as possible. Failure to protect a crime scene properly may result in the destruction or altering of evidence, which can hinder the search for the perpetrator by misleading investigators about the facts of the incident.

Securing the Crime Scene

The first officer to arrive at the scene of a crime is responsible for taking steps to preserve and protect the area to the greatest extent possible. The officer should not let his or her guard down; the scene should always be treated as though the crime were still occurring until it is proved otherwise. Arriving officers should immediately ascertain that the perpetrator is no longer in the immediate area of the crime scene and is not a threat to anyone at or near the crime scene. Special note should be taken of any vehicles or people leaving the scene.

Of course, first priority should be given to obtaining medical assistance for individuals in need of it. If medical assistance is needed, the officer should direct medical workers to approach the body by an indirect route to minimize the possibility of disturbing evidence. This pathway should later be used by investigative personnel for the same reason. The first responding officer must quickly evaluate the victim's condition before the victim is taken to a medical facility. The officer must also record any statements made by the victim and instruct the emergency medical personnel to record any statements the victim makes on the way to the hospital. This information should later be included in notes.

The officer should call for any backup or investigative personnel required and, as soon as possible, detain all potential suspects or witnesses still at the scene. The officer must identify all individuals at the scene, including bystanders and medical personnel. At the same time, he or she should exclude all unauthorized personnel from the scene. This includes family and friends of the victim, who should be shown as much compassion as possible.

The first responder(s) are responsible for establishing the boundaries of the scene to be protected. The boundaries should encompass the center of the scene where the crime occurred, any paths of entry or exit, and any areas where evidence may have been discarded or moved. For indoor scenes this may include anything from a single room to an entire house and yard. The center of the crime scene is usually apparent, and a sufficient area around this spot should be closed off. The boundaries of an outdoor crime scene are more difficult to determine and can span miles, especially if a vehicle is involved. The officer should initially denote the boundaries of the scene using crime-scene tape, ropes, or traffic cones (see Figure 1). As additional officers arrive, investigators should immediately take measures to isolate the area around the taped-off section. Police barricades, along with the strategic positioning of guards, will prevent unauthorized access to the area. Only investigative personnel assigned to the scene should be admitted. The responding officers must keep an accurate log of who enters and exits the scene and the time at which they do so.

Sometimes the exclusion of unauthorized personnel proves to be more difficult than expected. Crimes of violence are especially susceptible to attention by higher-level police officials and members of the media, as well as by emotionally charged neighbors and curiosity seekers. Every individual who enters the scene has the potential to destroy physical evidence, even if by

FIGURE 1 The first investigators to arrive must secure the crime scene and establish a perimeter. This perimeter may be delineated by crime-scene tape, ropes, or barricades. *Courtesy Sirchie Fingerprint Laboratories, Inc., Youngsville, NC, www.sirchie.com*

unintentional carelessness. To exercise proper control over the crime scene, the officer charged with the responsibility for protecting it must have the authority to exclude everyone, including fellow police officers not directly involved in processing the site or in conducting the investigation. Seasoned criminal investigators are always prepared to relate horror stories about crime scenes where physical evidence was rendered totally valueless by hordes of people who, for one reason or another, tramped through the site. Securing and isolating the crime scene are critical steps in an investigation, the accomplishment of which is the mark of a trained and professional crime-scene investigative team. It is also important to park the crime-scene vehicle where it will not destroy evidence but also be secure and easily accessible.

It is worth noting that personnel should *never* do anything while at the crime scene—including smoking, eating, drinking, or littering—that might alter the scene. No aspects of the scene, including a body at a death scene, should be moved or disturbed unless they pose a serious threat to investigating officers or bystanders. This means that no one should open or close faucets or flush toilets at the scene. Also, officers should avoid altering temperature conditions at the scene by adjusting windows, doors, or the heat or air-conditioning.

Quick Review

- The first officer arriving on the scene of a crime has the responsibility to preserve and protect the area to the greatest extent possible.
- First priority should be given to obtaining medical assistance for individuals in need of it.
- Steps must be taken by the first responder to exclude all unauthorized personnel from the scene and keep an accurate log of who enters and exits the scene and the time at which they do so.

Surveying the Crime Scene

Once the scene has been secured, with the help of others, a lead investigator will start the process of evaluating the area. The lead investigator will immediately gain an overview of the situation and develop a strategy for the systematic examination and documentation of the entire crime scene.

THE WALK-THROUGH

walk-through
The initial survey of the crime scene carried out by the lead investigator to gain an overview of the scene in order to formulate a plan for processing the scene.

The initial survey of the scene is typically called the **walk-through**. First, the perpetrator's path of entry and exit should be established. The investigators should then follow an indirect path to the center of the scene, possibly one already established by the first responding officer to allow for medical attention. Some investigators attempt to follow the path of the suspect, but this may destroy possible evidence.

Logic dictates that obvious items of crime-scene evidence will first come to the attention of the crime-scene investigator. The investigator must document and photograph these items. Any fragile evidence, such as shoe and tire impressions, may be secured by the investigator or tagged for the search team. Investigators conducting the first walk-through should carry reflective numbered markers and place a marker near each item of evidence they locate. These markers will alert other crime-scene personnel to the location of difficult-to-observe evidence. The investigators should remember that the crime scene is three-dimensional; evidence may be found on the walls or ceilings as well as on the floor and other surfaces. It may also be practical to have one or two individuals canvas the area outside the barricaded scene.

The investigator should ask the following questions:

- Is the scene indoors or outdoors?
- What is the location of the scene (street address if applicable)?
- What are the weather or temperature conditions?
- In what type of building and neighborhood is the scene located?
- Was there any odor detected by the first responder upon arrival?
- Are doors and windows open or closed, locked or unlocked?
- Given the states of windows and doors, what are possible points of entry and exit?
- Is anything damaged, out of place, or missing? Are there objects that do not appear to belong there?
- Does an object's condition suggest that a struggle took place?
- Are lights and electrical appliances on or off?
- Is food present? Is it in the middle of being prepared, partially eaten, etc.?
- Does this scene appear to involve violence?
- What are the contents of any ashtrays and trash cans at the crime site? Are there tooth marks or lipstick on cigarette butts?
- What is the state of the bathroom? Are towels wet or dry? Is the toilet seat up or down?
- Are there any places where the suspect could have easily and quickly hidden a weapon?
- Is there a vehicle nearby? If so, is the engine hot or cold?

Investigators should take particular note of aspects of the scene that suggest the timing of the incident. For example, if today's newspaper is on the table, it suggests that the incident occurred after the paper was delivered. The investigator's notes should include answers to basic questions and descriptions of everything observed at the scene. These simple observations may prove significant in the later investigation.

The presence or absence of certain evidence can offer key clues to the investigator. For example, objects that appear out of place, such as a child's toy in the house of a couple without children or relatives without children, may be very important. It is also important to observe whether objects that should be at the scene, such as a television or computer, are missing or displaced.

The presence or absence of evidence may also suggest whether the scene is a primary or secondary scene. A **primary scene** is one at which the original incident occurred. The **secondary scene** is a location that became part of the crime by activities after the initial incident, such as using a car to transport a body. If a victim suffered severe injury involving heavy loss of blood but little or no blood is present where the body is found, it is likely to be a secondary scene.

primary scene
A crime scene at which the original criminal act was perpetrated.

secondary scene
A crime scene separate from the primary scene that became part of the crime by its involvement in activities after the initial criminal act was perpetrated.

command center
A secure site outside the boundaries of a crime scene where equipment is stored, tasks are assigned, and communication occurs.

ASSIGNING TASKS

Investigators must establish a center of operations or **command center** at the scene. Here, members of the investigative team receive their assignments, store their equipment, and meet to discuss aspects of the case. The command center must be located outside the taped-off boundary of the scene and contain the basic equipment needed to photograph, sketch, process, and collect evidence. An equipped crime-scene vehicle usually serves the purpose well. If multiple scenes are involved, the command center should also be a center for communicating with investigators at the other scenes.

At the command center, the lead investigator assigns tasks after the initial walk-through. Basic tasks include locating possible evidence, assessing the evidence, processing evidence (e.g., dusting for fingerprints and casting footprints or tire impressions), and photographing and sketching the scene. The tasks should be carried out in this exact order to properly process the scene. The number of personnel assigned to each task depends on the scene and the discretion of the lead investigator. In some cases, a single crime-scene investigator might be required to handle all these tasks.

Quick Review

- The lead investigator is responsible for developing a strategy for the systematic examination and documentation of the entire crime scene.
- The lead investigator must gain an overview of the general setting of the scene. Of particular importance are objects that do not appear to belong or aspects of the scene that may suggest the timing of the incident.
- The presence or absence of evidence may also suggest whether the scene is a primary or secondary scene.
- At the command center, members of the investigative team receive their assignments, store their equipment, congregate to talk about aspects of the case, and communicate with personnel at other crime scenes.

Searching the Crime Scene

There are many methods for searching the scene in a logical and systematic fashion to locate evidence. How one carries out a crime-scene search depends on the locale and size of the area, as well as on the actions of the suspect(s) and victim(s) at the scene. When possible, it is advisable to have one person supervising and coordinating the collection of evidence. Without proper control, the search may be conducted in an atmosphere of confusion with needless duplication of effort. The areas searched must include all probable points of entry and exit used by the criminals. The search team may want to use a simple

flashlight to illuminate surfaces at an oblique angle to reveal latent (hidden) fingerprints, handprints, footwear imprints, and other residues.

TYPES OF SEARCH PATTERNS

line/strip search pattern
A search method used by one or two investigators who walk in straight lines across the crime scene.

LINE/STRIP SEARCH PATTERN In the **line/strip search pattern**, one or two investigators start at the boundary at one end of the scene and walk straight across to the other side. They then move a little farther along the border and walk straight back to the other side (see Figure 2[a]). This method is best used in scenes where the boundaries are well established because the boundaries dictate the beginning and end of the search lines. If the boundary is incorrectly chosen, important evidence may remain undiscovered outside the search area.

grid search pattern
A search method employed by two or more people who perform overlapping line searches forming a grid.

GRID SEARCH PATTERN The **grid search pattern** employs two people performing line searches that originate from adjacent corners and form perpendicular lines (see Figure 2[b]). One searcher will move in a north-south direction while a simultaneous search is conducted in an east-west direction. Both move back and forth as in the line/strip search pattern. This method is very thorough, but the boundaries must be well established.

spiral search pattern
A search method in which the investigator moves in an inward spiral from the boundary to the center of the scene or in an outward spiral from the center to the boundary of a scene.

SPIRAL SEARCH PATTERN The **spiral search pattern** usually employs one person. The investigator moves in an inward spiral from the boundary to the center of the scene or in an outward spiral from the center to the boundary (see Figure 2[c]). The inward spiral method is helpful because the searcher is moving from an area light with evidence to an area where more evidence will most likely be found. Either spiral approach facilitates the location of footprints leading away from the scene in any direction. However, it is often difficult for a searcher to complete a perfect spiral, and evidence could be missed.

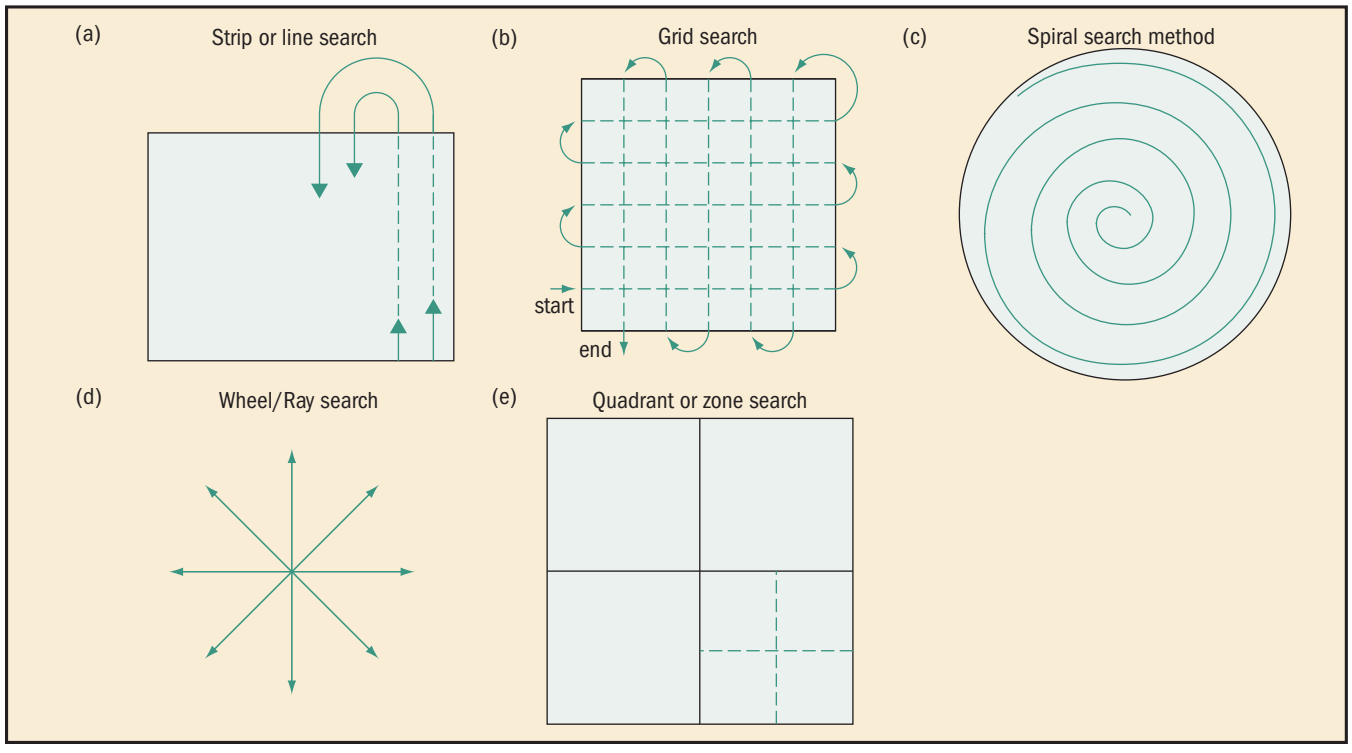


FIGURE 2 (a) Line/strip search pattern; (b) grid search pattern; (c) spiral search pattern; (d) wheel/ray search pattern; (e) quadrant/zone search pattern.

WHEEL/RAY SEARCH PATTERN The **wheel/ray search pattern** employs several people moving from the boundary straight toward the center of the scene (inward) or from the center straight to the boundary (outward). This method is not preferred because the areas between the "rays" are not searched (see Figure 2[d]).

wheel/ray search pattern
A search method employed by several people who move from the boundary straight toward the center of the scene (inward) or from the center straight to the boundary (outward).

QUADRANT/ZONE SEARCH PATTERN The **quadrant/zone search pattern** involves dividing the scene into zones or quadrants, and team members are assigned to search each section. Each of these sections can be subdivided into smaller sections for smaller teams to search thoroughly (see Figure 2[e]). This method is best suited for scenes that cover a large area.

quadrant/zone search pattern
A search method in which the crime scene is divided into smaller sections (zones or quadrants) and team members are assigned to search each section. Each of these sections can be subdivided into smaller sections for smaller teams to search thoroughly.

VEHICLE SEARCHES If the scene includes a vehicle, the vehicle search must be carefully planned and systematically carried out. The nature of the case determines how detailed the search must be. At all times investigators must be careful to avoid contact with surfaces that may contain fingerprints such as a steering wheel or door handle. In hit-and-run cases, the outside and undercarriage of the car must be examined with care. In this case the vehicle itself is the "weapon." Particular attention is paid to looking for any evidence resulting from a cross-transfer of evidence between the car and the victim; this includes blood, tissue, hair, fibers, and fabric impressions. Traces of paint or broken glass may be located on the victim or roadway. In a vehicle burglary or theft, the search focuses on the place of entry. Tool marks and fingerprints usually are important in these cases. If the car was used for transportation, more attention may be given to the interior of the car. However, all areas of the vehicle, inside and outside, should be searched with equal care for physical evidence at the scene, or the vehicle may be towed to a police department garage.

NIGHT SEARCHES Searches during the night are especially difficult. Indoors, artificial lights frequently can be used. However, it can be very difficult outdoors even to determine the boundaries of the scene. When possible, the scene should be taped off, left undisturbed, and guarded until daylight. If impending weather or other circumstances do not allow for waiting until daylight, a perimeter must be estimated and floodlights should be set up for the search.

LOCATING EVIDENCE

The purpose of the crime-scene search is to locate physical evidence. What to search for will be determined by the particular circumstances of the crime. This may include footprints, weapons, blood spatter, objects possibly touched by the suspect, trace fibers, or hairs. For example, in the case of homicide, the search will be centered on the weapon and any type of evidence left as a result of contact between the victim and the assailant. The cross-transfer of evidence, such as hairs, fibers, and blood, between individuals involved in the crime is particularly useful for linking suspects to the crime site and for corroborating events that transpired during the commission of the crime. Special attention should be paid to the body and the area surrounding it. During the investigation of a burglary, officers should attempt to locate tool marks at the point of entry. In most crimes, a thorough and systematic search for latent fingerprints is required. When an investigator finds an object of possible evidentiary value, he or she should record its location in notes, sketches, and photographs and then mark its location with an evidence marker (see Figure 3).

The search ends when the team or lead investigator determines that all pertinent evidence has been located to the best of the team's ability. When this determination is made, the team carries out a final survey of the scene. This should include a visual overview of all parts of the scene. Investigators should take an inventory of all evidence collected so nothing is lost or left behind.

FIGURE 3 Numbered evidence markers are used to show the location of (1) a firearm, (2) a beverage can, and (3) another beverage can at a crime scene. *Courtesy Sirchie Fingerprint Laboratories, Inc., Youngsville, NC, www.sirchie.com*

The team members should be sure to retrieve all equipment. They should also verify that any threats to health or safety at the scene have been or will be dealt with properly. Once all of these measures have been taken, the scene can be released to the proper authorities.

Obviously, the skill of crime-scene investigators at recognizing evidence and searching relevant locations is paramount to successfully processing the crime scene. Although training can impart general knowledge about conducting a proper crime-scene investigation, ultimately the investigator must rely on experience gained from numerous investigations to formulate a successful strategy for recovering relevant physical evidence at crime scenes. If the investigator cannot recognize physical evidence or cannot properly preserve it for laboratory examination, no amount of sophisticated laboratory instrumentation or technical expertise can salvage the situation.

The know-how for conducting a proper crime-scene search for physical evidence is not beyond the grasp of any police department, regardless of its size. With proper training, police agencies can ensure they competently process crime scenes. In many jurisdictions, however, police agencies have delegated this task to a specialized team of technicians known as crime-scene investigators.

WebExtra 1

Autopsy of a Murder
Search for clues at the scene of a murder. Once you've located the relevant evidence, you will need to collect the evidence for laboratory testing.
www.mycrimekit.com

Quick Review

- How one carries out a crime-scene search will depend on the locale and size of the area, as well as on the actions of the suspect(s) and victim(s) at the scene.
- The purpose of the crime-scene search is to locate physical evidence. The particular circumstances of the crime determine what to search for first.

- When evidence is found, the location is documented in notes, photographs, and sketches.
- When the search is deemed complete, the investigating team conducts a final survey that includes a visual overview of all parts of the scene, an inventory of all evidence collected, the retrieval of all equipment, and the neutralization of all health or safety threats. Once all of these measures have been taken, the scene can be released to the proper authorities.

CHAPTER REVIEW

- The first officer arriving on the scene of a crime has the responsibility to preserve and protect the area to the greatest extent possible.
- First priority should be given to obtaining medical assistance for individuals in need of it.
- Steps must be taken by the first responder to exclude all unauthorized personnel from the scene and keep an accurate log of who enters and exits the scene and the time at which they do so.
- The lead investigator is responsible for developing a strategy for the systematic examination and documentation of the entire crime scene.
- The lead investigator must gain an overview of the general setting of the scene. Of particular importance are objects that do not appear to belong or aspects of the scene that may suggest the timing of the incident.
- The presence or absence of evidence may also suggest whether the scene is a primary or secondary scene.
- At the command center, members of the investigative team receive their assignments, store their equipment, congregate to talk about aspects of the case, and communicate with personnel at other crime scenes.
- How one carries out a crime-scene search will depend on the locale and size of the area, as well as on the actions of the suspect(s) and victim(s) at the scene.
- The purpose of the crime-scene search is to locate physical evidence. The particular circumstances of the crime determine what to search for first.
- When evidence is found, the location is documented in notes, photographs, and sketches.
- When the search is deemed complete, the investigating team conducts a final survey that includes a visual overview of all parts of the scene, an inventory of all evidence collected, the retrieval of all equipment, and the neutralization of all health or safety threats. Once all of these measures have been taken, the scene can be released to the proper authorities.

KEY TERMS

command center
grid search pattern
line/strip search pattern
primary scene
quadrant/zone search pattern
secondary scene
spiral search pattern
walk-through
wheel/ray search pattern

REVIEW QUESTIONS

1. True or False: Failure to protect a crime scene properly may result in the destruction or altering of evidence. _____
2. The _____ arriving on the scene of a crime is responsible for taking steps to preserve and protect the area to the greatest extent possible, and he or she must rely on his or her training to deal with any violent or hazardous circumstances.
3. At a crime scene, first priority should be given to obtaining _____ for individuals in need of it and attempting to minimize the disturbance of evidence.
4. All unauthorized personnel must be _____ from crime scenes.
5. True or False: The boundaries of the crime scene, denoted by crime-scene tape, rope, or traffic cones, should encompass only the center of the scene where the crime occurred. _____
6. Even though all unauthorized personnel are not admitted to the scene, a very accurate _____ must be kept of those who do enter and exit the scene and the time at which they do so.

7. True or False: The lead investigator immediately proceeds to gain an overview of the situation and develop a strategy for the systematic examination of the crime scene during the final survey. _____
8. A(n) _____ crime scene is one at which the original incident, such as a beating or rape, occurred. A(n) _____ crime scene became part of the crime as a result of activities that occurred after the initial incident.
9. The investigative team receives assignments, stores equipment, and congregates to talk about aspects of the case at the _____.
10. A detailed search of the crime scene must be conducted in a(n) _____ fashion.
11. The crime-scene search is undertaken to locate _____.
12. True or False: The search patterns that may be used to search a crime scene for evidence include the line pattern, grid pattern, polar coordinate pattern, and spiral pattern. _____
13. When carrying out vehicle searches, investigators must be careful to avoid contact with surfaces that may contain _____ such as steering wheels or door handles.
14. True or False: During nighttime, outdoor scenes should be taped off, left undisturbed, and guarded until daylight. _____
15. True or False: The search is concluded when the district attorney determines that all pertinent evidence has been located to the best of the team's ability. _____
16. Once a(n) _____ of the scene has been carried out, the scene can be released to the proper authorities.
17. True or False: If the investigator does not recognize physical evidence or does not properly preserve it for laboratory examination, sophisticated laboratory instrumentation or technical expertise can salvage the situation and attain the desired results. _____

APPLICATION AND CRITICAL THINKING

1. You are the first officer at the scene of an outdoor assault. You find the victim bleeding but conscious, with two of the victim's friends and several onlookers standing nearby. You call for backup and quickly glance around but see no one fleeing the scene. Describe the steps you would take while you wait for backup to arrive.
2. What kind of search pattern(s) would investigators be most likely to employ in each of the following situations:
   a) Two people searching a small area with well-defined boundaries
   b) Several people searching a large area
   c) A single person searching a large area
3. Officer Bill Walter arrives at the scene of an apparent murder: a body bearing several gunshot wounds lies on the floor of a small, un-air-conditioned house in late July. A pungent odor almost overwhelms him when he enters the house, so he opens a window to allow him to breathe so he can investigate the scene. While airing out the house, he secures the scene and interviews bystanders. When he inspects the scene, he discovers very little blood in the room and little evidence of a struggle. What mistake did Officer Walter make in his investigation? What conclusion did he draw about the scene from his observations?

CASE ANALYSIS

Investigators looking into the kidnapping and murder of DEA special agent Enrique Camarena and DEA source Alfredo Zavala faced several hurdles that threatened to derail their efforts to collect evidence in the case. These hurdles almost prevented forensics experts from determining the facts of the case and threatened to undermine the investigation of the crime. However, despite these obstacles, use of standard forensic techniques eventually enabled investigators to solve the case. Read about the Camarena case in the following Case Reading, then answer the following questions:

1. What were the main challenges facing investigators who were collecting evidence in the case? Give specific examples.
2. Explain how investigators used reference samples to determine that the victims had been held at the residence located at 881 Lope De Vega.
3. Explain how investigators used soil evidence to determine that the victims' bodies had been buried and later moved to the site where they were discovered.

CASE READING

THE ENRIQUE CAMARENA CASE: A FORENSIC NIGHTMARE

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On February 7, 1985, US Drug Enforcement Agency (DEA) Special Agent (SA) Enrique Camarena was abducted near the US Consulate in Guadalajara, Mexico. A short time later, Capt. Alfredo Zavala, a DEA source, was also abducted from a car near the Guadalajara Airport. These two abductions would trigger a series of events leading to one of the largest investigations ever conducted by the DEA and would result in one of the most extensive cases ever received by the FBI Laboratory . . .

THE ABDUCTION

On February 7, 1985, SA Camarena left the DEA resident office to meet his wife for lunch. On this day, a witness observed a man being forced into the rear seat of a light-colored compact car in front of the Camelot Restaurant and provided descriptions of several of the assailants. After some initial reluctance, Primer Comandante Pavon-Reyes of the Mexican Federal Judicial Police (MFJP) was put in charge of the investigation, and Mexican investigators were assigned to the case. Two known drug traffickers, Rafael Caro-Quintero and Ernesto Fonseca, were quickly developed as suspects . . .

THE INVESTIGATION

During February 1985, searches of several residences and ranches throughout Mexico proved fruitless, despite the efforts of the DEA task force assigned to investigate this matter and the tremendous pressure being applied by the US government to accelerate the investigation. High-level US government officials, as well as their Mexican counterparts, were becoming directly involved in the case. It is believed that, because of this "heat," the Mexican drug traffickers and certain Mexican law enforcement officials fabricated a plan. According to the plan, the MFJP would receive an anonymous letter indicating that SA Camarena and Captain Zavala were being held at the Bravo drug gang's ranch in La Angostura, Michoacan, approximately 60 miles southeast of Guadalajara. The MFJP was supposed to raid the ranch, eliminate the drug gang, and eventually discover the bodies of SA Camarena and Captain Zavala buried on the ranch. The DEA would then be notified and the case would be closed. Thus, the Bravo gang would make an easy scapegoat.

During early March, MFJP officers raided the Bravo ranch before the DEA agents arrived. In the resulting shootout, all of the gang members, as well as one MFJP officer, were killed. However, due to a mix-up, the bodies of SA Camarena and Captain Zavala were not buried on the Bravo ranch in time to be discovered as planned. Shortly after this shootout, a passerby on a road near the Bravo ranch found two partially decomposed bodies wrapped in plastic bags. The bodies were removed and transported to a local morgue, where they were autopsied. The DEA was then advised of the discovery of the bodies and their subsequent removal to another morgue in Guadalajara, where a second autopsy was performed.

Cadaver number 1 was quickly identified by the fingerprint expert as SA Camarena. Although Mexican officials would not allow the second body to be identified at this time, it was later identified through dental records as Captain Zavala.

Undated photo of Enrique Camarena. *AP Wide World Photos*

Reprinted in part from *FBI Law Enforcement Bulletin,* September 1989.

The FBI forensic team requested permission to process the clothing, cordage, and burial sheet found with the bodies, but the request was denied. However, they were allowed to cut small, "known" samples from these items and obtain hair samples from both bodies. Soil samples were also removed from the bodies and the clothing items. FBI and DEA personnel proceeded to the Bravo ranch, where the bodies were initially found. Because this site had been a completely uncontrolled crime scene, contaminated by both police personnel and onlookers, only a limited crime scene search was conducted. It was immediately noted that there was no gravesite in the area and that the color of the soil where the bodies had been deposited differed from the soil that had been removed from the bodies. Therefore, "known" soil samples from the drop site were taken to compare with soil removed from the victims. It was also noted that there were no significant body fluids at the "burial" site. This led the forensic team to conclude that the bodies had been buried elsewhere, exhumed, and transported to this site.

In late March 1985, DEA agents located a black Mercury Grand Marquis that they believed was used in the kidnapping or transportation of SA Camarena. The vehicle had been stored in a garage in Guadalajara, and a brick wall had been constructed at the entrance to conceal it. The vehicle was traced to a Ford dealership owned by Caro-Quintero. Under the watchful eye of the MFJP at the Guadalajara Airport, the FBI forensic team processed the vehicle for any hair, fiber, blood, and/or fingerprint evidence it might contain.

During April 1985, the MFJP informed the DEA that they believed they had located the residence where SA Camarena and Captain Zavala had been held. The FBI forensic team was immediately dispatched to Guadalajara; however, they were not allowed to proceed to the residence, located at 881 Lope De Vega, until an MFJP forensic team had processed the residence and had removed all of the obvious evidence.

On the first day after their arrival, the FBI forensic team surveyed and began a crime-scene search of the residence and surrounding grounds (see Figure 1). The residence consisted of a large, two-story structure with a swimming pool, covered patio, aviary, and tennis court surrounded by a common wall. The most logical place to hold a prisoner at this location would be in the small outbuilding located to the rear of the main residence. This outbuilding, designated as the "guest house" by investigators, consisted of a small room with a beige rug and an adjoining bathroom. The entire room and bathroom were processed for hairs, fibers, and latent fingerprints. The single door into this room was made of steel and reinforced by iron bars. It was ultimately determined by means of testimony and forensic evidence that several individuals interrogated and tortured SA Camarena in this room. In addition, a locked bedroom, located on the second floor of the main house, was also processed, and the bed linens were removed from a single bed. Known carpet samples were taken from every room in the residence.

A beige Volkswagen Atlantic parked under a carport at the rear of the residence fit the general description of the smaller vehicle noted by the witness to SA Camarena's abduction. The VW Atlantic was also processed for hairs, fibers, and fingerprints.

On the second day, a thorough grounds search was conducted. As FBI forensic team members were walking around the tennis court, they caught a glimpse of something blue in one of the drains. On closer inspection, there appeared to be a folded license plate at the bottom of the drain. The license plate was retrieved, unfolded, and photographed. The MFJP officers, all of whom were now at the tennis court, became upset at this discovery, and one of them immediately contacted his superior at MFJP headquarters, who ordered them to secure the license plate until the assistant primer comandante arrived on the scene. Upon his arrival approximately 20 minutes later, he seized the license plate and would not allow the Americans to conduct any further searches.

In September 1985, DEA personnel went to La Primavera Park and recovered a soil sample. This sample matched the soil samples from SA Camarena and Captain Zavala's cadavers almost grain for grain, which indicated that this site was almost certainly their burial site before they were relocated to the Bravo ranch.

Later that fall, after further negotiations between the US and the Mexican governments, permission was finally granted for an FBI forensic team to process the evidence seized by the MFJP forensic team from 881 Lope De Vega the previous April. The evidence consisted of small samples the MFJP had taken of SA Camarena's burial sheet, a piece of rope used to bind SA Camarena, a portion of a pillowcase removed from bedroom number 3, a piece of unsoiled rope removed from the covered patio, and a laboratory report prepared by the MFJP Crime Laboratory. The remainder of the evidence had been destroyed for "health reasons."

In January 1986, a drug trafficker named Rene Verdugo, who was considered to be a high-ranking member of the Caro-Quintero gang, was apprehended and taken to San Diego, where he was arrested by the DEA. He was then transported to Washington, D.C., where samples of his hair were taken. He refused to testify before the federal grand jury investigating the Camarena case. Later that year, DEA personnel obtained hair samples in Mexico City from Sergio Espino-Verdin, a former federal comandante who is believed to have been SA Camarena's primary interrogator during his ordeal at 881 Lope De Vega.

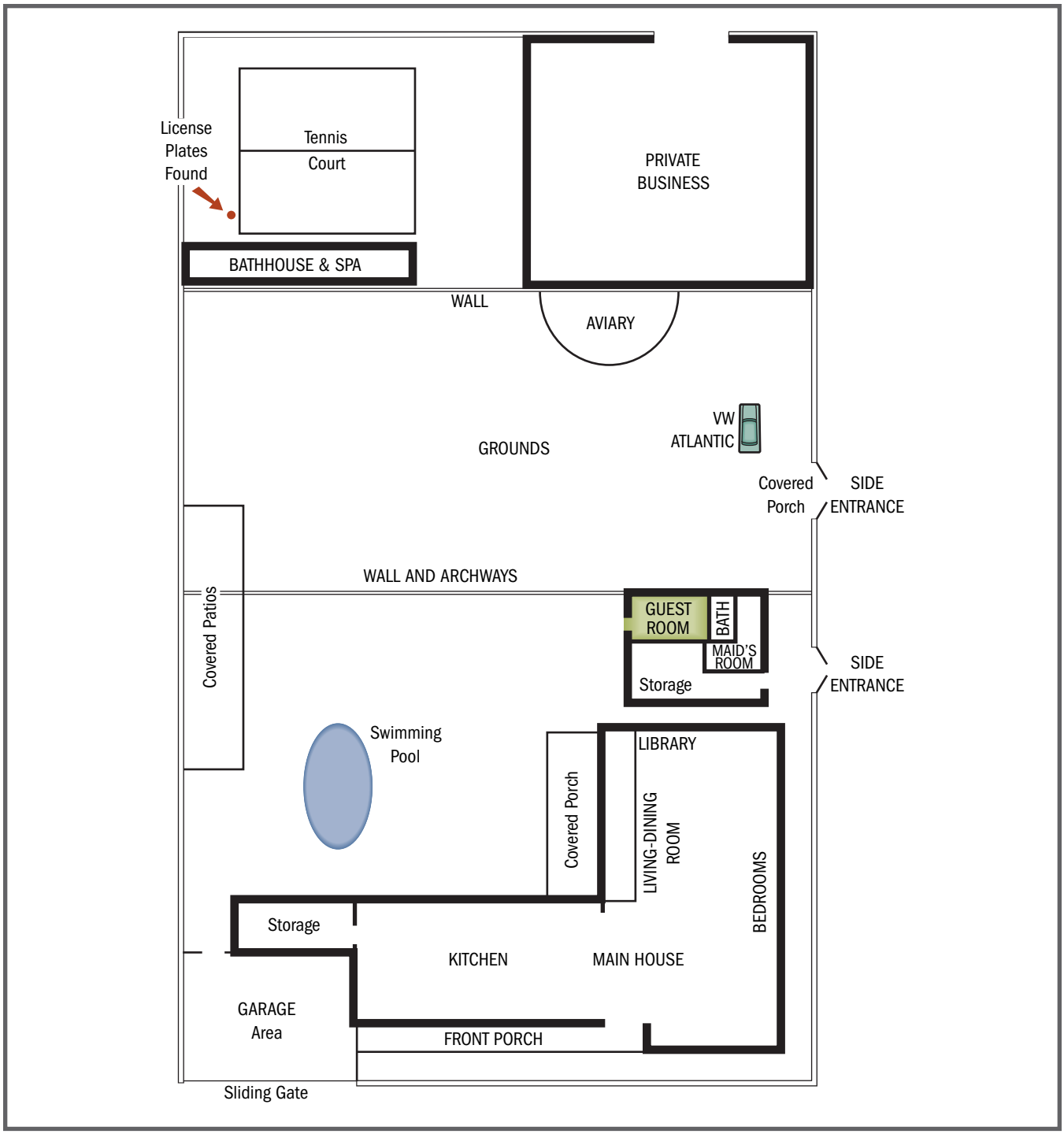

FIGURE 1 A diagram of the 881 Lope De Vega grounds. Camarena was held prisoner in the guest house. *FBI Law Enforcement Bulletin, September, 1989.*

THE TRIAL

In July 1988, the main trial for the murder, interrogation, and abduction of SA Camarena began in US District Court in Los Angeles, California. The forensic evidence presented in this trial identified 881 Lope De Vega as the site where SA Camarena had been held. The evidence also strongly associated two Mexican citizens, Rene Verdugo and Sergio Espino-Verdin, with the "guest house" at 881 Lope De Vega. Several types of forensic evidence were used to associate SA Camarena with 881 Lope De Vega: forcibly removed head hairs found in the "guest house" and bedroom number 4, in the VW Atlantic, and in the Mercury Grand Marquis, and two types of polyester rug

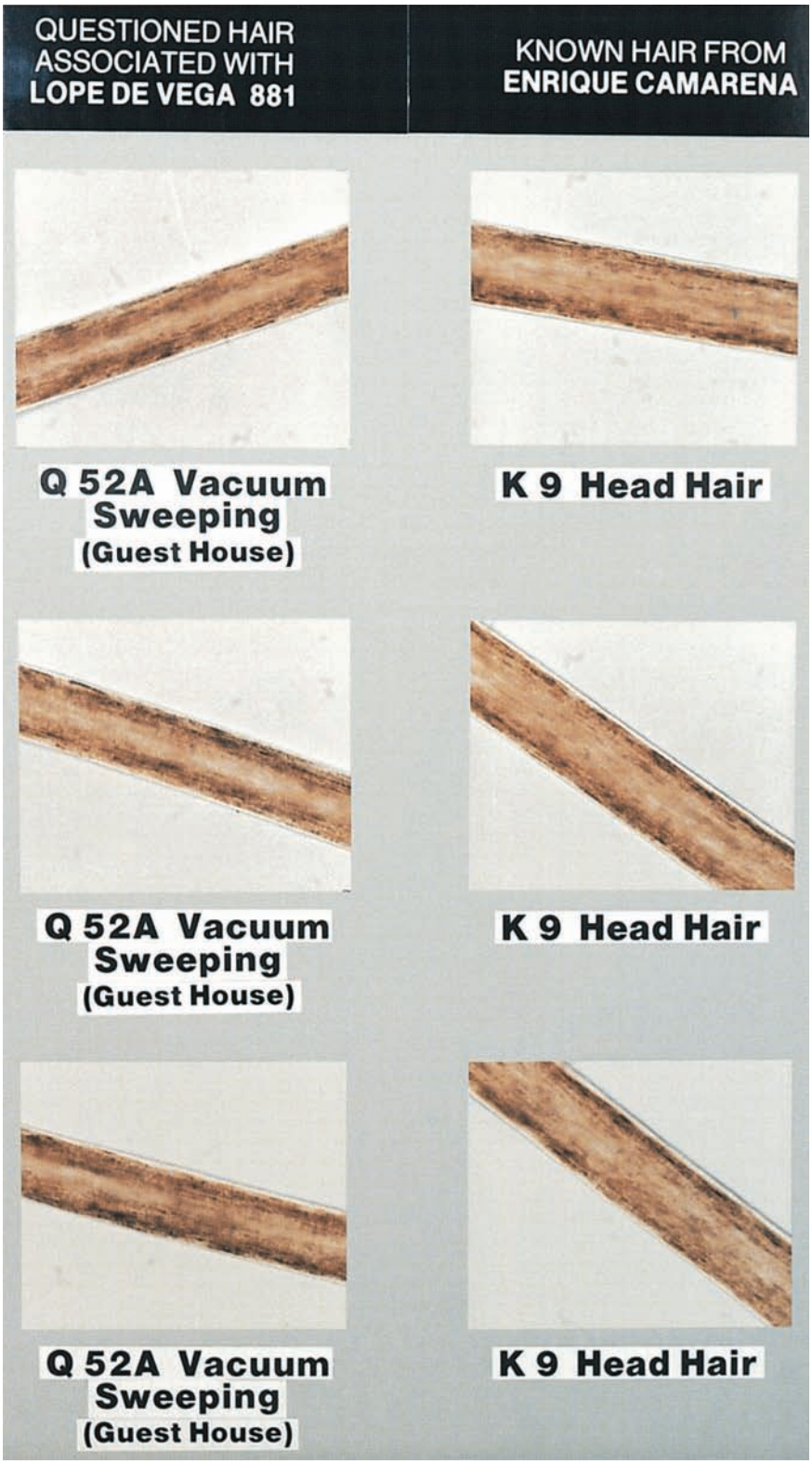

FIGURE 2 A trial chart showing hair comparisons between known Camarena hairs and hairs recovered from 881 Lope De Vega. *FBI Law Enforcement Bulletin, September, 1989.*

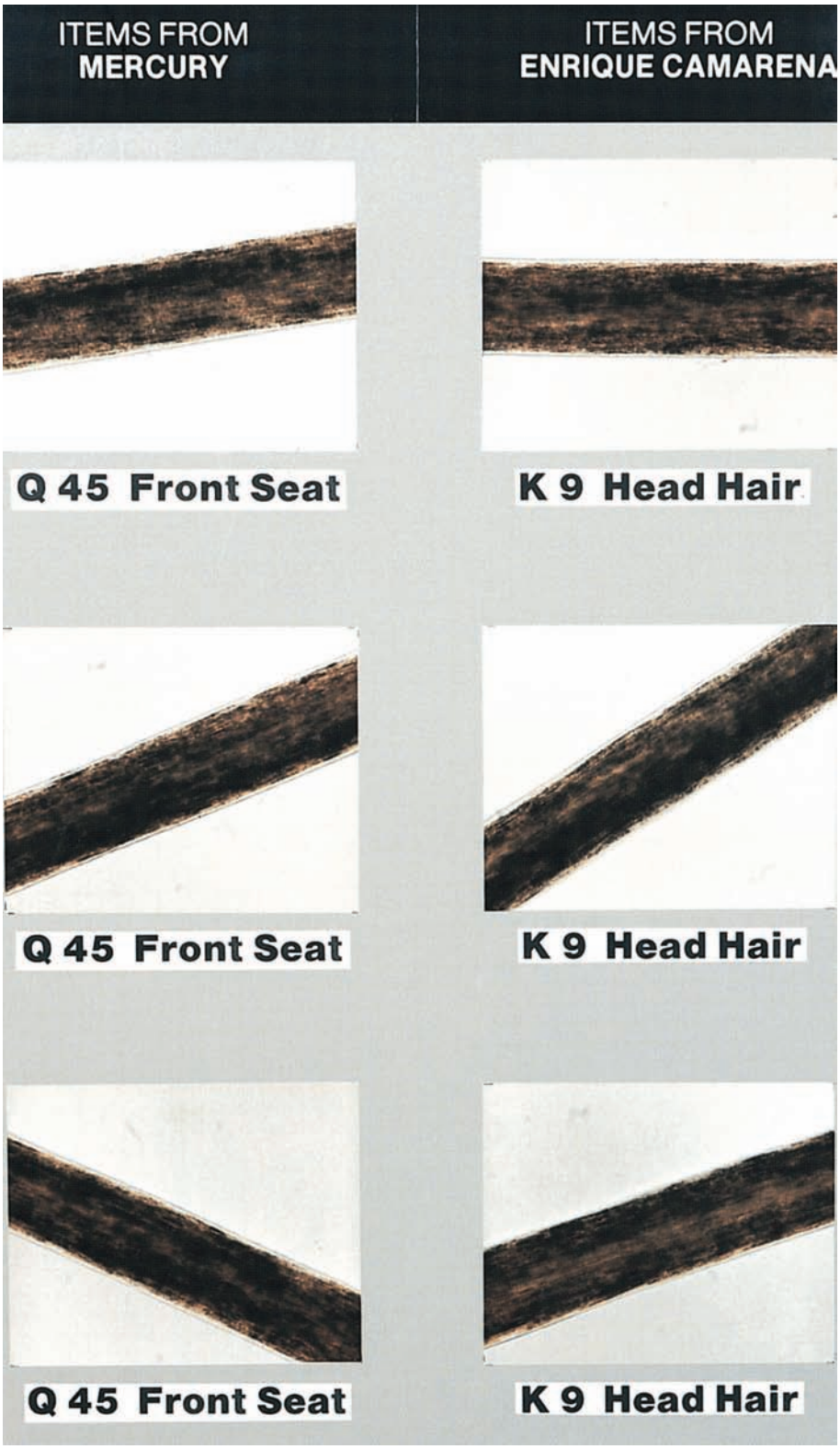

FIGURE 3 A trial chart showing hair comparisons between known Camarena hairs and hairs recovered from the Mercury Grand Marquis. *FBI Law Enforcement Bulletin, September, 1989.*

fibers: a dark, rose-colored fiber and a light-colored fiber (see Figures 2 and 3). Fabric evidence was also presented, which demonstrated the similarities of color, composition, construction, and design between SA Camarena's burial sheet and the two pillowcases recovered from bedrooms number 3 and 5.

Based on this evidence associating SA Camarena and 881 Lope De Vega, the FBI Laboratory examiner was able to testify that SA Camarena was at this residence, as well as in the VW Atlantic and the Mercury Grand Marquis, and that he had been in a position such that his head hairs were forcibly removed. Captain Alfredo Zavala was also found to be associated with the "guest house" at 881 Lope De Vega. Light-colored nylon rug fibers found on samples of his clothing taken at the second autopsy matched the fibers from the "guest house" carpet.

A detailed model of the residence at 881 Lope De Vega was prepared by the Special Projects Section of the FBI Laboratory for the trial (see Figure 4). Over twenty trial charts were also prepared to explain the various types of forensic evidence. These charts proved invaluable in clarifying the complicated techniques and characteristics used in the examination of the hair, fiber, fabric, and cordage evidence (see Figure 5).

CONCLUSION

After an eight-week trial, conducted under tight security and involving hundreds of witnesses, all of the defendants were found guilty and convicted on all counts, and are currently serving lengthy sentences.

FIGURE 4 A model of 881 Lope De Vega prepared as a trial exhibit. *FBI Law Enforcement Bulletin, September, 1989.*

CATEGORIES OF FORENSIC EVIDENCE
IN CAMARENA CASE

	TYPE OF EVIDENCE					
LOCATION	*Hair*	*Carpet Fibers*	*Fabric Match*	*Cordage Match*	*Tape Match*	*Misc.*
Mercury	**Camarena Head Hair**					Blood on Floor Mat
VW Atlantic	**Camarena Head Hair**					Blood on Tissue
Guest House	**Camarena Head Hair**	Zavala Clothes Nylon				
Bedroom #3		Camarena Blindfold Polyester	Pillow Case Camarena Burial Sheet			
Bedroom #4	**Camarena Head Hair**	Camarena Blindfold & Burial Sheet Polyester				
Bedroom #5			Pillow Case Camarena Burial Sheet			
Tennis Court						License Plate VW/Merc.
Camarena Burial Sheet	**Camarena Head Hair**	Bedroom #4 Polyester	Pillow Case Bedrooms #3 and #5			Soil La Primavera
Source — Blindfold/ Rope	**Camarena Head Hair**	Bedrooms #3 and #4 Polyester			Camarena Blindfold Tape	
Camarena Burial Cordage				Burial Rope from Covered Patio		
Zavala Clothing	**Zavala Head Hair**	Guest House Nylon				Soil La Primavera

FIGURE 5 A trial chart used to show the association of Camarena and Zavala with various locations. *FBI Law Enforcement Bulletin, September, 1989.*

Recording the Crime Scene