

## Learning Objectives

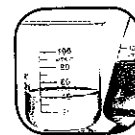
After studying this chapter you should be able to:

- Define forensic science and list the major disciplines it encompasses
- Recognize the major contributors to the development of forensic science
- Account for the rapid growth of forensic laboratories in the past 40 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
- Learn where to search for information about forensic science on the Internet

## National Science Content Standards



Scientific Inquiry



Physical Science



Life Science

## Ted Bundy, Serial Killer

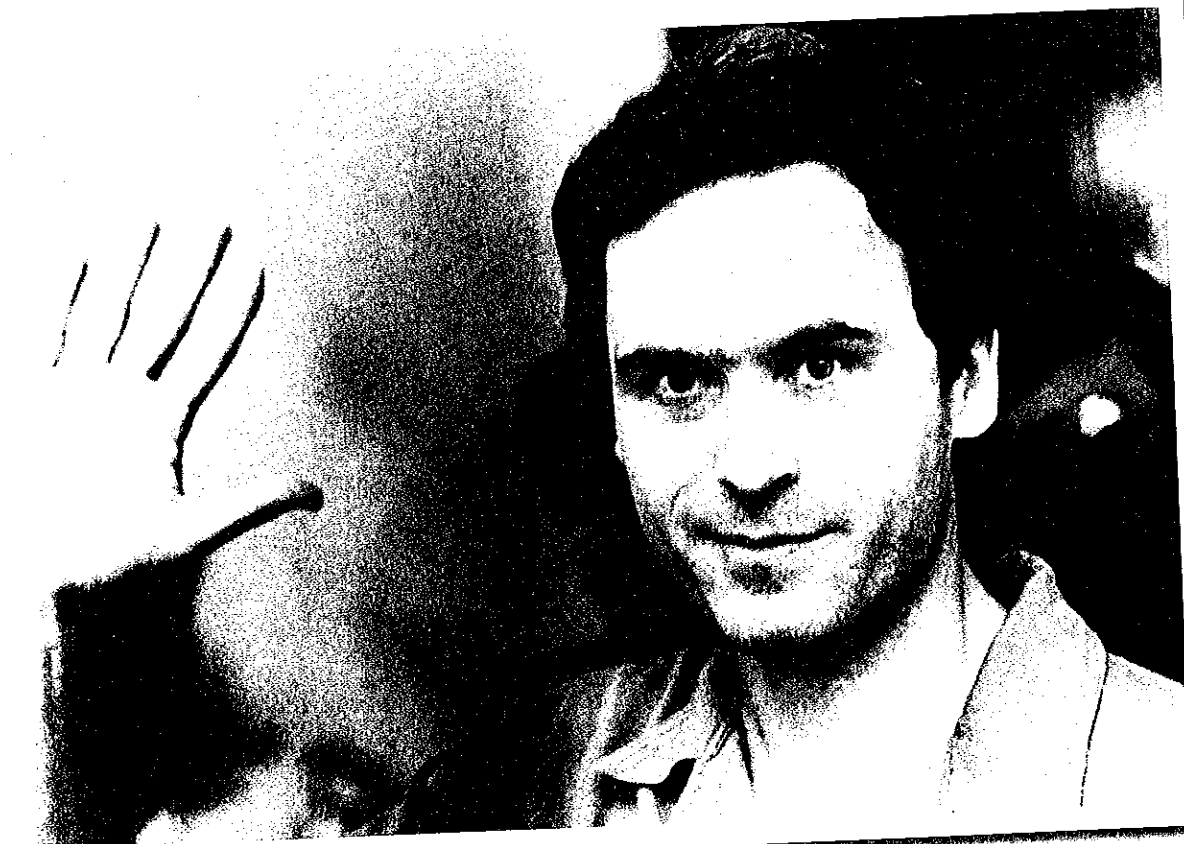
The name Ted Bundy is synonymous with the term serial killer. This handsome, gregarious, and worldly onetime law student is believed to be responsible for 40 murders between 1964 and 1978. His reign of terror stretched from the Pacific Northwest down to California and into Utah, Idaho, and Colorado, finally ending in Florida. His victims were typically young women, usually murdered with a blunt instrument or by strangulation, and sexually assaulted before and after death.

First convicted in Utah in 1976 on a charge of kidnapping, Bundy managed to escape after his extradition to Colorado on a murder charge. Ultimately, Bundy found his way to the Tallahassee area of Florida. There he unleashed mayhem, killing two women at a Florida State University sorority house and then murdering a 12-year-old girl three weeks later. Fortunately, future victims were spared when Bundy was arrested while driving a stolen vehicle. As police investigated the sorority murders, they noted that one victim, who had been beaten over the head with a log, raped, and strangled, also had bite marks on her left buttock and breast.

Supremely confident that he could beat the sorority murder charges, the arrogant Bundy insisted on acting as his own attorney. His unfounded optimism was shattered in the courtroom when a forensic odontologist matched the bite mark on the victim's buttock to Bundy's front teeth. Bundy was ultimately executed in 1989.

# Introduction

# 1



## Key Terms

expert witness  
Locard's exchange principle  
scientific method

## 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 any food and 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 contents of this book will attest, 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 that reflects the events that have occurred at a crime. A good deal of work remains to be done if the full potential of science as applied to criminal investigations is to be realized.

Considering the vast array of civil and criminal laws that regulate society, forensic science, in its broadest sense, has become so comprehensive a subject as to make a meaningful introductory textbook treatment of its role and techniques most difficult, if not overwhelming. For this reason, we must find practical limits that narrow the scope of the subject. Fortunately, common usage provides us with such a limited 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 help law enforcement officials conduct their investigations.

The diversity of professions practicing forensic science is illustrated by the 11 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 Sciences
10. Questioned Documents
11. Toxicology

Even within the limited definition just presented, we will restrict our discussion in this book to only the areas of chemistry, biology, physics, geology, and computer technology, which are useful for determining the evidential value of crime-scene and related evidence, omitting any references to medicine and law. Forensic pathology, psychology, anthropology, and odontology 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, except for brief discussions, these subjects go beyond the intended range of this book, and the reader is referred elsewhere for discussions of their applications and techniques.<sup>1</sup> Instead, we will attempt to focus 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. The two terms will be used interchangeably in this text. Regardless of 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 1-1](#)). However, by simplifying scientific procedures to fit into the available airtime, these shows have created unrealistic expectations of forensic science skills within both the public and the legal community. 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 delegated to different people in different parts of the criminal justice system. Procedures that could take days, weeks, months, or years in reality appear on these shows to take mere minutes. This false image is especially relevant to 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 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.

## 6 Chapter 1

**FIGURE 1-1**  
Scene from *CSI*, a  
forensic science  
television show.  
Courtesy Picture Desk,  
Inc./Kobal Collection



## 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 used close observation of 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.

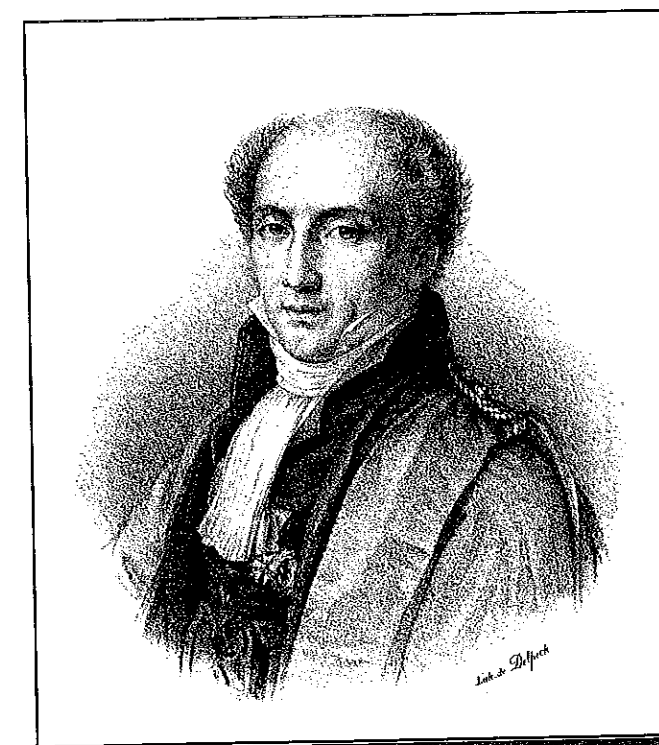
One of the earliest records of applying forensics to solve criminal cases comes from third-century China. A manuscript titled *Yi Yu Ji* (*A Collection of Criminal Cases*) reports how a coroner solved a case in which a woman was suspected of murdering her husband and burning the body, then claiming that 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 17th and early 18th 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 that work also did not recognize their potential as a form of identification.

*Handwritten text from a manuscript, likely related to the history of forensic science.*

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.

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 on the detection of arsenic in a victim's body. During the 1850s and 1860s, the new science of photography was also used in forensics, recording images of prisoners and crime scenes.



**FIGURE 1-2** Mathieu Orfila.  
Courtesy The Granger Collection, New York

### Late 19th Century Progress

By the late 19th 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 systematic procedure that involved taking a series of body 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, before being replaced by fingerprinting in the early 1900s. Bertillon's early efforts earned him the distinction of being known as the father of criminal identification.

Bertillon's anthropometry, however, would soon be supplanted by the more reliable method of identification by fingerprinting. Two years before the publication of Bertillon's system, the U.S. microscopist Thomas Taylor 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, the Englishman Francis Henry Galton 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 his method of personal identification. His work went on to describe the basic principles that form the 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 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 19th-century forensics was not a real person, but a fictional character, the legendary detective Sherlock Holmes. 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 first applied 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 in the following quote, Holmes probes and recognizes the potential usefulness of forensic serology to criminal investigation.

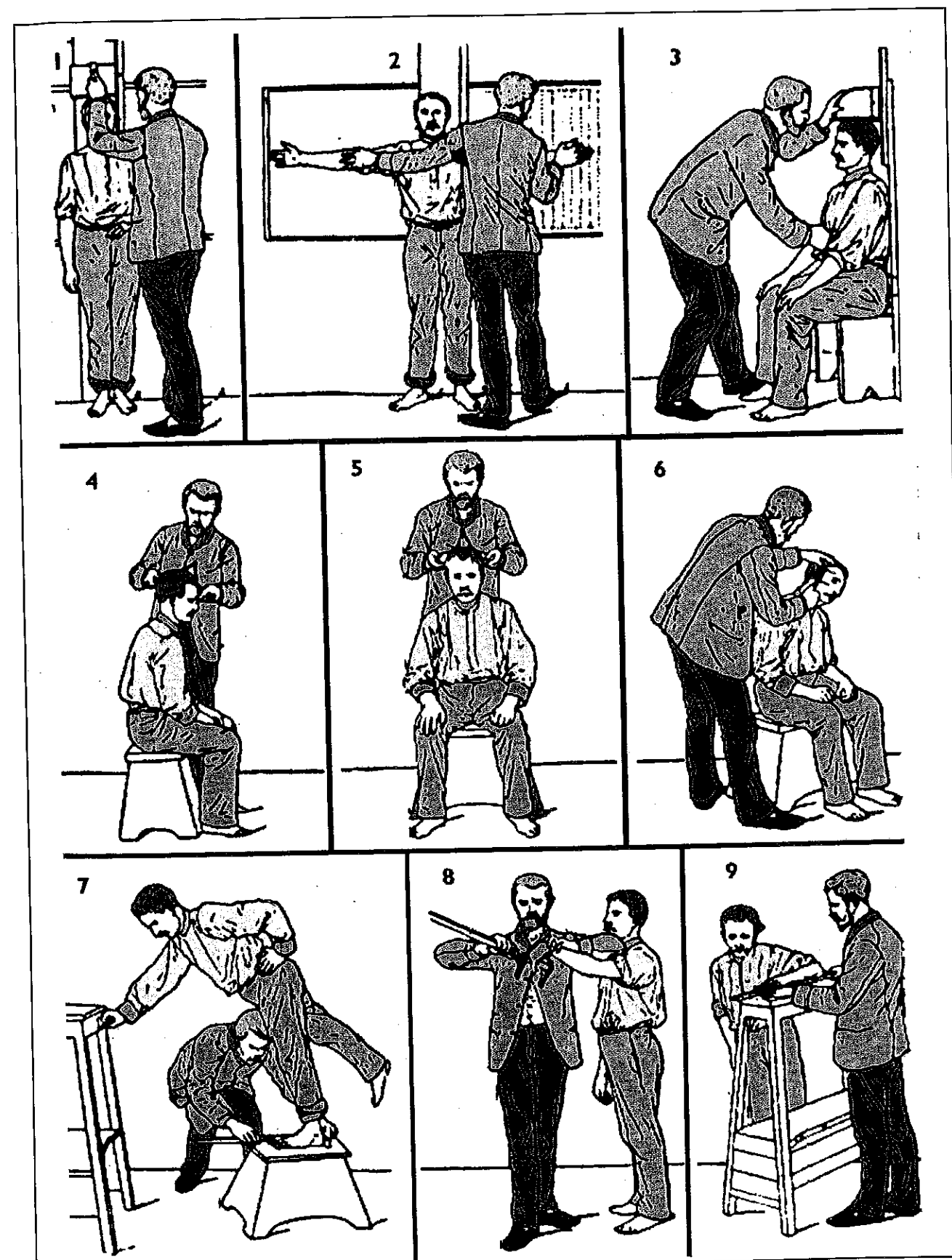
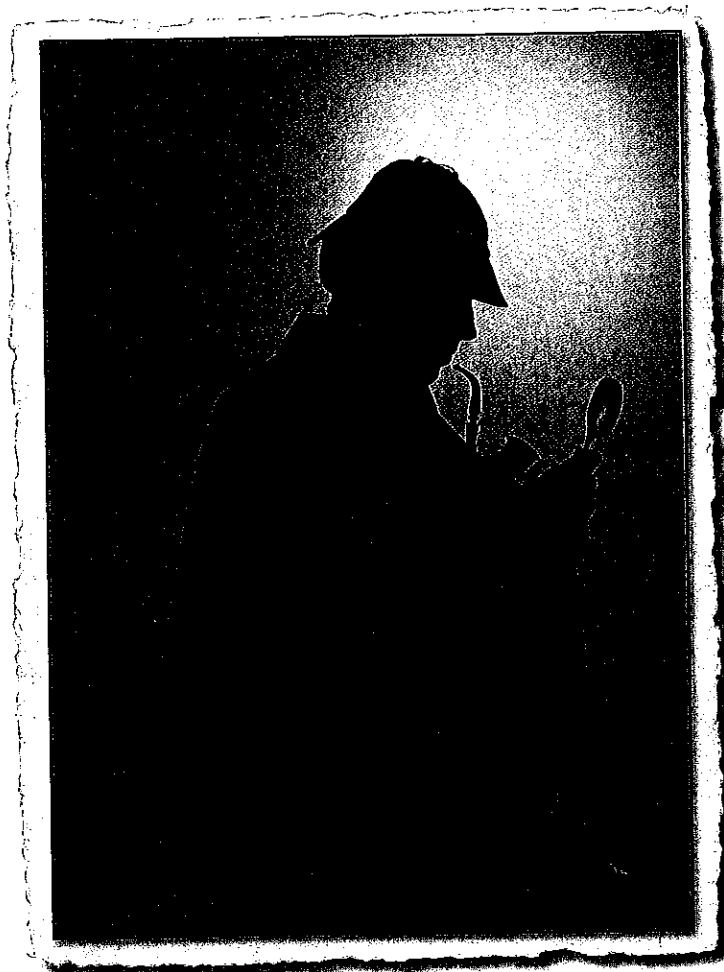


FIGURE 1-3 Bertillon's system of bodily measurements as used for the identification of an individual. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., [www.sirchie.com](http://www.sirchie.com)



*"I've found it. I've found it," he shouted to my companion, running towards 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."*

**FIGURE 1-4** 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 police. © Paul C. Chauncey/ CORBIS. All rights reserved.



The pace of technological change quickened considerably in the 20th century, and with it the rate of advancement in the field of 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 a dried 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 considered a primary reference for document examiners. Osborn's development of the 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 20th century was the Frenchman Edmond Locard. Although Hans Gross was a pioneer advocate of the use of the scientific method in criminal investigation, 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 only available instruments were a microscope and a rudimentary spectrometer. However, his enthusiasm quickly overcame the technical and monetary deficiencies he encountered. From these modest beginnings, Locard's research and accomplishments 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; this quickly developed into a leading international center for study and research in forensic science.

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 served as an impetus for the formation of police laboratories in Vienna, Berlin, Sweden, Finland, and Holland.

The microscope came into widespread use in forensic science during the 20th 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

**Locard's exchange principle**  
When two objects come into contact with one another, there is exchange of materials between them

**FIGURE 1-5**  
Edmond Locard.  
Courtesy Collection  
of Roger-Viollet,  
The Image Works



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 a long and illustrious career.

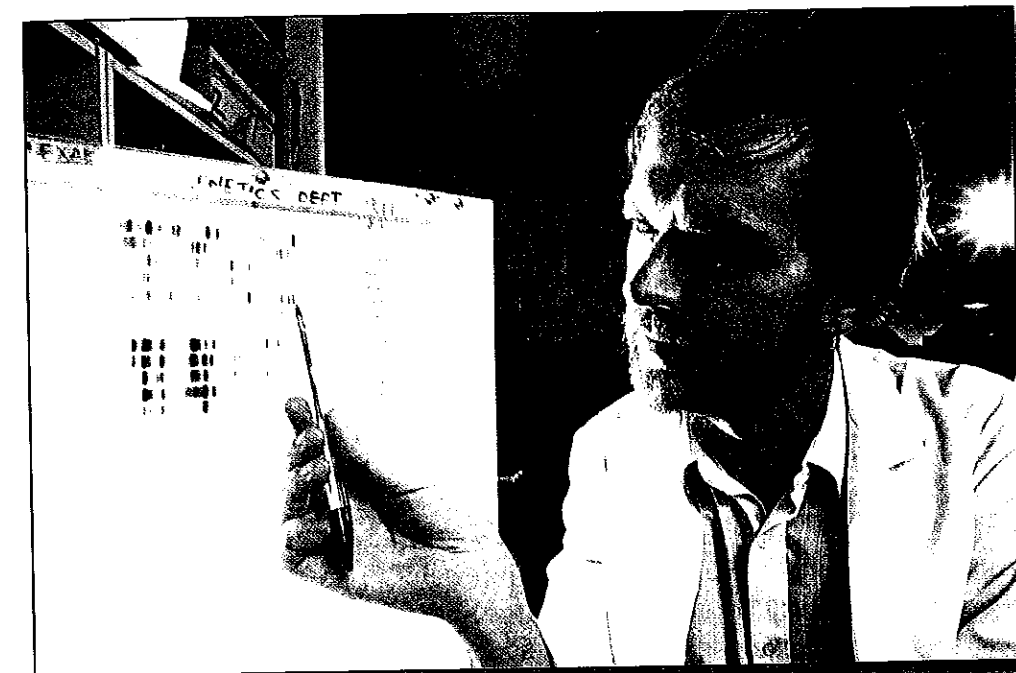
Another trailblazer in forensic applications of microscopy was U.S. Army Colonel Calvin Goddard, who refined the techniques of firearms examination by using the comparison microscope. Goddard's work allowed investigators to determine whether a particular gun has fired a bullet by comparing the bullet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

### Modern Scientific Advances

Since the mid-20th century, a revolution in computer technology has made possible a quantum leap forward in human knowledge. The resulting explosion of scientific advances has dramatically impacted 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 suspect substance, and to connect even tiny fragments of evidence to a particular person and place.

The most significant modern advance in forensic science undoubtedly has been the discovery and refinement of DNA typing in the late 20th and early 21st 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 by 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.



**FIGURE 1-6**  
Sir Alec Jeffreys.  
Courtesy Homer  
Sykes, Alamy Images  
Royalty Free

Another significant recent development in forensics is the establishment of computerized databases on physical evidence such as fingerprints, markings on bullets and shell casings, and DNA. These databases have proven to be invaluable, enabling law enforcement officials to compare evidence found at crime scenes to records of 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 made in the field by dedicated scientists and law enforcement personnel. Even Sherlock Holmes probably couldn't have imagined the lengths to which science today is applied in the service of criminal investigation.

**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 body 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 or compare physical evidence.
- Locard's exchange principle states that when two objects come into contact with each other, there is exchange of materials between them. This cross-transfer of materials can connect a criminal suspect to his or her victim.

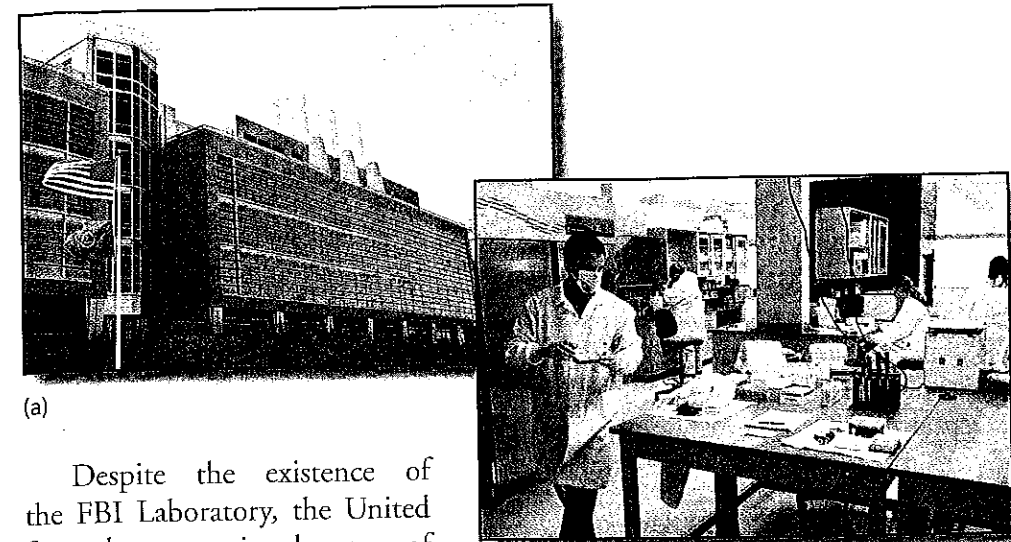
## Crime Laboratories

The steady advance of forensic science technologies during the 20th 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.

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 its 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. 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 to develop 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.

**FIGURE 1-7**  
(a) Exterior and (b) interior views of the FBI crime laboratory in Quantico, Virginia. Courtesy AP Wide World Photos



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—around the country 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 was 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.

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. 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; 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 a hundred, and their services may be diverse or specialized, depending on the responsibilities of the agency that houses the laboratory.

**The Growth of Crime Laboratories** Crime laboratories have mostly been organized by agencies that either foresaw their potential application to criminal investigation or were pressed by the increasing demands of casework. Several reasons explain the unparalleled growth of crime laboratories during the past 35 years. Supreme Court decisions in the 1960s were responsible for greater police 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 40 years. This factor alone would probably have accounted for the increased use of crime laboratory services by police agencies, but only a small percentage of police investigations generate evidence requiring scientific examination. There is, however, one important exception to this observation: 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. Current estimates indicate that nearly half of all requests for examination of forensic evidence deal with abused drugs.

A more recent impetus leading 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 at which traces of blood, semen stains, hair, and saliva residues left behind on stamps, cups, bite marks, and so on have made possible the individualization or near-individualization of biological evidence. 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 the technology have affected the structure of the forensic laboratory as has no other technology in the past 50 years. Likewise, DNA profiling has become the dominant factor in explaining how the general public perceives 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 is more

than 57,000. The estimated number of untested convicted offender samples is more than 500,000. 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 or 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 waiting until a person is convicted. 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 doing the same.

**Crime Laboratories in the United States** Historically, a 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 law 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. The concept of a regional laboratory operating 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 independently 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



**FIGURE 1-8** A forensic scientist performing DNA analysis. Courtesy Mauro Fermariello, Photo Researchers, Inc.



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, high 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 American 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 six regional laboratories, including the Metropolitan Police Laboratory (established in 1935), which services London. 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 packaged together and designed to be suitable for particular types of physical evidence. 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. One such organization, LGC in the United Kingdom, employs more than one thousand forensic scientists.

In Canada, forensic services are provided by three government-funded institutes: (1) six 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 a 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 total services offered in 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. However, even among crime laboratories providing services beyond drug identification, the diversity and quality of services rendered varies significantly. For the purposes of this text, I have arbitrarily designated the following units as those that should constitute 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 analysis, 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 dried bloodstains and other body fluids, compare hairs and fibers, and identify and compare botanical materials such as wood and plants.

**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 firearms discharge residues and to approximate the distance from a target at which a weapon was fired. The basic principles of firearms examination are also applied here to the comparison of marks made by tools.



**FIGURE 1-9**  
A forensic analyst  
examining a firearm.  
Courtesy Mediacolors,  
Alamy Images

**Document examination unit.** The document examination unit studies the handwriting and typewriting on questioned documents to ascertain authenticity and/or source. Related responsibilities include analyzing paper and ink and examining indented writings (the term usually applied to the partially visible depressions appearing on a sheet of paper underneath the one on which the visible writing appears), obliterations, erasures, and burned or charred documents.

**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, infrared, ultraviolet, 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 the alcoholic consumption of individuals. Often the toxicology section also trains operators and maintains and services these instruments.

**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 come to be recognized as 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.

**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.

**Crime-scene investigation unit.** The concept of incorporating crime-scene evidence collection into the total forensic science service is slowly gaining recognition 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 later be processed at the crime laboratory.

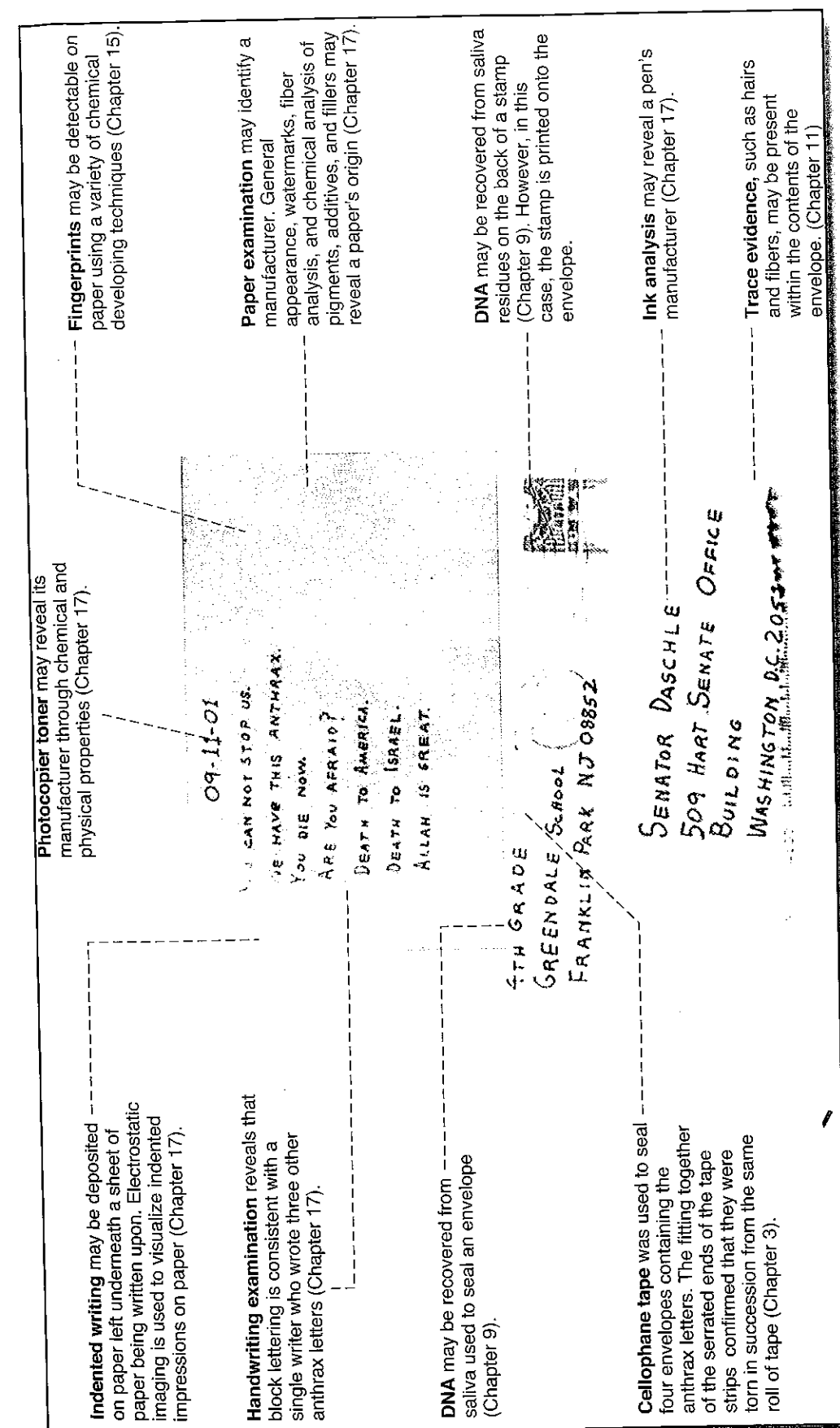
Whatever the organizational structure of a forensic science laboratory may be, specialization must not impede the overall coordination of services demanded by today's criminal investigator. Laboratory administrators need to keep open the lines of communication between analysts (civilian and uniform), 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 1-10** 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.

**Other Forensic Science Services** Even though this textbook 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 book. 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 and will be discussed at greater length when we examine crime-scene procedures in **Chapter 2**. Other services, such as those discussed next, are used in a wide variety of criminal investigations.

### MyCrimeKit: WebExtra 1.1

Take a Tour of a Forensic  
Laboratory  
[www.mycrimekit.com](http://www.mycrimekit.com)



**FIGURE 1-10**

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. Courtesy Getty Images, Inc.—Liaison

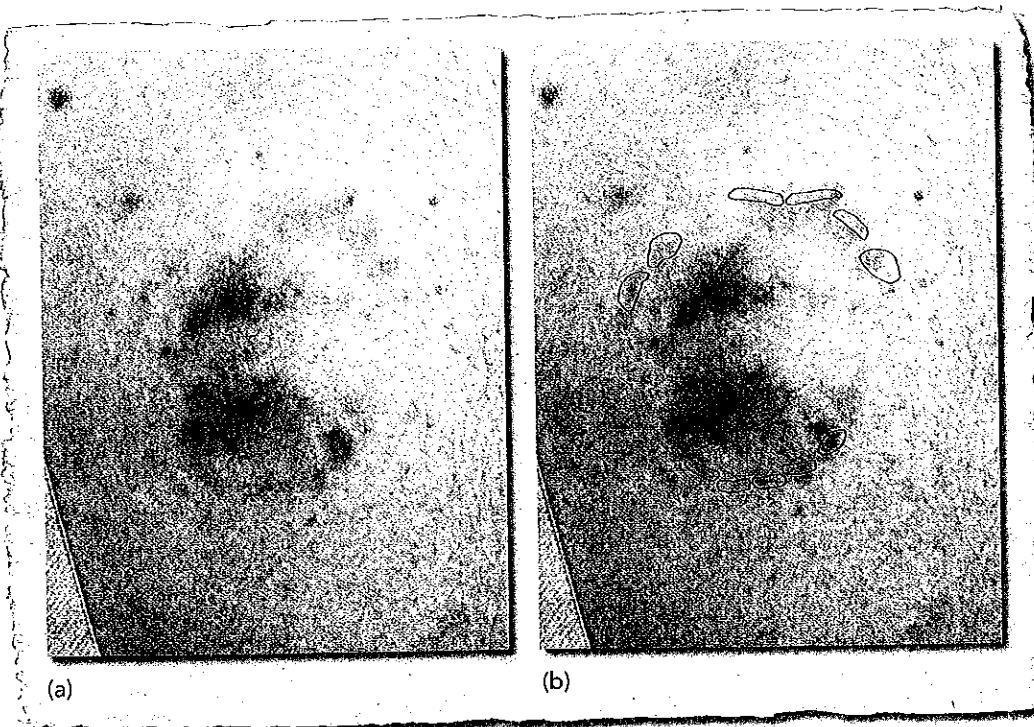
**Forensic psychiatry.** Forensic psychiatry is a specialized area that examines the relationship between human behavior and legal proceedings. Forensic psychiatrists are retained for both civil and criminal litigations. In civil cases, they typically perform tasks such as determining whether an individual 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 left 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 as decomposition begins. The characteristics of teeth, their alignment, and the overall structure of the mouth provide individual evidence for identifying a specific person. With the use of dental records such as X-rays and dental casts or even a photograph of the person's smile, a set of dental remains can be compared to a suspected victim. Another application of forensic odontology to criminal investigations is bite mark analysis. Bite marks are sometimes left on the victim in assault cases. A forensic odontologist can compare the marks left on a victim and the tooth structure of the suspect.

**Forensic engineering.** Forensic engineers are concerned with failure analysis, accident reconstruction, and causes and origins of fires or 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.

**MyCrimeKit:  
WebExtra 1.2**  
Explore Forensic Dentistry  
[www.mycrimekit.com](http://www.mycrimekit.com)

**FIGURE 1-11** (a) Bite mark on victim's body. (b) Comparison to suspect's teeth. Courtesy David Sweet, DMD, Ph.D., DABFO BOLD Forensic Laboratory, Vancouver, B.C., 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. This field of forensic computer analysis will be addressed in detail in [Chapter 18](#).

#### 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 fact that 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) the staggering increase in crime rates in the United States; (3) the fact that all illicit-drug seizures must be sent to a forensic laboratory for confirmatory chemical analysis before the case can be adjudicated in court; and (4) the advent of DNA profiling.
- 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.

## The 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.

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 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 may 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 what one wishes they were? The hallmark of physical evidence is that it must undergo scientific inquiry. Science derives its integrity from adherence to strict guidelines that ensure 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.

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*,<sup>2</sup> 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 sufficiently flexible to deal with new scientific issues that may not have gained widespread support within the scientific community.



FIGURE 1-12 An individual undergoing a polygraph test. Courtesy Woodfin Camp & Associates

The Federal Rules of Evidence offer an alternative to the *Frye* standard, one that some courts believe espouses a more flexible standard 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 upon 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.*,<sup>3</sup> the U.S. Supreme Court 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.

#### scientific method

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



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” in judging 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
3. The technique’s potential rate of error
4. 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

**FIGURE 1-13**  
Sketch of a US Supreme  
Court hearing.  
Courtesy Art Lien



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 American 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*,<sup>4</sup> 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*<sup>5</sup> (examined more closely in the following case study) exemplifies the flexibility and wide discretion that the *Daubert* ruling, 25 years later, apparently gave to trial judges in matters of scientific inquiry. The issue at question was whether the results of a new procedure that have 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 unproven 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 ultimately be a factor in determining a person’s guilt or innocence, forensic scientists may be required to testify about their methods and conclusions at a trial or hearing. 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 through experience, training, education, or a combination 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

### expert witness

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

## Case Files

### 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 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 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.

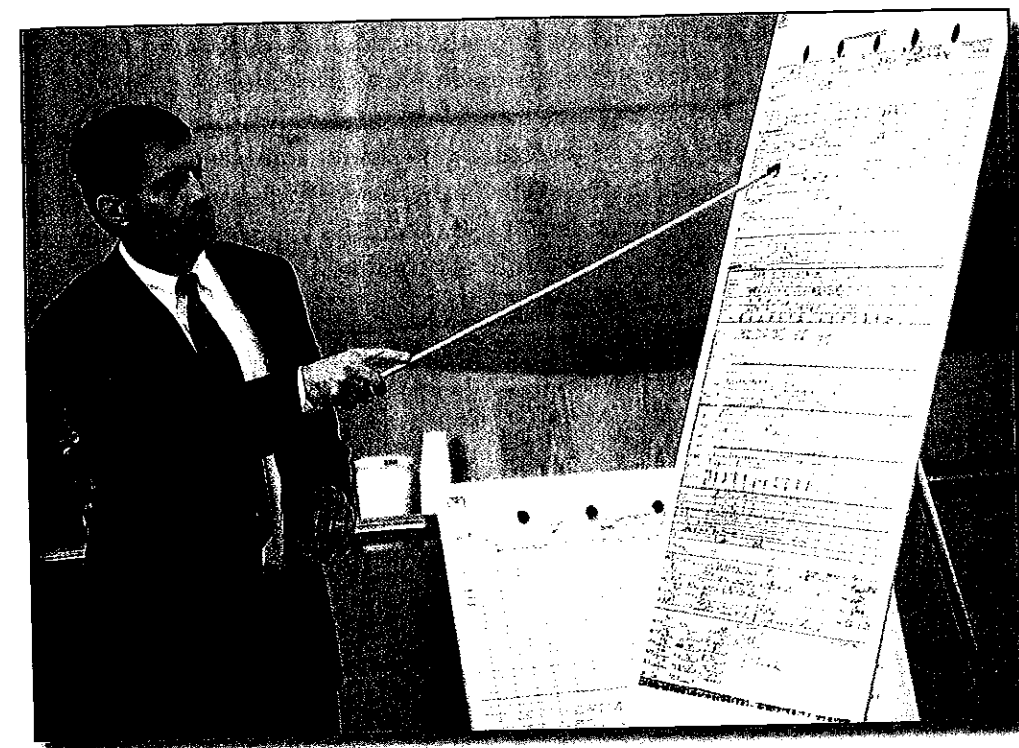
Marjorie Farber's astonishing story was supported in part by Carl's recent increase in his wife's life insurance. Carmela's \$65,000 policy, along with his new wife's fortune, would keep Dr. Coppolino in high society for the rest of his life. Based on this information, authorities in New Jersey and Florida now obtained exhumation orders for both William Farber and Carmela Coppolino. After examination of both bodies, 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, it was theorized that Coppolino had exploited his access to the many potent drugs used during surgery to commit these murders, specifically an injectable paralytic agent called succinylcholine chloride.

After having Carmela's body exhumed, 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. 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 the finding 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.

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 in areas related to the matter before the court.



**FIGURE 1-14**  
An expert witness  
testifying in court.  
Courtesy Jeff Siner,  
Corbis/Sygma

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 background 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 the value 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.

**MyCrimeKit:  
WebExtra 1.3**

 Watch a Forensic Witness  
Testify—I  
www.mycrimekit.com

**MyCrimeKit:  
WebExtra 1.4**

 Watch a Forensic Witness  
Testify—II  
www.mycrimekit.com

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.

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 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 only an advocate of truth. 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 in deciding guilt or innocence.

### Providing 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.

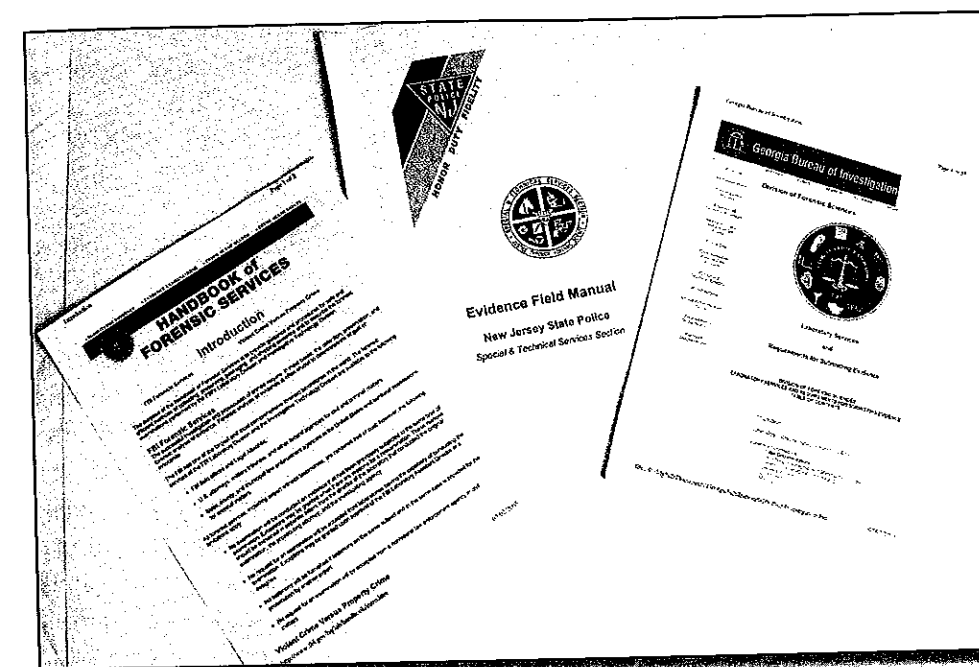
The most direct and effective response to this problem has been to dispatch specially trained evidence-collection technicians to the crime scene. A growing number of crime laboratories and the police agencies they service keep trained "evidence technicians" on 24-hour call to help criminal investigators 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.

A brief outline describing the proper collection and packaging of common types of physical evidence is found in the Appendix. The procedures and information summarized in this appendix are discussed in greater detail in forthcoming chapters.



**FIGURE 1-15** Representative evidence-collection guides prepared by various police 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 Web pages 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 or pages posted by law enforcement agencies that detail their activities, as well as possible employment opportunities.

Reddy's Forensic Home Page ([www.forensicpage.com](http://www.forensicpage.com)) is a valuable starting point. This site is a collection of forensic Web pages listed under categories such as new links in forensics; general forensic information sources; associations, colleges, and societies; literature and journals; forensic laboratories; general Web pages; forensic-related mailing lists and newsgroups; universities; conferences; and various forensic fields of expertise.

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

A comprehensive and useful Web site for those interested in law enforcement is Officer.com ([www.officer.com](http://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.

**An Introduction to Forensic Firearm Identification** This Web site 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.

**Carpenter's Forensic Science Resources** This site provides a bibliography with hypertext references pertaining to various aspects of criminal investigations 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 Web site is an excellent place to start a research project in forensic science.

**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 Web site. It explains the importance of inspecting the crime scene and the impact forensic evidence has on the investigation.

**Crimes and Clues** Users interested in learning about the forensic aspects of fingerprinting will find this a useful and informative Web site. 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 Web sites covering a variety of subjects pertaining to crime-scene investigation, documentation of the crime scene, and expert testimony.

**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.

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

**Questioned-Document Examination** This basic, informative Web page 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.

### MyCrimeKit: WebExtra 1.5

An Introduction to Forensic Firearm Identification  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.6

Carpenter's Forensic Science Resources  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.7

Crime Scene Investigator Network  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.8

Crimes and Clues  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.9

Interactive Investigator  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.10

The Chemical Detective  
[www.mycrimekit.com](http://www.mycrimekit.com)

### MyCrimeKit: WebExtra 1.11

Questioned-Document Examination  
[www.mycrimekit.com](http://www.mycrimekit.com)



## 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 body 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 or compare physical evidence.
- Locard's exchange principle states that when two objects come into contact with each other, there is exchange of materials between them. This cross-transfer of materials 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 fact that 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) the staggering increase in crime rates in the United States; (3) the fact that all illicit-drug seizures must be sent to a forensic laboratory for confirmatory chemical analysis before the case can be adjudicated in court; and (4) the advent of DNA profiling.
- 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.

## Review Questions

1. All the following are basic services provided by "full-service crime laboratories" except:
  - a. biology unit.
  - b. firearms unit.
  - c. document examination unit.
  - d. toxicology unit.
2. The standard guideline for determining the judicial admissibility of scientific examination stemmed from which court ruling?
  - a. *Mincey v. Arizona*
  - b. *Kumho Tire Co., Ltd. v. Carmichael*
  - c. *Frye v. United States*
  - d. *Coppolino v. State*
3. The scientist who maintained that when a criminal came in contact with an object or person a cross-transfer of evidence would occur was
  - a. Hans Gross.
  - b. Walter McCrone.
  - c. Edmond Locard.
  - d. Albert Osborn.
4. Which individual contributed knowledge to the forensic characterization of blood?
  - a. Albert Osborn
  - b. Calvin Goddard
  - c. Alec Jeffries
  - d. Thomas Taylor
5. The basic functions of a forensic scientist include:
  - a. furnishing training on the proper collection of physical evidence.
  - b. analysis of physical evidence.
  - c. providing expert testimony.
  - d. all of the above.
6. True or False: The first forensic laboratory in the United States was created in 1923.
7. True or False: The United States is one of only a handful of countries in the world that have created and now maintain forensic facilities.
8. True or False: In 1993 the U.S. Supreme Court decided that the *Frye v. United States* precedent is an absolute prerequisite to the admissibility of scientific evidence.

9. True or False: Only individuals who have accredited professional credentials from recognized university or medical programs are allowed to testify in court as an expert witness.
10. True or False: Strict guidelines that ensure careful and systematic collection, organization, and analysis of information is a process known as the scientific method.
11. Define forensic science.
12. What was the name of the first system of personal identification? What criteria did it use to distinguish individuals?
13. What was Francis Henry Galton's major contribution to forensic science? How did this advancement improve forensic science?
14. Who is known as "the father of forensic toxicology" and why?
15. Name two major contributions to forensic science made by Hans Gross. Why are they considered important to forensic science?
16. With what area of forensic investigation are Karl Landsteiner and Louis Lattes associated?
17. Who was the first person to apply the principles of forensic science to a working crime laboratory? What crime was he investigating?
18. What is Locard's exchange principle?
19. With what instrument did Dr. Walter C. McCrone make significant contributions to forensic science?
20. List four major reasons for the increase in the number of crime laboratories in the United States since the 1960s.
21. List four government agencies that offer forensic services at the federal level.
22. The current system of crime laboratories in the United States can best be described as
  - a. centralized.
  - b. regional.
  - c. decentralized.
  - d. national.
23. List three advantages of having regional crime laboratories operate as part of a statewide system. Are there any disadvantages to this setup?
24. How does the organization of Great Britain's forensic laboratories differ from that of the United States? Is this advantageous?
25. Which unit examines body fluids and organs for drugs and poisons?
26. Which unit examines and compares tool marks?
27. What part of the body do forensic odontologists use to identify a victim? Why is this body part particularly useful as a source of identification?

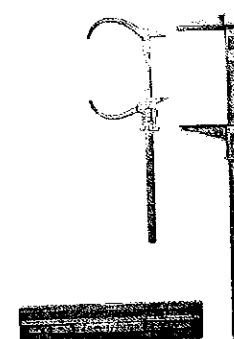
28. Describe the criteria for admissibility of scientific evidence as laid out in *Frye v. United States*.
29. In its decision in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, whom did the U.S. Supreme Court charge with ensuring that an expert's testimony rests on a reliable foundation and is relevant to the case?
30. What is an expert witness?
31. What is the main difference between the testimony given by an expert witness and that given by a lay witness?

## Application and Critical Thinking

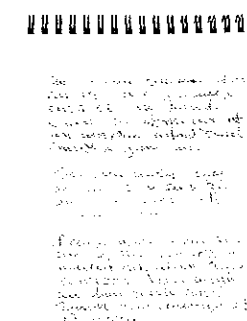
1. Most crime labs in the United States are funded and operated by the government and provide services free to police and prosecutors. Great Britain, however, uses a quasi-governmental agency that charges fees for its services and keeps any profits it makes. Suggest potential strengths and weaknesses 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

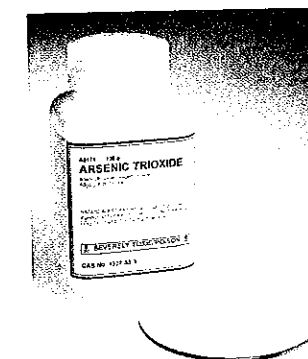
The following images depict different types of evidence or techniques for analyzing evidence. Place the images in order pertaining to the time in history (least recent to most recent) at which that evidence or technique was first introduced. Do this using the letter assigned to each image.



(A)



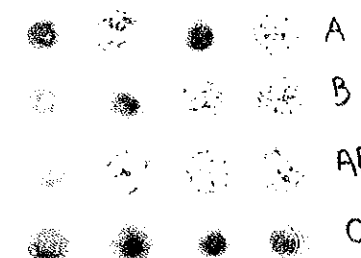
(B)



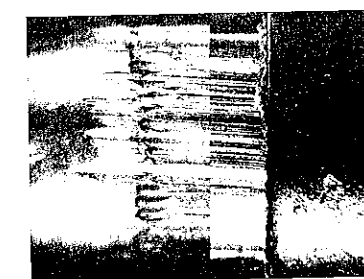
(C)



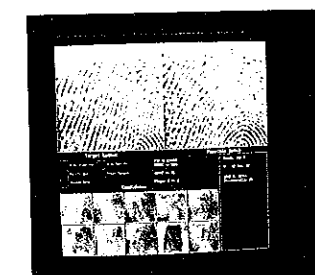
(D)



(E)



(F)



(G)



**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.

e.

f.

g.

h.

i.

j.

k.

l.

m.

**Endnotes**

- Two excellent references are André A. Moenssens, Fred E. Inbau, James Starrs, and Carol E. Henderson, *Scientific Evidence in Civil and Criminal Cases*, 4th ed. (Mineola, N.Y.: Foundation Press, 1995); and Werner U. Spitz, ed., *Medico-legal Investigation of Death*, 3rd ed. (Springfield, Ill.: Charles C. Thomas, 1993).
- 293 Fed. 1013 (D.C. Cir. 1923).
- 509 U.S. 579 (1993).
- 526 U.S. 137 (1999).
- 223 So. 2d 68 (Fla. App. 1968), app. dismissed, 234 So. 2d (Fla. 1969), cert. denied, 399 U.S. 927 (1970).



(A)



(B)



(C)



(D)



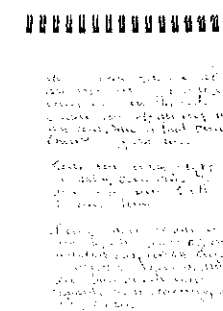
(E)



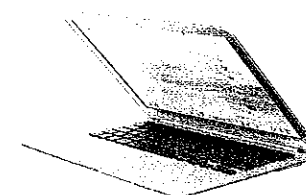
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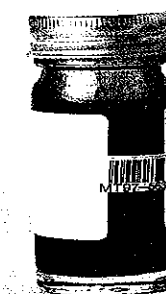
(G)



(H)



(I)



(J)



(K)



(L)



(M)