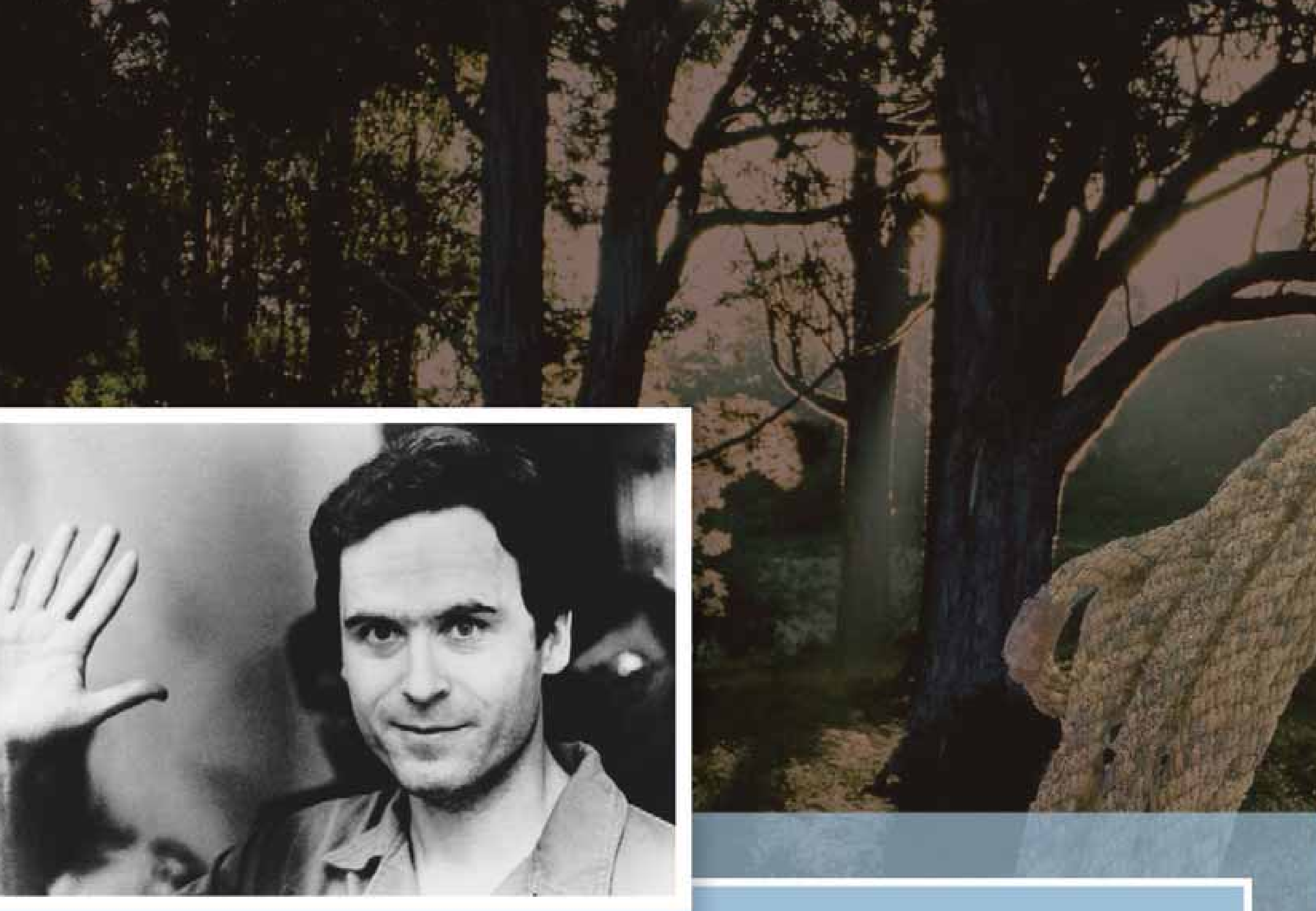


Ted Bundy, Serial Killer

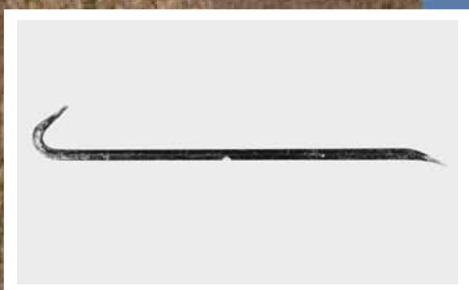
The name Ted Bundy is synonymous with the term *serial killer*. This handsome, gregarious, and worldly onetime law student is believed to be responsible for forty murders between 1964 and 1978. His reign of terror stretched from the Pacific Northwest down to California and into Utah, Idaho, and Colorado, 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.

chapter 1

Introduction



Key Terms

expert witness

Locard's exchange principle

scientific method

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 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.

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 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 that reflects 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.

Considering the vast array of civil and criminal laws that regulate society, forensic science, in its broadest sense, has become so comprehensive a

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

subject as to make a meaningful introductory textbook treatment of its role and techniques difficult, if not overwhelming. For this reason, we must 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 bring skills to bear to aid law enforcement officials in conducting their investigations.

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

1. Criminalistics
2. Engineering Science
3. General
4. Jurisprudence
5. Odontology
6. Pathology/Biology
7. Physical Anthropology
8. Psychiatry and Behavioral Science
9. Questioned Documents
10. 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, any intent 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 book will 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 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, along with pointing the reader to relevent websites, these subjects go beyond the intended scope of this book, and the reader is referred elsewhere for discussions of their applications and techniques.[1] 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. 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.

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.

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, 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.

While 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 seventeeth 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 that work 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.

FIGURE 1-2 Mathieu Orfila. *Courtesy 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 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.

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 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 nineteenth-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

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*

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 probes and recognizes the potential usefulness of forensic serology to criminal investigation:

> "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."

Twentieth-Century Breakthroughs

The pace of technological change quickened considerably in the twentieth 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 twentieth-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

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.*

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 exchange principle
When two objects come into contact with each other, a cross-transfer of materials occurs.

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

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 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 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-twentieth 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 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 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.

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.

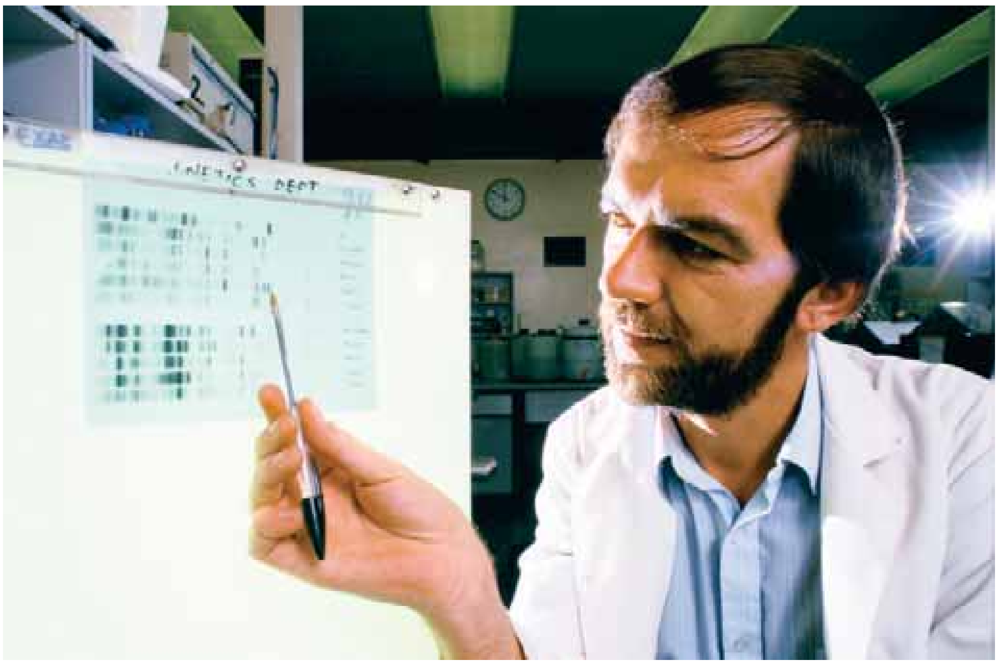


FIGURE 1–6 **Sir Alec Jeffreys.** *Courtesy Homer Sykes, Alamy Images Royalty Free*

While 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.

Key Points

- 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, 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 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

(a) (b)

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

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.

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.

Organization of a Crime Laboratory

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 350 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 100, 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 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. 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.

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 bloodstains; 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. While drug cases still far outnumber DNA cases, the labor-intensive demands and sophisticated technology requirements of the latter 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 explaining how the general public perceives the workings and capabilities of the modern crime laboratory.

In coming years an estimated ten thousand 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 will more than double the number of scientists currently employed by forensic laboratories in the United States. These DNA profiles are continually added to state and national DNA data banks, which have proven to be invaluable investigative resources for law enforcement. The United States has a substantial backlog of samples requiring DNA analysis. Approximately 200,000 to 300,000 convicted-offender samples and more than 540,000 evidentiary samples, for which no suspect has been located, remain to be analyzed nationwide.

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.

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

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 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 laboratory, Forensic Alliance, has two facilities employing more than one hundred 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 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 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.

Document examination unit. The documentation 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

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

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.

WebExtra 1.1
Take a Virtual Tour of a Forensic Laboratory
www.prenhall.com/hsforensics

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.

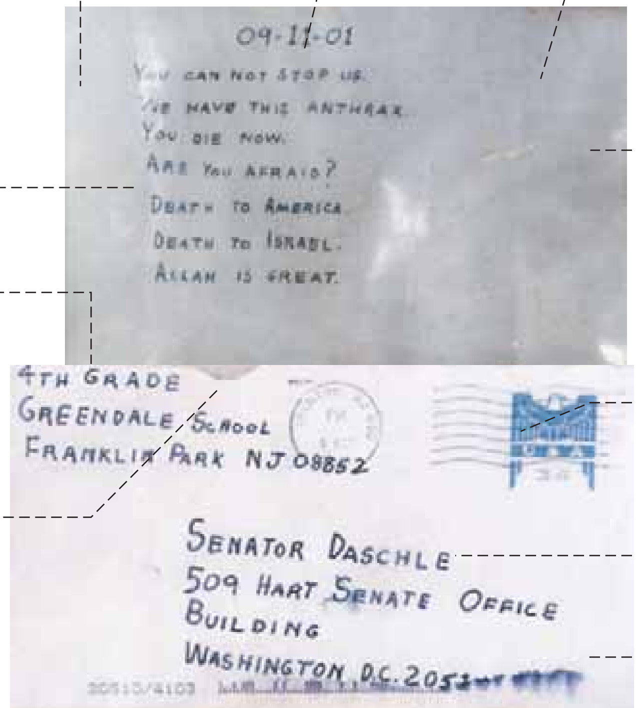
Photocopier toner may reveal its manufacturer through chemical and physical properties (p. 561).

Indented writing may be deposited on paper left underneath a sheet of paper being written upon. Electrostatic imaging is used to visualize indented impressions on paper (pp. 567–570).

Handwriting examination reveals that block lettering is consistent with a single writer who wrote three other anthrax letters (pp. 555–560).

DNA may be recovered from saliva used to seal an envelope (pp. 340–341).

Cellophane tape was used to seal four envelopes containing the anthrax letters. The fitting together of the serrated ends of the tape strips confirmed that they were torn in succession from the same roll of tape (p. 82).



Fingerprints may be detectable on paper using a variety of chemical developing techniques (pp. 489–490).

Paper examination may identify a manufacturer. General appearance, watermarks, fiber analysis, and chemical analysis of pigments, additives, and fillers may reveal a paper's origin (p. 573).

DNA may be recovered from saliva residues on the back of a stamp (pp. 340–341). However, in this case, the stamp is printed onto the envelope.

Ink analysis may reveal a pen's manufacturer (pp. 570–573).

Trace evidence, such as hairs and fibers, may be present within the contents of the envelope.

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

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.

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

(a) (b)

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

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.

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 Chapters 17 and 18.

WebExtra 1.2
Explore Forensic Dentistry
www.prenhall.com/hsforensics

Key Points

- 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.

Analyzing of 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 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.

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.

FIGURE 1–12 An individual undergoing a polygraph test. *Courtesy Woodfire Camp & Associates*

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.

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.,*[3] 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. 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

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,*[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 following case study) 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 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.

Case Study

Dr. Coppolino's Deadly House Calls

A frantic late-night telephone call to Dr. Juliette Karow brought her to the Longport Key, Florida, home of Drs. Carl and Carmela Coppolino. Carl had called for Dr. Karow's help because he believed Carmela was dying. He said she had complained of chest pains earlier in the evening and he was certain she had suffered a heart attack. Dr. Karow arrived to find Carmela beyond help.

Although Dr. Karow felt that the scene in the room appeared staged, and her own observations of Carmela's body did not support Carl's claim of heart trouble, she agreed to sign 32-year-old Carmela's death certificate. Dr. Karow cited "coronary occlusion" as the cause of death, but reported the death to the local police department. The investigating officer was satisfied that Dr. Karow had correctly listed the cause of death, so he did not apply the law that required that an autopsy be performed. The medical examiner could not order an autopsy without a request from the police or the district attorney, which was not forthcoming. Thus, 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 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.

In a cruel and ironic twist, Carl called his wife, Carmela, to sign William Farber's death certificate. She listed the cause of death, at Carl's insistence, as coronary artery disease. This type of death is common, especially in men in their fifties. Such deaths are rarely questioned, and the Department of Health accepted the certificate without any inquiry.

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. Coppolino was represented by the famous defense attorney F. Lee Bailey. 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, Bailey secured an acquittal for his client.

The Florida trial presented another chance to bring Carl Coppolino to justice. Florida officials called on the experienced New York City medical examiner Dr. Milton Halpern and his colleague, toxicologist Dr. Charles Umberger, to determine how Carl Coppolino had killed his wife. Recalling Dr. Coppolino's career as an anesthesiologist, Halpern 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.

(*continued*)

Case Study

Dr. Coppolino's Deadly House Calls (*continued*)

After having Carmela's body exhumed, Halpern examined her body with a magnifying glass in search of an injection site. He found that Carmela had been injected in her left buttock shortly before her death. Dr. Umberger's mission as the toxicologist in this case was to prove the administration of succinylcholine chloride by chemical analysis of Carmela's tissues.

This presented a serious problem because succinylcholine was purported to be untraceable in human tissue. The drug breaks down in the body to succinic acid and choline, both of which are naturally occurring chemicals in the human body. The chemical method necessary to make this determination did not exist at the time of the murder.

Ultimately, Dr. Umberger developed a completely novel procedure for detecting succinylcholine chloride. He isolated elevated levels of succinic acid 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.

On appeal, the defense raised an interesting point of law. Can a defendant be convicted of murder based on a series of tests that were specifically devised for this case? Tests that indirectly showed that Carmela had been injected with succinylcholine chloride had never before been used in a criminal trial. The court ruled that the novelty of a scientific method does not preclude its significance to a criminal prosecution. Just because an otherwise valid method was developed specifically for this trial and had not yet been proven in court did not mean that the murderer should be allowed to get away with the perfect crime. The conviction of Dr. Coppolino was upheld.

Providing Expert Testimony

expert witness
An individual whom the court determines to possess a particular skill or knowledge in a trade or profession that is not expected of the average layperson and that will aid a court in determining the truth of a matter at trial.

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 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

FIGURE 1–13 **An expert witness testifying in court.** *Courtesy Jeff Siner, Corbis/Sygma*

is the number of years of occupational experience the witness has 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 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.

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.

WebExtra 1.3
Watch a Forensic Expert Witness Testify—I
www.prenhall.com/hsforensics

WebExtra 1.4
Watch a Forensic Expert Witness Testify—II
www.prenhall.com/hsforensics

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

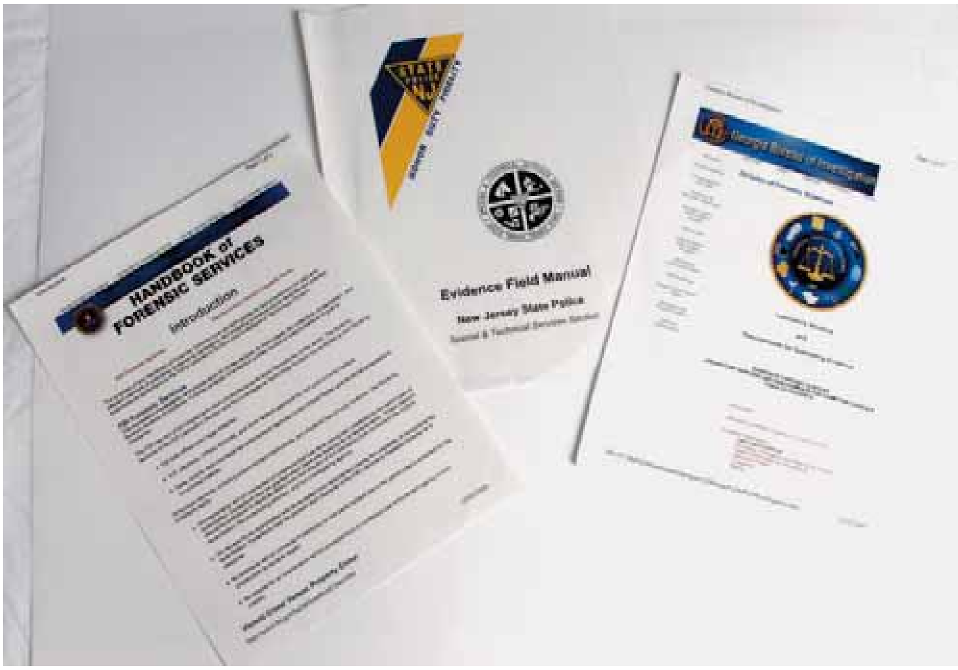


FIGURE 1–14 Representative evidence-collection guides prepared by various police agencies.

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 Appendix I. The procedures and information summarized in this appendix are discussed in greater detail in forthcoming chapters.

Key Points

- 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.

Chapter Summary

In its broadest definition, forensic science is the application of science to criminal and civil laws. This book emphasizes the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system. Forensic science owes its origins to a wide variety of individuals who developed the principles and techniques needed to identify or compare physical evidence.

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 350 public crime laboratories operate at various levels of government—federal, state, county, and municipal.

The technical support provided by crime laboratories can be assigned to five basic services. The physical science unit uses the principles of chemistry, physics, and geology to identify and compare physical evidence. The biology unit uses knowledge of biological sciences to investigate blood samples, body fluids, hair, and fiber samples. The firearms unit investigates discharged bullets, cartridge cases, shotgun shells, and ammunition. The document examination unit performs handwriting analysis and other questioned-document examination. Finally, the photography unit uses specialized photographic techniques to record and examine physical evidence.

Some crime laboratories offer the optional services of toxicology, fingerprint analysis, polygraph administration, voiceprint analysis, and crime-scene investigation. Several special forensic science services are available to the law enforcement community to augment the services of the crime laboratory. These services 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 analyze the many types of evidence that may be recovered during a criminal investigation. A forensic scientist may also provide expert court testimony. An expert witness evaluates evidence based on specialized training and experience and to express an opinion as to the significance of the findings. Also, forensic scientists participate in training law enforcement personnel in the proper recognition, collection, and preservation of physical evidence.

The *Frye* v. *United States* decision set guidelines for determining the admissibility of scientific evidence into the courtroom. To meet the *Frye* standard, the evidence in question must be "generally accepted" by the scientific community. However, in the 1993 case of *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.,* the U.S. Supreme Court asserted that the *Frye* standard is not an absolute prerequisite to the admissibility of scientific evidence. Trial judges were said to be ultimately responsible as "gatekeepers" for the admissibility and validity of scientific evidence presented in their courts.

Review Questions

Facts and Concepts

1. Define *forensic science*.
2. What was the name of the first system of personal identification? What criteria did it use to distinguish individuals?
3. What was Francis Henry Galton's major contribution to forensic science?
4. Who is known as "the father of forensic toxicology" and why?
5. Name two major contributions to forensic science made by Hans Gross.
6. Which of the following people did *not* make a contribution to forensic toxicology?
   a. Valentin Ross
   b. Alphonse Bertillon
   c. Carl Wilhelm Scheele
   d. Mathieu Orfila
7. With what area of forensic investigation are Karl Landsteiner and Louis Lattes associated?
8. Who was the first person to apply the principles of forensic science to a working crime laboratory?
9. What is Locard's exchange principle?
10. With what instrument did Dr. Walter C. McCrone make significant contributions to forensic science?
11. Which city's police department boasts the oldest forensic laboratory in the United States?
12. What is the world's largest forensic laboratory?
13. List four major reasons for the increase in the number of crime laboratories in the United States since the 1960s.
14. Demand for analysis of what substance is expected to lead to a dramatic increase in the number of crime lab personnel?
15. List four government agencies that offer forensic services at the federal level.
16. The current system of crime laboratories in the United States can best be described as
    a. centralized.
    b. regional.
    c. decentralized.
    d. national.
17. List three advantages of having regional crime laboratories operate as part of a statewide system.
18. How does the organization of Great Britain's forensic laboratories differ from that of the United States?

19. Which of the following is *not* a reason for the wide variation in services offered by crime laboratories in different communities?
    a. variations in local laws
    b. varying local approaches to crime-scene investigation
    c. different capabilities and functions of the organization to which a laboratory is attached
    d. budgetary and staffing limitations

20. Which unit examines body fluids and organs for drugs and poisons?

21. Which unit examines and compares tool marks?

22. 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?

23. List the three basic functions of a forensic scientist.

24. Describe the criteria for admissibility of scientific evidence as laid out in *Frye* v. *United States*.

25. What document offers an alternative to the *Frye* standard that some courts believe espouses a more flexible standard for admitting scientific evidence?

26. 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?

27. In *Kumho Tire Co., Ltd.* v. *Carmichael*, the U.S. Supreme Court ruled that the "gatekeeping" role of a trial judge
    a. was restricted to scientific testimony.
    b. applied only to cases involving capital crimes.
    c. was subject to appeal by a higher court.
    d. applied to all expert testimony.

28. What is an expert witness?

29. 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.

Case Analysis

The prosecution of Dr. Mario Jascalevich for murder turned on issues of both law and forensic science. Favorable resolution of the key legal issue was crucial to the state's ability to present a credible case against Dr. Jascalevich. Once in court, similarly unresolved issues pertaining to forensic science became central to the final verdict.

1. Describe the primary issue of law whose resolution by the court was critical to the state's case against Dr. Jascalevich.

2. How did the court ultimately rule on this issue? Describe the main arguments supporting the court's decision.

3. Describe the primary scientific issue raised during the trial. What were the defense's main challenges to the scientific evidence presented by the prosecution?

Web Resources

Admissibility of Scientific Evidence under *Daubert* (Brief comparison and discussion of the *Frye* and *Daubert* tests)
faculty.ncwc.edu/toconnor/425/425lect02.htm

Autopsy (Step-by-step description of an autopsy written by a pathologist with additional links to articles and videos about autopsies)
www.pathguy.com/autopsy.htm

Forensic Anthropology (Articles, essays, and links to topics in forensic anthropology)
library.med.utah.edu/kw/osteo/forensics/index.html

Forensic Science Resources in a Criminal Fact Investigation Index—Specific Topics (Online bibliography of topics in forensic science)
www.tncrimlaw.com/forensic/fsbindx.htm

History of Forensic Science
www.crimezzz.net/forensic_history/index.htm

Endnotes

1. 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., *Medicolegal Investigation of Death,* 3rd ed. (Springfield, Ill.: Charles C. Thomas, 1993).
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).

Case Reading

Detection of Curare in the Jascalevich Murder Trial

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Dr. Mario E. Jascalevich and his wife Nora display the "V for Victory" sign at their attorney's office in Hackensack, NJ. *Courtesy AP Wide World Photos*

The case of *State* v. *Jascalevich* that follows preceded the *Daubert* ruling by fifteen years. Nevertheless, it is interesting to note that the trial judge, after listening to both sides in his "gatekeeping" role, admitted into testimony what in 1978 were rather novel scientific test procedures for the drug curare. The case offers an excellent example of the legal and scientific issues involved in assessing the admissibility and value of scientific evidence in the courtroom. Dr. Jascalevich was accused of murdering several of his patients by administering lethal doses of curare. The issue of whether the curare was detected and identified in the exhumed bodies of the alleged murder victims was central to proving the state's case against the defendant. What ensued at the trial was a classic illustration of conflicting expert testimony on both sides of a scientific issue. Ultimately, the jury's task was to weigh the data and arguments presented by both sides and to reach a verdict.

The murder trial of Dr. Mario E. Jascalevich was one of the most complicated criminal proceedings ever tried in an American courtroom. The 34-week trial before a Superior Court judge in New Jersey resulted in a not-guilty verdict for the Englewood Cliffs, N.J., surgeon. The questions concerning analytical chemistry raised in the trial will continue to be discussed in years to come.

Not since the controversial trial of Dr. Carl Coppolino—convicted in a Florida courtroom in 1967 of murdering his wife with succinylcholine chloride—have so many forensic experts of national and international stature labored so long over the scientific questions at issue in the case:

> What happens to human tissue embalmed and interred for a decade? Assuming lethal doses of a drug such as curare were given to hospital patients, would the drug have changed chemically or have been destroyed entirely over a 10-year period?
>
> Assuming again that the drug had been injected, what analytical techniques could be employed to trace submicrogram amounts of it?
>
> Could components of embalming fluids or bacteria in the earth react chemically, forming substances giving a false positive reading in the analytical procedures used?

Forensic scientists first grappled with these questions during the latter part of 1966. Two of Jascalevich's colleagues at Riverdell Hospital in Oradell, N.J.—Dr. Stanley Harris, a surgeon, and

Dr. Allan Lans, an osteopathic physician—suspected him of murdering their patients with curare. There were no eyewitnesses to the alleged murders, but Drs. Harris and Lans discovered 18 vials of curare in Jascalevich's surgical locker after breaking into it.

They took their suspicions to the Bergen County Prosecutor's office in November 1966, and a brief but unpublicized investigation was launched. Items taken from the surgeon's locker, including the vials of curare and syringes, were sent for analysis at the New York City Medical Examiner's office.

In the interim, Jascalevich told authorities he used the muscle-relaxant drug in animal experiments at the Seton Hall Medical College. The surgeon presented the prosecutor his medical research papers and other documentation to support his contention. In addition, he reviewed the medical charts of the alleged murder victims and told the prosecutor there was no need for the operations the patients received. Malpractice and misdiagnosis were the causes of the deaths, Jascalevich stated at that time. Dr. Milton Helpern, chief of the New York City Medical Examiner's office, and his staff in early 1967 concluded their testing on the items taken from Jascalevich's locker. Dog hair and animal blood were detected on the vials of curare and syringes.

The prosecutor's office terminated its investigation and stated there were more reasons to look into allegations of malpractice than murder at the small osteopathic hospital.

In January 1976 a series of articles about a "Doctor X" suspected of murdering patients at Riverdell Hospital appeared in the *New York Times,* and the Bergen County Prosecutor's office reopened its case.

A month prior to the case being officially reopened, however, New York Deputy Medical Examiner Dr. Michael Baden supplied an affidavit to the Superior Court in Bergen County stating that at least a score of patients who died at Riverdell in 1966 succumbed from other reasons than those stated on death certificates.

A Superior Court judge signed the order in January 1976, granting the prosecutor's office the right to exhume the bodies of Nancy Savino, 4; Emma Arzt, 70; Frank Biggs, 59; Margaret Henderson, 27; and Carl Rohrbeck, 73.

All these patients entered Riverdell Hospital between December 1965 and September 1966 for routine surgical procedures and succumbed days afterward.

In mid-January 1976 the body of the Savino child was exhumed from a gravesite in Bergen County and taken to the medical examiner's office in New York City.

There, Dr. Baden, in the presence of New Jersey State Medical Examiner Dr. Edwin Albano and others, began performing the almost 4-hour examination of the child's body, which was said to be well preserved.

On May 18, 1976, Dr. Jascalevich was indicted for five murders.

A little more than a year later, the state's forensic experts began using radioimmunoassay (RIA) and high-performance liquid chromatography (HPLC) on the tissue specimens. In the fall of 1977, the defense received from Drs. Baden and Dal Cortivo samples of tissues and embalming fluids of the alleged murder victims.

For the remainder of the year, both the defense and the state experts worked to develop analytical procedures to settle the question of detection of curare in human tissue.

In addition, there were numerous pretrial hearings at which time the defense, headed by Jersey City attorney Raymond Brown, requested medical slides, reports, and patient charts relating to the alleged murder victims, as well as the methodologies used in treating the specimens.

On February 28, 1978, a panel of 18 jurors was chosen for what was to become the second longest criminal trial in the nation's history. At the outset, the defense wanted a hearing to ascertain the validity of the scientific procedures employed by the state to reportedly detect curare.

The defense contended that RIA and HPLC were relatively new procedures and could not be used to detect curare in human tissue. RIA, for example, could only be used to detect drugs in blood and body fluids, according to defense experts.

The defense motion for a hearing outside of the presence of the jury was denied by Superior Court Judge William J. Arnold, who maintained the motion could be made later in the trial when the evidence obtained by the analytical techniques would actually be scheduled for presentation to the jury.

The trial got underway with testimony by osteopathic physicians, nurses, and other hospital personnel employed by Riverdell during the time the alleged murders were committed. The physicians told Assistant Prosecutor Sybil Moses that in each instance the patient had been recovering from surgery when he succumbed.

However, on cross-examination, the physicians admitted they had misdiagnosed their patients' conditions and that there was inferior postoperative care. For example, in the case of the Savino child, the defense experts held that the little girl died of acute diffuse peritonitis—the source of her abdominal pain when she was brought into Riverdell after having been diagnosed as having acute appendicitis.

After the prosecution completed presentation of the medical aspects of its case, the defense renewed its request for a special hearing on the admissibility of the evidence obtained by radioimmunoassay, liquid chromatography, and other analytical techniques. This request came as Dr. Baden took the witness stand to explain why he had recommended reautopsy of the bodies. The prosecution was opposed to a hearing:

> The techniques used by the State are not new toxicological methodologies, but are standard methods, used widely throughout the field. These methodologies include radioimmunoassay and high-pressure liquid chromatography. . . .
>
> Since the methodologies used to detect the curare are widely accepted in the scientific community, there is no necessity for the Court to conduct a hearing as to their reliability.

Nevertheless, Judge Arnold ruled that a hearing should be held. Arguments began, in the absence of the jury, on June 10. Both sides presented statements by their technical experts and affidavits from other scientists regarding the validity of the analytical methods.

On June 20 the judge ruled that the analytical evidence was admissible. He stated,

> All I'm saying is under the law the evidence is admissible. I'm not going to comment on the value or trustworthiness of the witnesses [who testified]. The ultimate decision must be made by the jury.

Following this decision, the jury began listening to the scientific evidence, with the State's and the defense's witnesses in the process explaining such points as: What is curare, and specifically *d*-tubocurarine? What is radioimmunoassay? What is an antibody, and how is the antibody for *d*-tubocurarine created? What is high-pressure liquid chromatography?

Dr. Richard Coumbis testified about his finding tubocurarine in tissues from four of the five patients: "can only state there is presumptive evidence" that curare was discovered in the fifth patient. Under cross-examination by defense attorney Raymond Brown, Coumbis maintained that the RIA and HPLC procedures were valid methods of detecting curare because "on the basis of my personal experience, I did not find any other substance interfering with curare."

Dr. David Beggs of Hewlett-Packard then testified that he found curare in the Savino lung and liver samples using mass spectrometry. He said the Biggs and Arzt samples contained possible traces of curare; however, he could not be scientifically certain of this. He stated that mass spectrometry "is not an absolute test" for curare, but "just indicated that it is probably there."

Dr. Leo Dal Cortivo then took the witness stand and testified that he had found curare in tissue remains of three of the patients using HPLC. He also had measured curare in vials found in the defendant's locker at Riverdell Hospital in 1966, which the defense contended had been used in animal experiments conducted by Jascalevich at the College of Medicine in Jersey City. It was necessary to use RIA for the detection of curare in the HPLC eluates.

The prosecution then completed its case. At this point Judge Arnold dismissed two counts of murder and stated that the prosecution had not presented scientific evidence for the presence of curare in the bodies of Emma Arzt and Margaret Henderson. The defense then began presentation of its case with testimony about the medical aspects.

In September, attention returned to the analytical data. Drs. Frederick Rieders and Bo Holmstedt testified about the experiments they carried out on the samples provided by the prosecution. The major question they addressed was that of the long-term stability of curare under the conditions to which the bodies were subjected between 1966 and 1976.

Dr. Rieders maintained that, in his opinion, the RIA was not specific enough and "could only raise suspicions that something is there but it might not be there." The only procedure he found specific enough to be confident of identification of curare was mass spectrometry, using the entire spectrum, not just selected ion monitoring.

Rieders tested for the stability of curare and found that both embalming fluids and tissue juices (from the patients) had destructive effects on this compound. He added curare to these liquids and could detect it by TLC initially, but after a few days could find no trace of it or other nitrogenous bases. These liquids altered curare chemically to the point where it was no longer recognizable as such. He concluded that the rapid rate of decomposition meant that to detect curare in the specimens in 1976 would have required huge, medically impossible amounts to have been present in 1966.

Rieders tested the samples for curare and found it only in the liver specimen of Nancy Savino. He stated that mass spectrometry indicated that the curare in this sample was highly pure and could not have been present in the ground for 10 years. Furthermore, if curare was present in the liver, it should also have been found in the child's muscle tissue. That it was not detected in the latter specimen was a "tremendous inconsistency."

Dr. Bo Holmstedt then stated that curare could not survive in embalmed bodies for 10 years, especially because of the effects of bacteria and repeated fluctuations in temperature of the bodies. He reviewed experiments which showed that curare, upon injection, shows levels of the same order of magnitude in liver and muscle tissues. After 10 minutes, "40 percent of the drug is to be found in the muscle and 3 percent in the liver."

On October 14 the defense rested its case. On October 23, after both sides had presented summations of their cases, Judge Arnold gave his charge to the jury. The next day, October 24, 1978—seven and a half months after the trial had begun—the jury received the case. After just over 2 hours of deliberations, the jury returned a unanimous verdict of not guilty on all three remaining counts of murder. Two years and five months after the indictments against him had been returned, Dr. Mario Jascalevich was free.