

# chapter 1

## Introduction

### Key Terms

algor mortis

autopsy

expert witness

livor mortis

Locard's exchange principle

rigor mortis

### Learning Objectives

After studying this chapter you should be able to:

- Define and distinguish forensic science and criminalistics
- 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
- Understand what specialized forensic services, aside from the crime laboratory, are generally available to law enforcement personnel

## **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 into 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.**

## **DEFINITION AND SCOPE OF FORENSIC SCIENCE**

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

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

Laws are continually being broadened and revised to counter the alarming increase in crime rates. In response to public concern, law enforcement agencies have expanded their patrol and investigative functions, hoping to stem the rising tide of crime. At the same time they are looking more to the scientific community for advice and technical support for their efforts. Can the technology that put astronauts on the moon, split the atom, and eradicated most dreaded diseases be enlisted in this critical battle? Unfortunately, science cannot offer final and authoritative solutions to problems that stem from a maze of social and psychological factors. However, as the contents of this book will attest, science does occupy 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. It will also become apparent to the reader that a good deal of work remains to be done if the full potential of science as applied to criminal investigations is to be realized.

Considering the vast array of civil and criminal laws that regulate society, forensic science, in its broadest sense, has become so comprehensive a subject as to make a meaningful introductory textbook treatment of its role and techniques most difficult, if not overwhelming. For this reason, we must find practical limits that narrow the scope of the subject. Fortunately, common usage provides us with such a limited definition: **Forensic science is the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system.**

Even within this limited definition, we will restrict our discussion in this book to only the areas of chemistry, biology, physics, geology, and computer technology, which are useful for determining the evidential value of crime-scene and related evidence, omitting any references to medicine and law. Forensic pathology, psychology, anthropology, and odontology encompass important and relevant areas of knowledge and practice in law enforcement, each being an integral part of the total forensic science service that is provided to any up-to-date criminal justice system. However, except for a brief discussion at the end of this chapter, these subjects go beyond the intended range of this book, and the reader is referred elsewhere for discussions of their applications and techniques.<sup>1</sup> Instead, we will attempt to focus on the services of what has popularly become known as the crime laboratory, where the principles and techniques of the physical and natural sciences are practiced and applied to the analysis of crime-scene evidence.

For many, the term *criminalistics* seems more descriptive than *forensic science* for describing the services of a crime laboratory. The two terms will be used interchangeably in this text.

Regardless of title—criminalist or forensic scientist—the trend of events has made the scientist in the crime laboratory an active participant in the criminal justice system.

## **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.

Today, many believe that Sir Arthur Conan Doyle had a considerable influence on popularizing scientific crime-detection methods through his fictional character Sherlock Holmes, who first applied the newly developing principles of serology (see Chapter 12), fingerprinting, firearms identification, and questioned-document examination long before their value was first 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 micro-

scopic 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.”

Many people can be cited for their specific contributions to the field of forensic science. The following is just a brief list of those who made the earliest contributions to formulating the disciplines that now constitute forensic science.

**Mathieu Orfila (1787–1853).** Orfila is considered the father of forensic toxicology. A native of Spain, he ultimately became a renowned teacher of medicine in France. 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.

**Alphonse Bertillon (1853–1914).** Bertillon devised the first scientific system of personal identification. In 1879, Bertillon began to develop the science of *anthropometry* (see Chapter 14), a systematic procedure of taking a series of body measurements as a means of distinguishing one individual from another. See Figure 1–1. For nearly two decades, this system was considered the most accurate method of personal identification. Although anthropometry was eventually re-

placed by fingerprinting in the early 1900s, Bertillon's early efforts have earned him the distinction of being known as the father of criminal identification.

**Francis Galton (1822–1911).** Galton undertook the first definitive study of fingerprints and developed a methodology of classifying them for filing. In 1892, he 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.

**Leone Lattes (1887–1954).** In 1901, Dr. Karl Landsteiner discovered that blood can be grouped into different categories. These blood groups or types are now recognized as A, B, AB, and O. The possibility that blood grouping could be a useful characteristic for the identification of an individual intrigued Dr. Lattes, a professor at the Institute of Forensic Medicine at the University of Turin in Italy. In 1915, he devised a relatively simple procedure for determining the blood group of a dried bloodstain, a technique that he immediately applied to criminal investigations.

**Calvin Goddard (1891–1955).** To determine whether a particular gun has fired a bullet requires a comparison of the bullet with one that has been test-fired from the suspect's weapon. Goddard, a U.S. Army colonel, refined the techniques of such an examination by using the comparison microscope. Goddard's expertise established the comparison microscope as the indispensable tool of the modern firearms examiner.

**Albert S. Osborn (1858–1946).** Osborn's development of the fundamental principles of document examination was responsible for the acceptance of documents as scientific evidence by the courts. In 1910, Osborn authored the first significant text in this field, *Questioned Documents*. This book is still considered a primary reference for document examiners.

**Walter C. McCrone (1916–2002).** Dr. McCrone's career paralleled startling advances in sophisticated analytical technology. Nevertheless, during his lifetime McCrone became the world's preeminent microscopist. Through his books, journal publications, and research institute, McCrone 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 was responsible for educating 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.

**Hans Gross (1847–1915).** Gross wrote the first treatise describing the application of scientific disciplines to the field of criminal investigation in 1893. A public prosecutor and judge in Graz, Austria, Gross 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 serves as a medium for reporting improved methods of scientific crime detection.

**Edmond Locard (1877–1966).** Although Gross was a strong advocate of the use of the scientific method in criminal investigation, he did not make any specific technical contributions to this philosophy. Locard, a Frenchman, demonstrated how the principles enunciated by Gross could be incorporated within a workable crime laboratory. Locard's formal education was in both medicine and law. In 1910, he persuaded the Lyons police department to give him two attic



rooms and two assistants to start a police laboratory.

During Locard's first years of work, the only available instruments were a microscope and a rudimentary spectrometer. However, his enthusiasm quickly overcame the technical and monetary deficiencies he encountered. From these modest beginnings, Locard's research and accomplishments became known throughout the world by forensic scientists and criminal investigators. Eventually he became the founder and director of the Institute of Criminalistics at the University of Lyons; this quickly developed into a leading international center for study and research in forensic science.

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

The most ambitious commitment to forensic science occurred in the United States. 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, agents consulted extensively with business executives, manufacturers, and scientists whose knowledge and experience were useful in guiding the new facility

through its infancy. The FBI Laboratory is now the world's largest forensic laboratory, performing more than one million examinations every year. Its accomplishments have earned it worldwide recognition, and its structure and organization have served as a model for forensic laboratories formed at the state and local levels in the United States as well as in other countries. Furthermore, the opening of the FBI's Forensic Science Research and Training Center in 1981 gave the United States, for the first time, a facility dedicated to conducting research to develop new and reliable scientific methods that can be applied to forensic science. This facility is also used to train crime laboratory personnel in the latest forensic science techniques and methods.

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 (see Figure 1–2) was selected to head its criminalistics department. Many graduates of this school have gone on to help develop forensic laboratories in other parts of the state and country.

California has numerous federal, state, county, and city crime laboratories, many of which operate independently. However, in 1972 the California Department of Justice embarked on an ambitious plan to create a network of state-operated crime laboratories. As a result, California has created a model system of integrated forensic laboratories consisting of regional and satellite facilities. An informal exchange of information and expertise is facilitated among 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.

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.

## **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. At present, approximately 350 public crime laboratories operate at various levels of government—federal, state, county, and municipal—more than three times the number of crime laboratories operating in 1966.

The size and diversity of crime laboratories make it impossible to select any one model that can best describe 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 affi-

ated with universities or exist as independent agencies in government. Laboratory staff sizes range from one person to more than a hundred, and their services may be diverse or specialized, depending on the responsibilities of the agency that houses the laboratory.

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 thirty-five years. Supreme Court decisions in the 1960s were responsible for greater police emphasis on securing scientifically evaluated evidence. The requirement to advise criminal suspects of their constitutional rights and their right of immediate access to counsel has all but eliminated confessions as a routine investigative tool. Successful prosecution of criminal cases requires a thorough and professional police investigation, frequently incorporating the skills of forensic science experts. Modern technology has provided forensic scientists with many new skills and techniques to meet the challenges accompanying their increased participation in the criminal justice system.

Coinciding with changing judicial requirements has been the staggering increase in crime rates in the United States over the past 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 blood; semen stains; hair; and saliva residues left behind on stamps, cups, bite marks, and so on have made possible the individualization or near-individualization of biological evidence. To meet the demands of DNA technology, crime labs have expanded staff and in many cases modernized their physical plants. 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 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, currently remain to be analyzed nationwide.

Historically, a federal system of government, combined with a desire to retain local control, has produced a variety of independent laboratories in the United States, precluding the creation of a national system. Crime laboratories to a large extent mirror the fragmented law enforcement structure that exists on the national, state, and local levels. The federal government has no single law enforcement or investigative agency with unlimited jurisdiction. Four major federal crime laboratories have been created to help investigate and enforce criminal laws that extend beyond

the jurisdictional boundaries of state and local forces. The FBI (Department of Justice) maintains the largest crime laboratory in the world. An ultramodern facility housing the FBI's forensic science services is located in Quantico, Virginia (see Figure 1–3). 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 will offer 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 gov-

ernment. 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.

Like the United States, most countries in the world have created and now maintain forensic facilities. The British regional laboratory system has already been discussed. 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 services in the field of forensic science.

## **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 identi-

fication, the diversity and quality of services rendered varies significantly. For the purposes of this text, I have taken the liberty of arbitrarily designating 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 document examination unit studies the handwriting and typewriting on questioned documents to ascertain authenticity and/or source. Related responsibilities include analyzing paper and ink and examining indented writings (the term usually ap-



plied to the partially visible depressions appearing on a sheet of paper underneath the one on which the visible writing appears), obliterations, erasures, and burned or charred documents.

**Photography Unit.** A complete photographic laboratory examines and records physical evidence. Its procedures may require the use of highly specialized photographic techniques, such as digital imaging, infrared, ultraviolet, and X-ray photography, to make invisible information visible to the naked eye. This unit also prepares photographic exhibits for courtroom presentation.

### **Optional Services Provided by Full-Service Crime Laboratories**

**Toxicology Unit.** The toxicology group examines body fluids and organs to determine the presence or absence of drugs and poisons. Frequently, such functions are shared with or may be the sole responsibility of a separate laboratory facility placed under the direction of the medical examiner's or coroner's office.

In most jurisdictions, field instruments such as the Intoxilyzer are used to determine the alcoholic consumption of individuals. Often the toxicology section also trains operators and maintains and services these instruments.

**Latent Fingerprint Unit.** The latent fingerprint unit processes and examines evidence for latent fingerprints when they are submitted in conjunction with other laboratory examinations.

**Polygraph Unit.** The polygraph, or lie detector, has come to be recognized as an essential tool of the criminal investigator rather than the forensic scientist. However, during the formative years of polygraph technology, many police agencies incorporated this unit into the laboratory's administrative structure, where it sometimes remains today. In any case, its functions are handled by people trained in the techniques of criminal investigation and interrogation.

**Voiceprint Analysis Unit.** In cases involving telephoned threats or tape-recorded messages,

investigators may require the skills of the voiceprint analysis unit to tie the voice to a particular suspect. To this end, a good deal of casework has been performed with the sound spectrograph, an instrument that transforms speech into a visual 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 to uncover the source of the anthrax letters mailed shortly after September 11, 2001. Figure 1–4 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.

## **FUNCTIONS OF THE FORENSIC SCIENTIST**

### **Analysis 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 the analysis of the many types of evidence that may be

recovered during a criminal investigation. However, the scientist must also be aware of the demands and constraints imposed by the judicial system. The procedures and techniques used in the laboratory must not only rest on a firm scientific foundation but also satisfy the criteria of admissibility that have been established by the courts.

In rejecting the scientific validity of the lie detector (polygraph), the District of Columbia Circuit Court in 1923 set forth what has since become a standard guideline for determining the judicial admissibility of scientific examinations. In *Frye v. United States*,<sup>2</sup> the court stated the following:

Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while the courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.

To meet the *Frye* standard, the court must decide whether the questioned procedure, technique, or principle is “generally accepted” by a meaningful segment of the relevant scientific community. In practice, this approach required the proponent of a scientific test to present to the court a collection of experts who could testify that the scientific issue before the court is generally accepted by the relevant members of the scientific community. Furthermore, in determining whether a novel technique meets criteria associated with “general acceptance,” courts have frequently taken note of books and papers written on the subject, as well as prior judicial decisions relating to the reliability and general acceptance of the technique. In recent years this approach

has engendered a great deal of debate as to whether it is sufficiently flexible to deal with new and novel scientific issues that may not have gained widespread support within the scientific community.

As an alternative to the *Frye* standard, some courts came to believe that the Federal Rules of Evidence espoused a more flexible standard that did not rely on general acceptance as an absolute prerequisite 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 deals with the admissibility of expert testimony:

If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

In a landmark ruling in the 1993 case of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,<sup>3</sup> the U.S. Supreme Court asserted that “general acceptance,” or the *Frye* standard, is not an absolute prerequisite to the admissibility of scientific evidence under the Federal Rules of Evidence. According to the Court, the Rules of Evidence—especially Rule 702—assign to the trial judge the task of ensuring that an expert’s testimony rests on a reliable foundation and is relevant to the case. 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.

What the Court advocates in *Daubert* is 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 practitioners 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:

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

In a 1999 decision, *Kumho Tire Co., Ltd. v. Carmichael*,<sup>4</sup> the Court unanimously ruled that the “gatekeeping” role of the trial judge applied not only to scientific testimony, but to all expert

testimony:

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

A leading case that exemplifies the type of flexibility and wide discretion that the *Daubert* ruling apparently gives trial judges in matters of scientific inquiry is *Coppolino v. State*.<sup>5</sup> Here a medical examiner testified to his finding that the victim had died of an overdose of a drug known as succinylcholine chloride. This drug had never before been detected in the human body. The medical examiner's findings were dependent on a toxicological report that identified an abnormally high concentration of succinic acid, a breakdown product of the drug, in the victim's body. The defense argued that this test for the presence of succinylcholine chloride was new and the absence of corroborative experimental data by other scientists meant that it had not yet gained general acceptance in the toxicology profession. The court, in rejecting this argument, recognized the necessity for devising new scientific tests to solve the special problems that are continually arising in the forensic laboratory. It 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: “The tests by which the medical examiner sought to determine whether death was caused by succinylcholine chloride were novel and devised specifically for this case. This

does not render the evidence inadmissible. Society need not tolerate homicide until there develops a body of medical literature about some particular lethal agent.”

### **Provision of Expert Testimony**

Because their work product may ultimately be a factor in determining a person’s guilt or innocence, forensic scientists may be required to testify with respect to 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 sufficient grounds for qualification as an expert witness.

In court, the qualifying questions that counsel asks the expert are often directed toward demonstrating the witness’s ability and competence pertaining to the matter at hand. Competency may be established by having him or her cite educational degrees, participation in special courses, membership in professional societies, and any professional articles or books published. Also important is the number of years of occupational experience the witness has in areas related to the matter before the court.

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 provides the scientist with 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 is given the opportunity to cross-examine the witness and to point out weaknesses in his or her background and knowledge. Most courts are very 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. However, the weight that a judge or jury assigns to "expert" testimony in subsequent deliberations is quite another matter. Undoubtedly, education and experience have considerable bearing on the value assigned to the expert's opinions. Just as important may be the witness's 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, who must endeavor to prepare themselves adequately for this undertaking.

The ordinary or lay witness must give testimony 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.

It must be recognized that the expert cannot render any view with absolute certainty. At best, he or she may only be able to offer an opinion that is 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 .

### **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 administratively assigned to the laboratory to facilitate their 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 have still not adopted this approach. Often a patrol officer or detective is charged with collecting the evidence. His or her 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 a difficult and time-consuming operation 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 facilitated through periodic lectures, laboratory tours, and dissemination of manuals prepared by the laboratory staff that outline proper methods for collecting and submitting physical evidence to the laboratory. Examples of such manuals are shown in Figure 1–5.

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.

## **OTHER FORENSIC SCIENCE SERVICES**

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

**Forensic Pathology.** This field involves the investigation of sudden, unnatural, unexplained, or violent deaths. Typically, forensic pathologists, in their role as medical examiners or coroners, must answer several basic questions: Who is the victim? What injuries are present? When did the injuries occur? Why and how were the injuries produced? The primary role of the medical examiner is to determine the cause of death. If a cause cannot be found through observation, an **autopsy** is normally performed to establish the cause of death. The manner in which death occurred is classified into five categories: natural, homicide, suicide, accident, or undetermined, based on the circumstances surrounding the incident.

After a human body expires, it goes through several stages of decomposition. A medical examiner participating in a criminal investigation can often estimate the time of death by evaluating the stage of decomposition in which the victim was found. Immediately following death, the muscles relax and then become rigid. This condition, **rigor mortis**, manifests itself within the first twenty-four hours and disappears within thirty-six hours. Another condition occurring in the early stages of decomposition is **livor mortis**. When the human heart stops pumping, the blood begins to settle in the parts of the body closest to the ground. The skin will appear dark blue or purple in these areas. The onset of this condition begins immediately and continues for up to twelve hours after death. The skin will not appear discolored in areas where the body is restricted by either clothing or an object pressing against the body. This information can be useful in determining if the victim's position was changed after death occurred.

Other physical and chemical changes within the body are also helpful in approximating the time of death. **Algor mortis** is the process by which the body temperature continually cools after death until it reaches the ambient or room temperature. The rate of heat loss is influenced by factors such as the location and size of the body, the victim's clothing, and weather conditions. Be-

cause of such factors, this method can only estimate the approximate time period since death. As a general rule, beginning about an hour after death, the body will lose heat at a rate of approximately 1–1.5°F per hour until the body reaches the environmental temperature.

Another approach helpful for estimating the time of death is determining potassium levels in the ocular fluid (vitreous humor). After death, cells within the inner surface of the eyeball release potassium into the ocular fluid. By analyzing the amount of potassium present at various intervals after death, the forensic pathologist can determine the rate at which potassium is released into the vitreous humor and use it to approximate the time of death. During the autopsy, other factors may indicate the time period in which death occurred. For example, the amount of food in the stomach can help estimate when a person's last meal was eaten. This information can be valuable when investigating a death.

Frequently, medical examiners must perform autopsies if a death is deemed suspicious or unexplained. The cause of death may not always be what it seems at first glance. For example, a decedent with a gunshot wound and a gun in his hand may appear to have committed suicide. However, an autopsy may reveal that the victim actually died of suffocation and the gunshot wound occurred after death to cover up the commission of a crime.

**Forensic Anthropology.** Forensic anthropology is concerned primarily with the identification and examination of human skeletal remains. Skeletal bones are remarkably durable and undergo an extremely slow breakdown process that lasts decades or centuries. Because of their resistance to rapid decomposition, skeletal remains can provide a multitude of individual characteristics. An examination of bones may reveal their sex, approximate age, race, and skeletal injury. See Figure 1–6. For example, a female's bone structure will differ from a male's, especially within the pelvic area because of a woman's childbearing capabilities. This area of expertise is not lim-

ited just to identification, however. A forensic anthropologist may also be of assistance in creating facial reconstructions to help identify skeletal remains. With the help of this technique, a composite of the victim can be drawn and advertised in an attempt to identify the victim. Forensic anthropologists are also helpful in identifying victims of a mass disaster such as a plane crash. When such a tragedy occurs, forensic anthropologists can help identify victims through the collection of bone fragments.

**Forensic Entomology.** The study of insects and their relation to a criminal investigation is known as forensic entomology. Such a practice is commonly used to estimate the time of death when the circumstances surrounding the crime are unknown. After decomposition begins, insects such as blowflies are the first to infest the body. Their eggs are laid in the human remains and ultimately hatch into maggots or fly larvae (see Figure 1–7), which consume human organs and tissues. Forensic entomologists can identify the specific insects present in the body and approximate how long a body has been left exposed by examining the stage of development of the fly larvae. These determinations are not always straightforward, however. The time required for stage development is affected by environmental influences such as geographical location, climate, and weather conditions. For example, cold temperatures hinder the development of fly eggs into adult flies. The forensic entomologist must consider these conditions when estimating the postmortem interval. Knowledge of insects, their life cycles, and their habits make entomological evidence an invaluable tool for an investigation. See Figure 1–8.

**Forensic Psychiatry.** Forensic psychiatry is a specialized area in which the relationship between human behavior and legal proceedings is examined. Forensic psychiatrists are retained for both civil and criminal litigations. For civil cases, forensic psychiatrists normally determine whether people are competent to make decisions about preparing wills, settling property, or re-

fusing medical treatment. For criminal cases, they evaluate behavioral disorders and determine whether people are competent to stand trial. Forensic psychiatrists also examine behavioral patterns of criminals as an aid in developing a suspect's behavioral profile.

**Forensic Odontology.** Practitioners of forensic odontology help identify victims 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. At times in assault cases, bite marks are left on the victim. A forensic odontologist can compare the marks left on a victim and the tooth structure of the suspect. See Figure 1–9.

**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 the identification, collection, preservation, and examination of information derived from computers and other digital devices, such as cell phones. Law enforcement aspects of this work normally involve the recovery of deleted or overwritten data from a computer's hard drive and the tracking of hacking activities within a compromised system. This field

of forensic computer analysis will be addressed in detail in Chapters 17 and 18.

## **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 individuals such as Bertillon, Galton, Lattes, Goddard, Osborn, and Locard, 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. At present, 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 and evidence collection.

A forensic scientist must be skilled in applying the principles and techniques of the physical and natural sciences to the analysis of 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 is called on to evaluate 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 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.

A number of 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.

## Review Questions

1. The application of science to law describes \_\_\_\_\_.
2. The fictional exploits of \_\_\_\_\_ excited the imagination of an emerging generation of forensic scientists and criminal investigators.
3. A system of personal identification using a series of body measurements was first devised by \_\_\_\_\_.



4. \_\_\_\_\_ is responsible for developing the first statistical study proving the uniqueness of fingerprints.
5. The Italian scientist \_\_\_\_\_ devised the first workable procedure for typing dried bloodstains.
6. The comparison microscope became an indispensable tool of firearms examination through the efforts of \_\_\_\_\_.
7. Early efforts at applying scientific principles to document examination are associated with \_\_\_\_\_.
8. The application of science to criminal investigation was advocated by the Austrian magistrate \_\_\_\_\_.
9. One of the first functional crime laboratories was formed in Lyons, France, under the direction of \_\_\_\_\_.
10. The transfer of evidence expected to occur when two objects come in contact with one another was a concept first advocated by the forensic scientist \_\_\_\_\_.
11. The first forensic laboratory in the United States was created in 1923 by the \_\_\_\_\_ Police Department.
12. The state of \_\_\_\_\_ is an excellent example of a geographical area in the United States that has created a system of integrated regional and satellite laboratories.
13. In contrast to the United States, Britain's crime laboratory system is characterized by a national system of \_\_\_\_\_ laboratories.
14. The increasing demand for \_\_\_\_\_ analyses has been the single most important factor

in the recent expansion of crime laboratory services in the United States.

15. Four important federal agencies offering forensic services are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
16. A decentralized system of crime laboratories currently exists in the United States under the auspices of various governmental agencies at the \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ levels of government.
17. The application of chemistry, physics, and geology to the identification and comparison of crime-scene evidence is the function of the \_\_\_\_\_ unit of a crime laboratory.
18. The examination of blood, hairs, fibers, and botanical materials is conducted in the \_\_\_\_\_ unit of a crime laboratory.
19. The examination of bullets, cartridge cases, shotgun shells, and ammunition of all types is the responsibility of the \_\_\_\_\_ unit.
20. The examination of body fluids and organs for drugs and poisons is a function of the \_\_\_\_\_ unit.
21. The \_\_\_\_\_ unit dispatches trained personnel to the scene of a crime to retrieve evidence for laboratory examination.
22. The “general acceptance” principle, which serves as a criterion for the judicial admissibility of scientific evidence, was set forth in the case of \_\_\_\_\_.
23. In the case of \_\_\_\_\_, the Supreme Court ruled that in assessing the admissibility of new and unique scientific tests the trial judge did not have to rely solely on the concept of “general acceptance.”

24. True or False: The U.S. Supreme Court decision in *Kumho Tire Co., Ltd. v. Carmichael* restricted the “gatekeeping” role of a trial judge only to scientific testimony. \_\_\_\_\_
25. A Florida case that exemplifies the flexibility and wide discretion that the trial judge has in matters of scientific inquiry is \_\_\_\_\_.
26. A(n) \_\_\_\_\_ is a person who can demonstrate a particular skill or has knowledge in a trade or profession that will help the court determine the truth of the matter at issue.
27. True or False: The expert witness’s courtroom demeanor may play an important role in deciding what weight the court will assign to his or her testimony. \_\_\_\_\_
28. True or False: The testimony of an expert witness incorporates his or her personal opinion relating to a matter he or she has either studied or examined. \_\_\_\_\_
29. The ability of the investigator to recognize and collect crime-scene evidence properly depends on the amount of \_\_\_\_\_ received from the crime laboratory.
30. When \_\_\_\_\_ sets in after death, the skin appears dark blue or purple in the areas closest to the ground.
31. True or False: One method for approximating the time of death is to determine body temperature. \_\_\_\_\_

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## **Case Study**

Detection of Curare in the Jasclevich Murder Trial

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**Dr. Mario E. Jasclevich 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. Jasclevich* 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. Jasclevich was accused of murdering a number 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, it was the jury’s task to weigh the data and arguments presented by both sides and to reach a verdict.

The murder trial of Dr. Mario E. Jasclevich 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 Coppelino—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 Jasclevich'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 Jasclevich'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, Jasclevich 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, Jasclevich 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 Jasclevich'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.

In his affidavit in support of exhumation of the patients' remains, Dr. Baden stated,

It is my professional opinion that the majority of these cases reviewed are not explainable on the basis of natural causes and are consistent with having been caused by a respiratory depressant.

[The deputy medical examiner continued] I am aware that because unexplainable respiratory arrests have been involved in many of these deaths, the possibility of poisoning by a curare-like substance (specifically *d*-tubocurarine) was considered and investigated at the time of the initial inquiry in 1966.

The ability to identify *d*-tubocurarine, often referred to as curare, in human tissue was limited at the time of the initial investigation.

It is my professional opinion that recent technological advances now permit the detection of very minute amounts of d-tubocurarine in tissues removed from dead bodies. This is because d-tubocurarine is a chemically stable compound that can exist unaltered for many years.

Therefore, the aforementioned new techniques to detect curare-like compounds can be applied to tissues removed from bodies that have been interred for long periods of time.

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.

Assisting Dr. Baden in the analytical studies carried out on the tissues were Dr. Leo Dal Cortivo, chief toxicologist for Suffolk County, N.Y., and Dr. Richard J. Coumbis, chief toxicologist for the New Jersey Medical Examiner's office. The defense experts, headed by former Westchester County (N.Y.) Medical Examiner Dr. Henry Siegel, were not permitted to be present at the re-autopsies.



The state began its work. In March, a week before the grand jury met, a newspaper article declared that curare had been detected in the Savino child. However, in his grand jury testimony weeks later, Dr. Baden stated his experts could not be certain if curare could be detected: “We have to look and see whether or not we can develop adequate procedures.”

On May 18, 1976, Dr. Jasclevich 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. The prosecution cited various cases in support of its position:

Practically every new scientific discovery had its detractors and unbelievers, but neither unanimity of opinion nor universal infallibility is required for judicial acceptance of generally recognized matters [*State v. Johnson*, 42 N.J. 146, 171 (1964)].

The law, in its efforts to enforce justice by demonstrating a fact in issue, will allow evidence of those scientific processes, which are the work of educated and skillful men in their various departments and apply them to the demonstration of a fact, leaving the weight and effect to be given to the effort and its results entirely to the consideration of the jury [*State v. Cerciello*, 86 N.J.L. 309, 314 (E&A 1914)].

The prosecution stated, “Federal courts have held that newness or lack of absolute certainty in a test does not require its inadmissibility.” In one case involving neutron-activation analysis, a federal appellate court held in part:

Every useful new development must have its first day in court. And court records are full of the conflicting opinions of doctors, engineers, and accountants to name just a few of the legions of expert witnesses [*United States v. Stifel*, 433 F. 2d. 431, 437, 438 (6th Cir. 1970)].

The prosecution noted,

The Florida Appellate Court in *Coppolino v. State* ... held that not only established techniques but methods developed specifically for that case could be used to detect a previously undetectable drug in the body of the decedent....

The tests by which the medical examiner sought to determine whether death was caused by succinylcholine chloride were novel and devised specifically for this case. This does not render the evidence inadmissible. Society need not tolerate homicide until there develops a body of medical knowledge about some particular lethal agent. The expert witnesses were examined and cross-examined at great length and the jury could either believe or doubt the prosecution's testimony as it chose [*Coppolino v. State*, 223 So. 2d. 75 (Fla. App. 1968)].

Finally, the prosecution noted the following holding of the New Jersey Superior Court Appellate Division:

The general rule in New Jersey regarding the admissibility of scientific test results is that, if the equipment or the methodology used is proven to have a high degree of scientific reliability, and if the test is performed or administered by qualified persons, the results will be admissible at trial [*State v. Chatman*, 101 N.J.L.S. index 307, 308 (App. Div. 1973)].

The defense contended that

The methodologies of thin layer chromatography (TLC), high pressure liquid chromatography, ultraviolet spectrophotometry, and radioimmunoassay which have been utilized by the State do not meet the required level of acceptance under the circumstances of the tissues in this case.... Since there have never been any

attempts to demonstrate the presence of *d*-tubocurarine in embalmed, buried tissue ... the State cannot even assert that the techniques it wishes to utilize to demonstrate this have been generally accepted.

The defense presented affidavits from a variety of forensic scientists, from which we present one example:

It should be noted that even though the newer analytical methods and some of the sophisticated equipment are extremely sensitive for drug detection, the sensitivity of some method is not a criterion of its specificity. Sensitivity is the minimum amount of an unknown substance below which a test gives a negative result. Specificity is the ability of a test to establish the individual characteristics and/or configuration of a particular substance by differentiating it from all other substances, especially in a biologic mixture.

Currently, the reported analytical methods, which include ultraviolet absorption spectrophotometry, thin layer chromatography and radioimmunoassay, alone or in conjunction, lack such a degree of specificity with any degree of scientific certainty required to support the opinion that they identified the isolated material as *d*-tubocurarine in embalmed, decomposed and skeletonizing tissues that have been in the ground for ten years under varying climatic conditions [Abraham Stolman, Chief Toxicologist, State of Connecticut Department of Health].

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 com-

ment 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."

The toxicologist admitted that the counting efficiencies of the instruments he used to get the RIA displacement values varied from day to day and were subject to error. Brown disagreed with the displacement figures Coumbis arrived at, and wanted to know whether there was a "cut-off point" whereby he arrived at the conclusion that curare was or was not present in tissues. The RIA results ranged from as low as 77 counts all the way up to 700. Somewhere within that range, Brown argued, was a point at which Coumbis arrived at the decision that the drug was detected or not. Where, he asked, was that point? The toxicologist responded by saying that the higher the figure, the more likely curare was present. He said in many instances, however, he had to use his discretion to determine the cut-off point.

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.” He did carry out a solvent blank as a means of eliminating false positives. He held under cross-examination that the electron impact technique used by him resulted in a spectrum with 12 major peaks and that 10 were sufficient for “fingerprint” identification of curare.

Dr. Sidney Spector of the Roche Institute testified about how he had developed the antibody for *d*-tubocurarine and applied it in RIA analysis of body fluids such as urine and blood. He had not himself run any tests for curare in human tissue samples and stated, “If there were curare in tissues, there is the possibility it could be detected.” He said that the State’s RIA experiments were “inadequate” in relying on aqueous solutions of curare to develop a standard curve. He held that the RIA procedure could give an indication that curare was present, but that the finding would only be presumptive evidence and not sufficient to say that the muscle-relaxant drug was positively present. He made the same point about HPLC and said that even if the two techniques were used together, there still would only be presumptive proof that the drug was present.

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 Jasclevich at the College of Medicine in Jersey City. It was necessary to use RIA for the detection of curare in the HPLC eluates. The samples were prepared for LC analysis by an extraction procedure which Dal Cortivo stated gave a 75 percent recovery. He rejected the contention that the extraction and LC method might have allowed positive results because of an interfering substance.

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. In critical analyses, a four-step extraction procedure was used to isolate *d*-tubocurarine from the samples ....

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 Jasclevich was free.

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### **Locard's Exchange Principle**

Whenever two objects come into contact with one another, there is exchange of materials between them.

### **WebExtra 1.1**

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## **Expert Witness**

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

### **WebExtra 1.2**

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#### **Watch a Forensic Expert Witness Testify—II**

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## **Autopsy**

The medical dissection and examination of a body in order to determine the cause of death.

## **Rigor Mortis**

The medical condition that occurs after death and results in the stiffening of muscle mass. The rigidity of the body gradually disappears 24 hours after death.

## **Livor Mortis**

The medical condition that occurs after death and results in the settling of blood in areas of the body closest to the ground.

## **Algor Mortis**

Postmortem changes that cause a body to lose heat.

### **WebExtra 1.4**

## **See How an Autopsy Is Done**

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**Figure 1–1 Bertillon’s system of bodily measurements as used for the identification of an individual.** *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C.,*

[www.sirchie.com](http://www.sirchie.com)

**Figure 1–2 Paul Leland Kirk, 1902—1970.** *Courtesy Blackstone-Shelburne, N.Y.*

**Figure 1–3 (a) Exterior and (b) interior views of the FBI crime laboratory in Quantico, Virginia.**

*Courtesy AP Wide World Photos*

**Figure 1–4 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.*

**Figure 1–5 Representative evidence-collection guides prepared by various police agencies.**

**Figure 1–6 Crime-scene site showing a pelvis partly buried in sand and a femur lying across a pistol.** *Courtesy Paul Sledzik.*

**Figure 1–7 A scanning electron micrograph of 2-hour-old blowfly maggots.** *Courtesy Dr. Jeremy Burgess, Photo Researchers, Inc.*

**Figure 1–8 Typical blowfly life cycle from egg deposition to adult fly emergence. This cycle is representative of any one of the nearly ninety species of blowflies in North America.**

*Courtesy E.P. Catts, Ph.D., deceased, and Neal H. Haskell, Ph.D., forensic entomology consultant [www.forensic-entomology.com](http://www.forensic-entomology.com)*

**Figure 1–9 (a) Bite mark on victim’s body. (b) Comparison to suspect’s teeth.** *Courtesy David Sweet, DMD, Ph.D., DABFO BOLD Forensic Laboratory, Vancouver, BC Canada*

<sup>1</sup> 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).

<sup>2</sup> 293 Fed. 1013 (D.C. Cir. 1923).

<sup>3</sup> 509 U.S. 579 (1993).

<sup>4</sup> 526 U.S. 137 (1999).

<sup>5</sup> 223 So. 2d 68 (Fla. Dist. Ct. App. 1968), *app. dismissed*, 234 So. 2d 120 (Fla. 1969), *cert. denied*, 399 U.S. 927 (1970).