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questioned documents
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What Is Forensic Science?

The *Oxford English Dictionary* lists one of the first uses of the phrase "forensic science" to describe "a mixed science" (Oxford English Dictionary, 2005). The early days of forensic science could certainly be called mixed, when science served justice by its application to questions before the court. Forensic science has grown as a profession and into a science in its own right. Given the public's interest in using science to solve crimes, it looks as if forensic science has an active, if hectic, future.

Forensic science describes the science of associating people, places, and things involved in criminal activities; these scientific disciplines assist in investigating and adjudicating criminal and civil cases. The discipline divides neatly into halves, like the term that describes it. "Science" is the collection of systematic methodologies used to increasingly understand the physical world. The word "forensic" is derived from the Latin *forum* for "public" (*Oxford English Dictionary,* 2005). In ancient Rome, the Senate met in the Forum, a public place where the political and policy issues of the day were discussed and debated; even today, high school or university teams that compete in debates or public speaking are called "forensics teams." More technically, "forensic" means "as applied to public or legal concerns." Together, "forensic science" is an apt term for the profession of scientists whose work answers questions for the courts through reports and testimony.

Areas of Forensic Science

Criminalistics

The term **criminalistics** is sometimes used synonymously with forensic science. "Criminalistics" is a word imported into English from the German *kriminalistik*. The word was coined to capture the various aspects of applying scientific and technological methods to the investigation and resolution of legal matters. In some forensic science laboratories, forensic scientists may be called **criminalists**. Criminalistics is generally thought of as the branch of forensic science that involves the collection and analysis of physical evidence generated by criminal activity. It includes areas such as drugs, firearms and toolmarks, fingerprints, blood and body fluids, footwear, and trace evidence. "Trace evidence" is a term of art that means different things to different people. It might include fire and explosive residues, glass, soils, hairs, fibers, paints, plastics and other polymers, wood, metals, and chemicals. These items are generally analyzed by forensic science or forensic science laboratories. To avoid confusion, unnecessary terminology, and regionalism, the phrases "forensic sciences" and "forensic scientists" instead of "criminalistics" and "criminalist" will be used.

Forensic Pathology

Back in the days when the *Quincy* television show was popular, many people thought of **forensic pathology** and forensic science as the same thing—this misperception persists today. Forensic pathology is conducted by a medical examiner, who is a physician, specially trained in clinical and anatomic pathology, whose function is to determine the cause and manner of death in cases where the death occurred under suspicious or unknown circumstances. This often involves a teamwork approach with the autopsy or post-mortem examination of the body as the central function. Other team members may include toxicologists, anthropologists, entomologists, and radiologists. Medical examiners are often called to death scenes to make some preliminary observations including an estimate of the time since death.

Forensic Anthropology

Forensic anthropology is a branch of physical anthropology, the study of humans and their ancestors. Forensic anthropology deals with identifying people who cannot be identified through soft tissue features, such as fingerprints or photographs. Typically, forensic anthropologists analyze skeletal remains to determine if they are human and, if so, the age, sex, height, and other characteristics, such as socioeconomic status, of the deceased. If the characteristics of the remains compare favorably with those of the missing person in question, then further methods (such as x-rays) are employed to positively identify (individualize) the remains.

Forensic anthropologists figure prominently in the reconstruction and identification of victims in mass fatalities, such as bombings and airplane crashes. Working closely with pathologists, dentists, and others, forensic anthropologists aid in the identification of people who otherwise might never be identified.

Forensic Odonotology

Sometimes called forensic dentistry, **forensic odontology** has a large number of applications to the forensic sciences. They include identification of human remains in mass disasters (enamel is the hardest material produced by the body and intact teeth are often found), post-mortem x-rays of the teeth can be compared to ante-mortem x-rays, and the comparison of bitemarks. One of the most famous of all serial killers in the United States, Theodore Bundy, was brought to justice in part on evidence of bitemarks. He bit his last victim after her death. The forensic pathologist was able to obtain a plaster impression of the bitemark, which was compared to a known impression of Bundy's teeth (see **Figure 1.1**). Lowell Levine, a forensic odontologist, testified at Bundy's trial that the bitemarks on the victim's body were made by Bundy. This was important evidence that the jury used to convict him of the murder. As a consequence of this conviction, Bundy was executed (Rule, 1980).

Forensic Engineering

Forensic engineering involves the investigation and testing of materials, products, or structures that do not function like they were designed or built to; in essence, they "fail." These failures cause personal injury or damage to property, typically resulting in civil cases although some forensic engineering is used in criminal cases, such as transportation accidents or airplane disasters. A forensic engineer's goal is to locate the cause (or causes) of the failure; this information can be used to improve the performance or safety of a product or to determine liability in a legal case. Forensic engineering played a large role in the 1980 balcony collapse in the lobby of a large hotel in Kansas City where many people were injured and some died. Forensic engineers investigated the site and determined that the concrete supports used in construction of the balcony were made of substandard materials. This led to criminal charges against the contractor. This example illustrates the value that a forensic

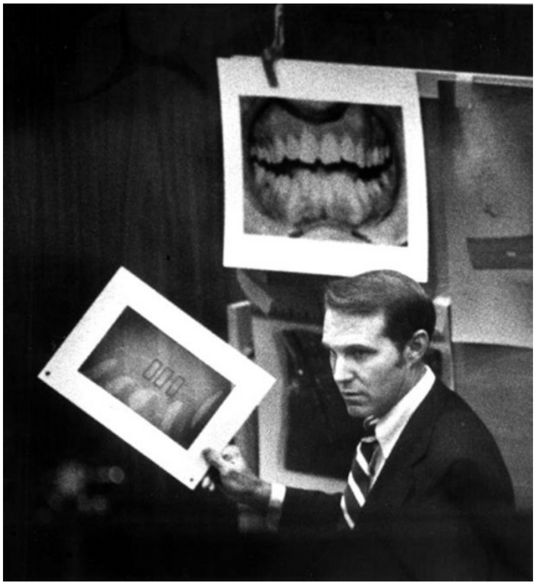


FIGURE 1.1 Picture of bitemark evidence at the 1979 Chi Omega murder trial of Ted Bundy. From the Florida Memory Project, image #MF0013.

engineer has in helping to investigate situations involving failure analysis of materials and constructions. Forensic engineers are also heavily involved in reconstruction of traffic accidents. They can determine path, direction, speed, the person who was driving, and the type of collision from what may seem to the layperson as scant evidence.

Toxicology

Toxicology involves the chemical analysis of body fluids and tissues to determine if a drug or poison is present. Toxicologists are then able to determine how much and what effect, if any, the substance might have had on the person. Forensic toxicologists often work hand in hand with forensic pathologists. More than half of the cases that forensic toxicologists receive involve drunk driving cases and the determination of the level of alcohol in blood or breath.

Behavioral Sciences

The forensic application of the **behavioral sciences**, psychiatry, psychology, and their related disciplines, ranges from the study of human behavior, including the investigation to the courtroom. Forensic psychiatrists and psychologists have long been involved in the forensic sciences in the determination of a person's competency to stand trial and to aid in one's own defense. Although each state has its own standards for determining insanity, the question usually revolves around whether or not the defendant had the mental capacity to form an intent to commit the crime and/or whether he or she knew right from wrong.

In recent years, behavioral forensic scientists have been called upon to assist law enforcement agents and forensic pathologists in the investigation of serial crimes by creating psychological profiles of the criminals. Such profiling has provided useful information about the person who the police should look for as they investigate serial crimes. People generally act in predictable, reproducible ways when they commit crimes and the discovery of these behavioral patterns can provide clues to the personality of the offender. Behavioral scientists may also be called upon to help in interviewing or interrogating suspects in crimes or to develop profiles of likely airplane hijackers and possible terrorists.

Questioned Documents

Questioned document examination is a complicated and broad area of study; a trainee may study with an experienced examiner for several years before being qualified. This field has many facets including the comparison of handwritten or typewritten documents to determine their source or authenticity. In addition, questioned document examiners may be called upon to detect erasures or other obliterations, forgeries, altered documents, charred documents, and counterfeit currencies. Questioned document examiners analyze papers and inks to determine their source and age.

Other Specialties

Many kinds of scientists may be called upon to play a role in a forensic investigation. This does not mean, however, that this is their full-time job: Their area of expertise may need to be called upon only rarely or only in particular cases. Artists, biologists, chemists, and other specialists may be needed to answer questions in investigations as diverse as mass disasters, airplane crashes, missing persons, and art forgeries (see "In More Detail: Birds of a Forensic Feather").

In More Detail: Birds of a Forensic Feather

When US Airways Flight 1549 made its amazing crash landing in the Hudson River in 2009, probably the last thing on anyone's mind was the word "snarge." The word may sound funny, but "snarge" is the technical term for the pulverized bird guts resulting from the collision of an airplane and a bird. Dr. Carla Dove, at the Smithsonian Institution's Museum of Natural History in Washington, DC, is the Director of the Feather Identification Laboratory, where thousands of bird samples are sent each year for identification, most of them involving bird strikes

(*Continued*)

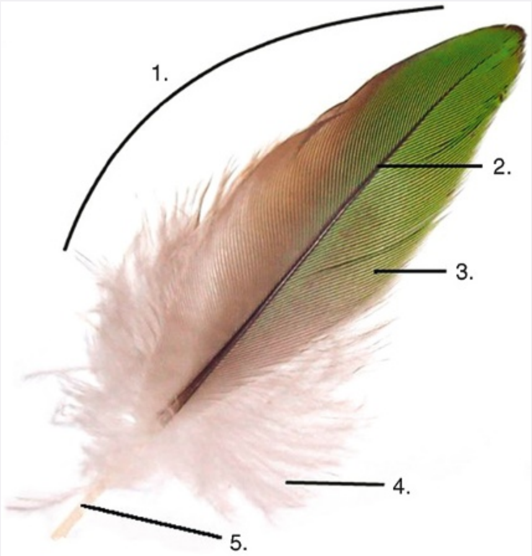


FIGURE 1.2 The anatomy of a feather. (1) Vane; (2) Rachis; (3) Barb; (4) Afterfeather; (5) Hollow shaft, calamus. Public domain image at www.wikipedia.com.

with airplanes. Forensic feather identification is important to not only determine the cause of a crash but also to potentially help rule out other types of causes, such as mechanical issues or terrorist activities. The feathers or other bird parts are examined and compared with the Laboratory's extensive reference collection (over 620,000 samples, some collected by Theodore Roosevelt and possibly Charles Darwin, representing 85% of the world's bird species) to determine the bird's species (see Figure 1.2). If that does not work, the snarge is sent to the DNA laboratory for genetic analysis. A working knowledge of avian anatomy is still crucial in the age of forensic DNA work. In one case, deer DNA was identified on a plane that had a strike at 1,500 feet—clearly not possible. Analysis of a tiny piece of feather identified the bird as a black vulture, which apparently had flesh from a deer carcass in its stomach. The Laboratory, which started analyzing bird remains from airplane crashes in 1960, does work for military crashes as well as commercial airlines. Forensic feather analysis will become more important as the world's climate changes and birds begin to appear where they are not expected to be, either geographically or seasonally.

Wald, M. "They Can Say Which Bird Hit a Plane, Even When Not Much Bird Is Left," *New York Times*, January 25, 2009, page 27.

A Bit of Forensic Science History

Some forms of what we would now call forensic medicine were practiced as far back as the 5th century. During the next thousand years there were many advances in science, but only forensic medicine was practiced to any great extent. The science of toxicology was one of the first "new" forensic sciences to emerge. In an early case, a Mr. Lefarge died under mysterious circumstances and his wife fell under suspicion. The French scientist Mathieu Orfilia, in 1840, examined Lafarge's remains and determined that he had ingested arsenic. He further showed that the source of the arsenic could only have been poisoning, and his wife was subsequently convicted of the crime (Wilson and Wilson, 2003).

The 18th and 19th centuries saw considerable advances in the science of personal identification. As police photography had not been developed and fingerprints weren't being used, there needed to be methods of reliably tracking a person either through the police process or during incarceration. Enter Alphonse Bertillon, a French criminologist, who developed a method of recording physical features of a person in such a way that the record would be unique to that person, referred to as *anthropometry* or *Bertillonage*, after its creator. He developed a set of precise measuring instruments to be used with his method. The Bertillonage system became very popular throughout Europe and the United States. It became widely used in U.S. prisons, which needed a way to track the prisoners. The Bertillon system was plagued by problems of reproducibility and was finally discredited in the United States Penitentiary (USP) Leavenworth in Kansas. In 1903 William West was admitted to the prison to serve a sentence. When he was measured using the Bertillon system, it was found that a man with the name William West with virtually the same set of measurements was already at the prison! This sounded the death knell for Bertillonage and opened the door for the study of fingerprints. Bertillon used fingerprints in his system but didn't have a good way to organize them for mass searches (Wilson and Wilson, 2003). Dr. Juan Vucetich, a Croatian who lived in Argentina and worked for the La Plata police force, conceived of a method of fingerprint classification in 1894 that provided for 1,048,576 primary classifications of fingerprints. As history and culture would have it, his work was largely unheard of in Europe until much later. Sir William Herschel, a British officer in India, and Henry Faulds, a Scottish medical doctor, both studied fingerprints as a scientific endeavor to see whether they could be used reliably for identification. In 1901, Sir Edward Henry devised a fingerprint classification system still used today to categorize sets of fingerprints and store them for easy retrieval (Thorwald, 1964).

Modern blood and body fluid typing got its start around 1900 when Karl Landsteiner showed that human blood came in different types, and his work led to the ABO blood typing system. This work, in turn, led to the discovery of other blood antigen systems such as Rh, MnSs, and the Lewis systems. White blood cell antigen systems were also discovered. From these discoveries came the forensic typing of blood to help distinguish one individual from another (Nuland, 1988).

After Watson and Crick discovered the structure and functions of DNA in the early 1950s, it wasn't until Sir Alec Jeffries developed the first forensic DNA typing method, which he coined, regrettably, "DNA fingerprinting," in 1984 that forensic DNA technology was born. The work of Kary Mullis in the 1980s led to the discovery of the polymerase chain reaction (PCR), the way our bodies reproduce DNA. This discovery led to Mullis's being awarded the 1993 Nobel Prize in Chemistry (Malmstrom, 1997).

In the early part of the 20th century, Goddard popularized the comparison microscope, which is two standard microscopes joined by an optical bridge. This revolutionized the comparison of bullets, cartridges, toolmarks, hairs, and fibers. Microscopy is the mainstay of forensic science laboratories and includes newer methods, such as the scanning electron microscope.

Several professional forensic organizations help forensic scientists keep current and membership can convey many benefits, not the least of which is meeting other forensic scientists and developing contacts. Many of these organizations have journals associated with them. Refer to "On the Web: Professional Forensic Organizations" for more information about these groups.

On the Web: Professional Forensic Organizations

Some professional forensic organizations have regional groups affiliated with them; check the websites for contact information.

American Academy of Forensic Sciences	www.aafs.org
International Association for Identification	www.theiai.org
Association of Firearms and Toolmarks Examiners	www.afte.org
American Society of Questioned Document Examiners	www.asqde.org
Society of Forensic Toxicologists	www.soft-tox.org

Forensic Science Laboratory Organization and Services

Although it may seem contradictory, there is no single structure for the organization of a forensic science laboratory. Their organization varies by jurisdiction, agency, and history. The variation becomes more pronounced when laboratories in the United States are compared with those in other countries. The examinations and services that a forensic science laboratory offers will also vary, depending on budget, personnel, equipment, and crime statistics. This section will focus on laboratories in the United States and answer two questions: First, how is the laboratory administered and second, what services does the laboratory provide?

Forensic Science Laboratory Administration

The vast majority of forensic science laboratories in the United States are public; that is, they are financed and operated by a federal, state, or local unit of government. These number something over 470 today. There are also an undetermined number of private forensic science laboratories, and some estimates put this number at 50 to 100.

Private Forensic Science Laboratories

Most private laboratories serve a niche by performing only one or two examinations, such as drugs, toxicology, or **questioned documents**—many are "one-person" operations, often a retired forensic scientist providing services in the specialties practiced when employed in a public laboratory. Today a significant number of the private laboratories are devoted to DNA analysis in either criminal cases or in the civil area, chiefly in paternity testing. Private laboratories serve a necessary function in our criminal justice system in that they are able to provide forensic science services directly to persons accused of crimes. Most public laboratories can provide forensic science services only to police or other law enforcement departments and will not analyze evidence requested by an accused person except under a court order. Some public laboratories, however, will accept evidence from private citizens, and the fee is subsidized by the jurisdiction where the laboratory operates.

Public Forensic Science Laboratories

Public forensic science laboratories are administered and financed by a unit of government which varies with the jurisdiction. Different states have different models, and the federal government has its own collection of laboratories. Laboratories administered by the federal government, typical state systems, and local laboratories will be discussed separately.

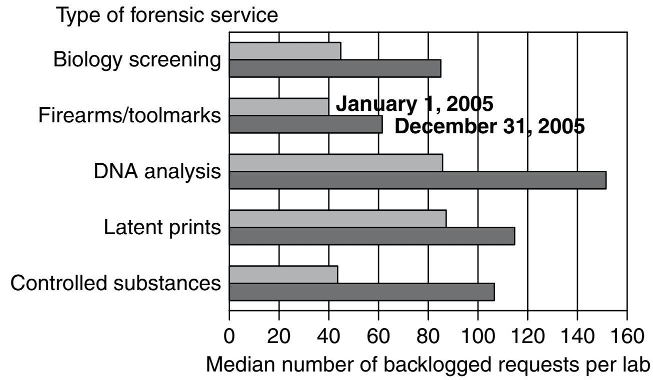
In 2002 and in 2005, the Bureau of Justice Statistics conducted censuses on public forensic science laboratories to provide a basis for better understanding the industry (Durose, 2008). Both reports are available free from the National Criminal Justice Reference Service (www.ncjrs.gov), but the most recent census revealed some troubling facts:

- An estimated 359,000 cases were backlogged at the end of 2005 (see Table 1.1).
- Controlled substance casework accounted for just over half of all backlogged casework (not completed within 30 days) requests.
- About half the laboratories sent casework to a private laboratory to try to stay current in their work.

The census also showed hope for the quality of the nation's forensic laboratories:

- 80% of public forensic laboratories are accredited.
- 80% have some sort of laboratory information management system.
- The overall number of forensic scientists rose by 5%.

TABLE 1.1 The nation's public forensic laboratories experienced an increase in the median number of backlogged requests during 2005 (Durose, 2008).



Another approach to understanding the forensic industry is the FORESIGHT Project, funded by the National Institute of Justice (NIJ) through West Virginia University's College of Business and Economics. Volunteer laboratories in local, state, and national jurisdictions across North America submit standardized business measures for analysis, and this provides a comparison between laboratories' effectiveness (a process called "benchmarking"). The laboratories, in turn, can now self-evaluate their performance against their peers and allocate their resources to the best result. More on the FORESIGHT Project can be found at www.be.wvu.edu/forensic.

Federal Government Forensic Science Laboratories

When most people think of federal forensic science laboratories, the only name that usually pops up is the Federal Bureau of Investigation (FBI) Laboratory. While this is certainly the most famous forensic science laboratory in the United States, if not the world, it is far from being the only one in the federal government. There are a surprising number and types of laboratories administered by several departments of the U.S. government.

The Department of Justice

The Federal Bureau of Investigation (FBI) is a unit of the Department of Justice. It has one laboratory, in Quantico, Virginia, near its training academy. It also maintains a research laboratory, the Forensic Science Research and Training Center in Quantico. The FBI laboratory supports investigative efforts of the FBI and will, upon request, analyze certain types of evidence for state and local law enforcement agencies and forensic science laboratories.

The Drug Enforcement Administration (DEA) is responsible for investigating major illicit drug enterprises and to help interdict shipments of drugs from other countries. In support of this function, the DEA maintains a network of seven drug laboratories throughout the United States. They are in Washington, DC, Miami, Chicago, Dallas, San Francisco, New York, and San Diego. There is also a research and support laboratory, the Special Testing and Research Laboratory, in Chantilly, Virginia. The DEA laboratories not only support the efforts of the DEA investigators but also work with local law enforcement in joint operations.

The Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) has three regional laboratories including Greenbelt, MD, Atlanta, and San Francisco. There is also a fire research laboratory in conjunction with the Washington, DC, laboratory. Although the primary responsibilities of the ATF are embodied in its name—the regulation of alcohol, tobacco, and firearms—the laboratories have particular expertise in fire scene analysis and explosives. It also has the capability of questioned document and fingerprint analyses as well as trace evidence. In 2006, ATF established a DNA analysis capability in its Maryland facility.

The Department of the Treasury

Although one wouldn't usually think of looking at the Treasury Department for forensic science laboratories, it has several. The first laboratory within the Department of the Treasury is the Secret Service Laboratory in Washington, DC. This laboratory has two major functions. The first is in the area of counterfeiting and fraud; counterfeit currency, fraudulent credit cards, and related documents are handled in this laboratory. One of the world's largest libraries of ink standards is located here, and questioned document analysis is also a major function. The second major component of the Secret Service laboratory supports its function of executive protection. This laboratory engages in research and development of countermeasures and protection of the president and other officials.

Then there is the Internal Revenue Service Laboratory in Chicago. This laboratory specializes in the various disciplines of questioned document analysis including inks and papers. A good deal of its work includes authentication of signatures on tax returns, fraudulent documentation relating to taxation, and other forms of fraud in the name of avoiding federal taxation.

The Department of the Interior

The Department of the Interior has a unique laboratory: The U.S. Fish and Wildlife Service operates a forensic science laboratory in Ashland, Oregon. One of the few animal-oriented forensic science laboratories in the world, its mission is to support the efforts of the Service's investigators who patrol the national parks. Among other duties, these agents apprehend poachers and people who kill or injure animals on the endangered species list. Thus, the laboratory does many examinations involving animals and has particular expertise in the identification of hooves, hairs, feathers, bone, and other animal tissues. The laboratory also provides consulting services for other countries in their efforts to track people who traffic in animal parts such as bear gall (in certain parts of Asia bear gallbladders are thought to improve sexual potency) and elephant ivory. The laboratory maintains some of the most sophisticated instrumentation and has some of the world's leading experts in animal forensic science.

The U.S. Postal Service

Although the Postal Service is not strictly a federal agency, nor is it managed by one, it is considered to be a quasi-federal agency. The service maintains a laboratory in the Washington, DC, area that supports the service's efforts to combat postal fraud. This effort mainly involves questioned document analysis although the laboratory also has fingerprint and trace evidence capabilities.

Additional federal laboratories include the Department of Defense's Army Criminal Investigation Division laboratory in Georgia; the Navy drug laboratories in Norfolk, Long Beach, Honolulu, and Japan; and Air Force drug laboratory in San Antonio.

State and Local Forensic Science Laboratories

Every state in the United States maintains at least one forensic science laboratory. Historically, there has been no nationwide effort to standardize laboratory organization or function, so each state has developed a system that meets its particular needs. These forensic science laboratories have arisen from two sources. The most prevalent is law enforcement: The majority of forensic science laboratories are administered by a unit of a state or local police or other law enforcement agency. The other source of forensic science laboratories is health departments or other scientific agencies. In Michigan, for example, the modern Michigan State Police Laboratory system developed from the merger of a smaller MSP laboratory and the state's health department laboratory. The Michigan State Police laboratory had expertise in firearms, questioned documents, and fingerprints, whereas the health department laboratory had expertise in drugs, toxicology, and trace evidence, such as hairs and fibers. The state police in Michigan now operate a network of seven regional laboratories. In all states there is a statewide laboratory or laboratory system that is operated by the state police, state department of justice, or as an independent state laboratory system, such as in Virginia. In California, for example, the state department of justice operates an extensive network of state-financed laboratories, whereas West Virginia has a single laboratory that serves the whole state.

Besides the statewide laboratory system, most states also have one or more laboratories operated by a local governmental unit. For example, in Maryland some counties have laboratories under the jurisdiction of the county police department separate from the state system. In Texas, some police or sheriffs' departments in major cities operate city laboratories, as in Fort Worth; and in California, Los Angeles has a county and a city laboratory. In Michigan, the Detroit City Police Department has its own forensic science laboratory, but the rest of Wayne County surrounding Detroit is serviced by the state police laboratories. This patchwork of political, geographical, and historical jurisdictions can be confusing but is usually maintained because of real societal needs, such as population levels, crime rates, and geography.

Forensic Science Laboratory Services

Forensic science laboratories offer different levels of service. In a statewide system, for example, at least one laboratory will offer a full range of forensic science services (typically at the headquarters laboratory) while the regional laboratories may offer only limited services (say, fingerprints and drugs) and then send the other evidence to the headquarters laboratory. This section discusses the capabilities of a typical full-service forensic laboratory. Keep in mind that the designation of "full service" may mean different things in different states—a laboratory may not offer gunshot residue analysis in even its best-equipped laboratory but would still describe it as "full service" (see Table 1.2).

Standard Laboratory Services

Evidence Intake

All forensic science laboratories have a system for receiving evidence. The laboratory may have one employee assigned to manage this unit full time and may employ several additional people, depending on the volume of evidence and casework. The evidence intake unit will have a secured area for storing evidence, the size of which depends again on the volume of work: It may be a room or a warehouse. A police officer or investigator will bring evidence to the laboratory and fill out a form that describes the evidence and the types of

TABLE 1.2 Forensic functions performed by laboratories, 2005, by type of jurisdiction. *Detail sums to more than 100% because some laboratories reported more than one function; the total includes federal laboratories, not shown separately (Durose, 2008).

Forensic Function	Total*	State	County	Municipal
Controlled substances	89%	88%	94%	85%
Firearms/toolmarks	59	60	59	56
Biology screening	57	58	61	51
Latent prints	55	50	51	76
Trace evidence	55	57	59	44
DNA analysis	53%	55%	61%	42%
Toxicology	53	57	49	47
Impressions	52	50	53	56
Crime scene	40	36	46	56
Questioned documents	20	18	22	24
Computer crimes	12	9	16	15
Number of labs reporting	351	207	79	55

examinations requested. A unique laboratory number will be assigned to the case, and each item of evidence will be labeled with this number, along with other identifying information, such as the item number. This continues the **chain of custody** of the evidence, which is the documentation of the location of evidence from the time it is obtained to the time it is presented in court. The chain of custody begins at the crime scene when the evidence is collected. The job of the evidence intake unit is like that of inventory control for a business.

Modern intake systems use computerized systems that generate barcodes that are placed on each item of evidence or its container. The barcode is scanned by each unit of the laboratory that takes possession of that item so the evidence can be easily traced by computer as it makes its way through the laboratory. Paperwork accompanies the evidence, either in hard copy or electronically, as each analyst signs or accepts possession of the evidence.

Analytical Sections

Once the evidence has been received by the laboratory, it will be assigned to one or more forensic units for analysis; each unit, in turn, assigns a scientist to take charge of the evidence and its analysis. Many times, more than one scientist will be asked to analyze an item of evidence, and then arrangements must be made to get the evidence to each scientist in a logical order. For example, a gun may have to be test fired, but also may contain fingerprints and suspected blood. The examinations must be performed in an order that will not disrupt or destroy any of the evidence on the gun. A full-service laboratory analytical section might contain the following:

- Photography
- Biology/DNA
- Firearms and Toolmarks
- Footwear and Tire Treads
- Questioned Documents
- Friction Ridge Analysis (fingerprints)
- Chemistry/Illicit Drugs
- Toxicology
- Trace Evidence

What all these analyses have in common is that a microscope is used in some fashion because the items examined are small. In some laboratories, one forensic scientist may be certified to examine several of these evidence types; in larger laboratories that have the luxury of specialization, a scientist may examine only one or two.

Other Laboratory Services

Some laboratories offer services in addition to those listed in the preceding section, depending on the need for such services and the availability of qualified scientists. Laboratories that have an occasional need for these services may submit the evidence to the FBI laboratory, a private laboratory, or a local specialist. Specialists areas include polygraph (so-called lie detectors), voiceprint and speaker identification, bloodstain pattern analysis, entomology, odontology, and anthropology.

Administrative Issues with Forensic Science Laboratories

Forensic science laboratories are faced with ever increasing demands and workloads. Courts have come to expect more and higher quality expert testimony and speedier turnaround times from forensic laboratories. More scrutiny also has been placed on the forensic science systems around the world by the public, the media, and government officials. This has caused a number of administrative issues to assume greater importance; two of the major ones are accountability and access.

Accountability

Virtually every hospital and clinic in the United States has to be accredited by a responsible agency. Environmental and pharmaceutical companies, among others, also have accreditation procedures. Thus, it might come as a surprise to many people to find out that there is no mandatory accreditation process for the nation's forensic science laboratories. Considering the impact that forensic science can have on trials, this situation is disturbing.

Arguably, the major reason for this state of affairs is that forensic science laboratories historically have arisen within police agencies whose focus is not science. Movements in the United States and worldwide to accredit forensic science laboratories have had some success: Some states, such as New York, make it mandatory for forensic laboratories to be accredited, but many seek accreditation voluntarily. In the United States, the **American Society of Crime Laboratory Directors** (**ASCLD**) has formed a subsidiary, the **ASCLD Laboratory Accreditation Board** (**ASCLD-LAB**), which provides accreditation services for public and private laboratories worldwide. The accreditation process is rigorous and involves a self-study process, an extensive checklist of requirements, and an on-site evaluation by trained members of the accrediting board. It should be stressed that ASCLD accreditation does not directly address the competence of the individual forensic scientists who work at the laboratory. It does mean that the laboratory meets certain minimum criteria for the physical plant (facilities, heating-cooling, etc.), security, training, equipment, quality assurance and control, and other essential features. Re-accreditation is required every 5 years to maintain the laboratory's status.

Standards play a major role in helping laboratories become accredited. The **American Society for Testing and Materials, International** (**ASTM**), publishes voluntary consensus standards for a wide variety of sciences, including forensic science (Committee E30, Volume 14.02). They are voluntary because individuals and agencies independently choose to adhere to them. The standards are written through a consensus process, meaning that everyone on the subcommittee, committee, and the Society has had a chance to read, comment, and vote on the standard.

Other accreditation processes, such as the **International Organization for Standardization** (**ISO**), are gaining headway, and it is hoped that someday soon forensic science laboratory accreditation will become mandatory and every laboratory will become accredited. More information about forensic standards and accrediting agencies can be found on the websites listed in "On the Web: Accreditation."

On the Web: Accreditation

American Society of Crime Laboratory Directors (ASCLD)	www.ascld.org
ASCLD Laboratory Accreditation Board (ASCLD-LAB)	www.ascld-lab.org
American Society for Testing and Materials, International (ASTM)	www.astm.org
International Organization for Standardization (ISO)	www.iso.org

Access to Laboratory Services

The majority of forensic science laboratories in the United States are funded by the public and administered by a unit of federal, state, or local government. These laboratories support the law enforcement functions of the parent agency or the government. Police officers, detectives, crime scene investigators, and prosecutors generally have open access to the services of the laboratory, including expert testimony by its forensic sciences at no cost to the agency. Considering that the public pays for these services, it might seem obvious that a person accused of a crime should also have access to these services. That, however, is not the case. Very few public forensic science laboratories will permit accused persons access to forensic science services even if that person is willing and able to pay for them.

How then do criminal defendants gain access to forensic science services? The options are limited. Private laboratories serve defendants (and anyone, really), but the cost is generally high and often courts will not authorize enough money for indigent defendants to cover the costs of analysis and testimony. If an accused person has a public defender for an attorney, most public defenders' offices do not have sufficient funds to pay for analyses of evidence. Even people willing and able to pay may not have a qualified forensic science laboratory available. This results in an imbalance in the resources available to the prosecution and defense in a criminal case. It is interesting to note that the British justice system, faced with this same problem, is addressing this imbalance by requiring public laboratories to charge all agencies for scientific analysis and testimony. It has not been universally embraced (see "In More Detail: Public or Private?"), however, and only time will tell if it succeeds or creates new problems.

In More Detail: Public or Private?

The majority of forensic science laboratories in the United States are public; that is, they are funded by and operated within government agencies, such as local or state police departments. Police and prosecutors submit evidence for analysis, and they don't need to pay for this service. The costs are covered by taxes. A few private commercial laboratories charge for their services. Anyone with sufficient money can walk in and request examinations.

In the United Kingdom, the Forensic Science Service (FSS) is a quasi-governmental forensic laboratory. It is a governmental agency, but it also charges police and agencies for its services. If it gets to make a profit, the agency keeps it: In 2003, the FSS made a profit of £10 million (US $17,475,937 in 2003), which was reinvested in public service. A movement to fully privatize the FSS is afoot, and forensic agencies around the world are watching to see what happens. The implications strike to the core of what constitutes forensic investigations and analyses.

Police need accurate information and they need it quickly. A profit-oriented FSS would, in essence, charge by the hour and the examination. Thus, dollars, and not necessarily solutions, would drive the investigation. At £1,375 (about US $2,400 in 2003) per DNA sample, an investigator might think twice about indiscriminately submitting evidence that would clog up the laboratory. This situation should lead investigators to investigate, collect, and submit smarter rather than out of fear.

(*Continued*)

But the police might also find all kinds of ways to cut costs. What if, as an example, five cigarette butts were found at a crime scene and the victim was known not to smoke. The most effective method for determining if the suspect's DNA is on the cigarette butts (offering probable cause to arrest him) is to test them all. This testing is costly—almost $10,000 by the prices quoted previously. The cost-effective approach, however, would be to test one and see whether a result is obtained; if that one didn't yield a result, the next one could be tried, and so on. This process could take, literally, months and give the suspect time to flee or, worse, commit more crimes. This situation has been referred to as the "staging problem," where evidence is analyzed in stages.

Selectivity and screening can also be problems. In the case of a rape, a vaginal swab is collected to check for the rapist's semen but, for the sake of argument, the results are inconclusive. Paying a scientist to pour over the victim's bedding in search of semen stains or other trace evidence wouldn't be cheap. If the police are pressured to save money, the cheap and easy method wins—although it isn't effective.

Another method to reduce costs would be to quickly screen evidence and not continue an analysis if the initial presumptive test is negative. Sensitivity of presumptive tests is an issue, however; so-called screening tests may not be as sensitive as other, "in lab" tests. Major cases or those with a high media profile would probably get nearly unlimited budgets, but what about the "average" rapes, burglaries, and death investigations? DNA isn't always found or effective; in some cases, like spousal rape, it can't prove a thing. Hours and hours of searching for microscopic evidence may not be cost-effective, but it can be *results*-effective. And in some instances, it could be cost-effective (see Table 1.3).

For example, in three hypothetical cases involving hairs in three laboratories with differing sampling protocols, the laboratory employing microscopic hair examinations has a more efficient and cost-effective supply chain than laboratories that do not. Therefore, while hair examiners may be considered to be a "waste of time and money" by some laboratory managers, they, in fact, can save both time and money.

Regardless of how the FSS proceeds with privatization, the argument about the best way to provide proper access to forensic sciences for all citizens has yet to be concluded.

TABLE 1.3 Cost effectiveness of microscopical hair examination

($1,500 per sample for MTDNA)	Lab#1 analyzes DNA on all Q hairs, plus all K samples		Lab#2 analyzes only two hairs from victim's underwear and SAK, plus all K samples		Lab#2 analyzes only one hair after microscopic exam from each item, plus 2 K samples	
	Cost	**Accuracy**	**Cost**	**Accuracy**	**Cost**	**Accuracy***
Small Case 2 positive/ 5 total 2 known samples	$10,500	100%	$9,000	80%	$6,000	90%
Medium Case 5 positive/ 15 total 4 known samples	$36,000	100%	$12,000	27%	$9,000	90%
Large Case 15 positive/ 50 total 6 known samples	$84,000	100%	$15,000	8%	$12,000	90%

* Based on rates published in Houck, M.M. and Budowle, B. *JFS*, V47, N5, 2002; these rates are not applicable to any one particular case, set of samples, or examiner.
Table taken from Houck, M.M. & Walbridge, S. (2004, February). *Could Have, Should Have, Would Have: The Utility of Trace Evidence*. Presented at the American Academy of Forensic Sciences annual meeting, Dallas, TX.

The Forensic Scientist

Forensic scientists have two major duties: performing scientific analysis of evidence and offering expert testimony in criminal and civil proceedings. There are sometimes other responsibilities such as offering training in evidence collection and preservation, doing research, or performing other studies such as validation procedures for new methods, but the major duties take up most of the forensic scientist's time.

Education and Training of Forensic Scientists

Science is the heart of forensic science. Court decisions, such as *Daubert v. Merrell Dow* (1993), have reinforced this fact. A forensic scientist must be well versed in the methods and requirements of good science in general and in the specific techniques used in the particular disciplines being practiced.

Additionally, the forensic scientist must be familiar with the rules of evidence and court procedures in the relevant jurisdictions. The knowledge, skills, and aptitudes needed in these areas are gained by a combination of formal education, formal training, and experience.

Education

Historically, forensic scientists were recruited from the ranks of chemistry or biology majors in college. Little or no education was provided in the forensic sciences themselves—all of that was learned on the job. Since the middle of the 20th century, undergraduate, and then graduate, programs in forensic science have been offered by a handful of colleges and universities in the United States. The early bachelor's degree programs provided a strong chemical, mathematical, biological, and physical science background coupled with applied laboratory experience in the analysis of evidence with classes in law and criminal procedure mixed in. These programs also offered opportunities for a practicum in a functioning forensic science laboratory to see how science was applied in forensic laboratories. The American Academy of Forensic Sciences website (www.aafs.org) lists about 40+ programs that offer a bachelor's degree with some level of forensic emphasis.

In the past 20 years or so, graduate degrees, particularly at the master's level, have become the norm. They typically require a bachelor's degree in a science and then teach the applications of the science to forensic work, as well as relevant aspects of law, criminal investigation, and criminal justice classes. A research component is also generally required. For more information about forensic science educational accreditation standards, see "In More Detail: FEPAC."

In More Detail: FEPAC

The American Academy of Forensic Sciences (AAFS) initiated the **Forensic Science Education Programs Accreditation Commission** (**FEPAC**) as a standing committee of the Academy. The mission of the FEPAC is to maintain and to enhance the quality of forensic science education through a formal evaluation and recognition of four-year, college-level academic programs. The primary function of the Commission is to develop and to maintain standards and to administer an accreditation program that recognizes and distinguishes high-quality undergraduate and graduate forensic science programs. As of January 2009, 26 graduate and undergraduate programs have been accredited by FEPAC. In 2009, FEPAC began a process for programs offering degrees in digital evidence and computer forensic investigation. The FEPAC Standards are based on a guideline published by the National Institute of Justice, *Education and Training in Forensic Science*, which was the work product of the Technical Working Group on Education and Training in Forensic Science (TWGED). For more information about FEPAC and a listing of accredited forensic science programs, visit www.aafs.org.

Educational programs are not, however, designed to provide training so that graduates can start working cases on their first day in a forensic science laboratory.

Formal Training

Once scientists are employed by a forensic science laboratory, they begin formal training. New scientists are normally hired as specialists; they will learn how to analyze evidence in one or a group of related areas. Thus, someone may be hired as a drug analyst, a trace evidence analyst, or a firearms examiner. Training requires a period of apprenticeship where the newly hired scientist works closely with an experienced scientist. The length of time for training varies widely with the discipline and the laboratory. For example, a drug chemist may train for three to six months before taking cases, while a DNA analyst may train for one to two years, and a questioned document examiner may spend up to three years in apprenticeship. Training usually involves mock casework as well as assisting in real cases. Ideally, it will also include proficiency testing at intervals and mock trials at the end of the training.

On-the-Job Training: Experience

Once a forensic science student graduates, his or her professional learning really has only begun. Laboratories train new employees in the technical and administrative aspects specific to that agency. Each case is a project of sorts and managing time and resources is a new experience for many new employees. The pressures of testifying in court must be managed, the "hurry up and wait" of testifying, the media (possibly), and dealing with harried attorneys are all important skills not taught in college courses. These aspects of the forensic career are difficult to convey to someone who has not experienced them.

Analysis of Evidence

The reason someone wants to become a forensic scientist is to analyze evidence. The science and method of this process fill much of the rest of this book. But besides the routine analysis of evidence, many important aspects other than science affect how evidence gets analyzed:

- *Chain of custody:* The forensic scientist must be constantly aware of the requirements of the chain of custody. Evidence can be rendered inadmissible if the chain of custody is not properly constructed and maintained.

- *Turn-around time:* There are federal and state "speedy trial" laws that require that an accused person be brought to trial within a specified window of time after arrest; this is usually 180 days but may vary with the jurisdiction. If the forensic science laboratory cannot analyze and report evidence out in a timely manner, the accused may be released for failure of the government to provide a speedy trial.
- *Preservation and spoilage:* Forensic scientists have a duty to preserve as much of the evidence as is practical in a each case and to ensure that the evidence is not spoiled or ruined. In some cases, so little evidence exists that there is only one chance for analysis. In such cases, the prosecutor and defense attorney should be apprised before the analysis takes place.
- *Sampling:* In many cases there is so much evidence that sampling becomes an issue. This often happens with large drug cases in which there may be hundreds or thousands of similar exhibits; it can also be true of bloodstains, fibers, or any type of evidence. The opposite may also be true: insufficient sample for complete or repeat analysis. Finally, in some cases any type of analysis may be destructive, and there is no opportunity for re-analysis.
- *Reports:* Every laboratory has protocols for writing laboratory reports, but a surprising lack of uniformity exists from laboratory to laboratory. Some laboratories mandate complete reports for each case, whereas others have bare-bones reports with a minimum of description and explanation. Reports of forensic science analysis are scientific reports and should be complete like any other scientific report.

Expert Testimony

Being a competent analytical scientist is only half the battle in a forensic science laboratory. The forensic scientist must also be able to explain his or her findings to a judge or jury in a court of law. This is one of the key factors that distinguish careers in forensic science from those in other sciences.

There are a number of definitions of an expert. For forensic science purposes, an expert may be thought of as a person who possesses a combination of knowledge, skills, and abilities in a particular area that permit him or her to draw inferences from facts that the average person would not be competent to do. In short, an expert knows more about something than the average person and has the credentials to prove it. An expert does not have to possess a Ph.D. Many experts have accumulated expertise over many years of experience and may not have much education. For example, suppose that a man is killed while driving his car because the brakes failed and he crashed into a tree. If an average group of people were to inspect the brakes of the car, those people would not be competent to determine why the brakes failed or even if they did. This would require the services of an expert mechanic to examine the brake system and then make conclusions about if, why, and how the brakes failed. A difference exists, however, between an expert and a forensic scientist: A mechanic is not a forensic scientist. That difference is what this book is about.

Summary

Forensic science is a wide-ranging field with a rich, if untapped, history. In many ways, the discipline has suffered from that lack of historical knowledge and our ignorance of it—not knowing the past dooms one to repeat it, and so forth. Forensic science also occupies what may be a unique niche between law enforcement and the courts. The pressures from either side color much of what is accepted as forensic science, and yet practitioners must adhere to the tenets of science. Because forensic science is seen as a growth industry, one would be hard pressed to find another discipline with so much rich material to mine or such promise in the dazzling future of technology.

Test Your Knowledge

1. What is forensic science?
2. How is forensic science different from other sciences, like biology and physics?
3. What does the word "forensic" mean?
4. Name four disciplines within the forensic sciences.
5. What are the two kinds of forensic science laboratories?
6. What is the main difference between these two types of forensic laboratories?
7. Name three federal agencies that have forensic science laboratories.
8. What is a chain of custody?
9. Who accredits forensic science laboratories?
10. Who was Will West?
11. What is FEPAC?
12. What is ASCLD?
13. What is ASCLD-LAB?
14. To whom are forensic laboratories accountable?
15. What is a forensic anthropologist?
16. Who was Bertillon?
17. What laboratory analyzes wildlife samples in criminal cases?
18. Why would the Department of Defense need forensic laboratories?
19. What is a forensic toxicologist? How would this differ from a regular toxicologist?
20. What's an expert?

Consider This …

1. Why do you think a mechanic who helps to determine if the brakes failed in one automobile accident is or is not a "forensic scientist"?
2. Is privatization a good way to ensure every citizen has access to forensic science services?
3. Why is formal training necessary once someone is hired by a forensic science laboratory? Why is a forensic science education alone not sufficient?

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