CHAPTER 13  Forensic Scientists

Forensic Scientists

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KEY TERMS

Bloodstain Pattern Analysis: The examination of the shapes, locations, and distribution patterns of bloodstains for the purpose of interpreting the physical events that caused them (Chieum, 2007).

Crime Reconstruction: The determination of the actions and events surrounding the commission of a crime.

Digital Evidence Analysis: The examination of any data stored or transmitted using a computer or other personal electronic device, that tends to support or refute a theory of how an offense occurred or that addresses critical elements of the offense such as intent or alibi.

Fire Debris Analysis: The examination of material collected at fire scenes for chemical and physical properties related to flammable and combusted liquids that may have been used as accelerants.

Firearms and Tool Mark Examiners: Forensic examiners who use microscopic comparisons of markings to associate an item of evidence with a particular source (Rowe, 2003, p. 327).

Forensic Accountants: Accountants who examine, or audit, financial records to answer investigative questions and help resolve legal disputes.

Forensic Biologists: Scientists such as DNA analysts and serologists who attempt to identify biological material, such as bodily fluids, hair, bones, and tissue.

Forensic Generalists: Forensic scientists who are broadly educated and trained in a variety of forensic specialties.

Forensic Odontology: (a.k.a. forensic dentistry) The "application of the arts and sciences of dentistry to the legal system" (Glass, 2003, p. 61).

Forensic Pathologists: Scientists charged with determining cause and manner of death in cases of violent or unexpected death.

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Forensic Science: The application of scientific knowledge and principles to the resolution of legal disputes, whether criminal or civil.

Forensic Specialists: Forensic scientists trained in a specific forensic subspecialty, such as an area of criminalistics, forensic toxicology, forensic pathology, or forensic anthropology.

Forensic Toxicologists: Scientists who can collect and examine all manner of biological specimens for testing whether and in what quantity certain substances are present.

Trace Evidence Analysis: The examination of the nature of unknown samples and their comparison with others of a similar nature to determine their origin by establishing the physical, microscopic, and chemical characteristics.

"Sir Arthur Conan Doyle authored the very first Sherlock Holmes mystery, A Study in Scarlet, which was published in November 1887 as the main part of Beeton's Christmas Annual."

Students and professionals alike have a long tradition of approaching those who call themselves "forensic scientists" with awe and deference. The author's experience is that this behavior is largely in response to a historically favorable portrayal in true crime dramas. Since the publication of the first story featuring the fictional detective Sherlock Holmes, books, and later television and film, have depicted forensic scientists as deeply astute crimefighters. They are shown to be capable of rendering a world of dead-on inferences from a drop of blood, a strand of hair, or an object just out of place in a crime scene. They are also presented in near-complete alignment with law enforcement efforts, either as part of the police investigation or the later prosecution of a case.

Unfortunately, this uniformed and embellished view has left a false portrait of infallibility. Since the late 20th century, judges, prosecutors, and attorneys have scrutinized the individualizing and reconstructive claims and qualifications of forensic experts. Although various reasons exist as to why these legal actors did not forcefully and repeatedly challenge such evidence, it is undeniable that this lack of scrutiny has permitted the forensic community to operate below the radar. Left unchecked by the courts, much of the forensic community has grown and evolved believing that it is immune to error, and therefore free from it.
Subsequently, there have been more than a few forensic examiners, and disciplines, that have felt justified in portraying themselves as essentially infallible. This self-congratulatory portrayal has in turn perpetuated the apathetic approach that courts, prosecutors, and defense attorneys have historically taken. These circumstances have also fostered an unsettling and nonscientific atmosphere in which much of the forensic community does not feel obligated to conduct research and substantiate the certainty of their claims. Moreover, these circumstances have created a culture in which forensic examiners feel justified in asserting to statistics, reenactments, and interpretations that often have little, if any, foundation in science or logic.

In February of 2009, however, the climate of unquestioned adulation changed with the publication of a report by the National Academy of Science (a.k.a. the NAS Report), *Strengthening Forensic Science in the United States: A Path Forward* (Edwards and Goranson, 2009). The impetus for this systemwide investigation and review of the forensic sciences included the following: the publication of an ongoing series of critical legal reviews regarding the tremendous bias and lack of science in forensic practice (e.g., Cole, 2005; Cooley, 2004; Raiser, Saks, Thompson, and Rosenthal, 2002; Schwartz, 2005), the occurrence of numerous highly publicized forensic blunders and crime lab scandals across the United States, the ever increasing number of DNA exonerations sourced back to flawed or misleading forensic evidence documented by groups like the Innocence Project, and the publication of Chisum and Turvey (2007), all referenced in the final version of the report. The findings were prepared to inform the U.S. Congress, to help them with related legislative and budgetary decisions, per the role of the NAS.

Judge Harry T. Edwards was the co-chair of the NAS Committee responsible for investigating the forensic science community and the final NAS Report. He testified to the Senate Committee on the Judiciary on March 18, 2009, regarding his role and perspective (Edwards, 2009):

I started this project with no preconceived views about the forensic science community... And I do not watch CSI programs on television, so I was not affected by Hollywood’s exaggerated views of the capacities of forensic disciplines. Rather, I simply assumed, as I suspect many of my judicial colleagues do, that forensic science disciplines typically are grounded in scientific methodology and that crime laboratories and forensic science practitioners generally are bound by solid practices that ensure that forensic evidence offered in court is valid and reliable. I was surprisingly mistaken in what I assumed. The truth is that the manner in which forensic evidence is presented on television—as invariably conclusive and final—does not correspond with reality.

Subsequently, they will be asked to explain to the history of the relationship between criminology and clinical psychology to digital evidence to criminal profiling and more. The relationship between forensic science and criminology may be observed through the lens of higher education. Though many students with chemistry and biology majors go on to work in crime labs, forensic science programs themselves are applied and vocationally oriented. Most such programs, even those with a DNA component, tend to be housed within schools of forensics and criminal justice when found on the college or university campus.

Skeptics may also wish to examine the pages of James and Nordby’s *Forensic Science* (2003) or the Encyclopedia of Forensic Science by Seigel, Sautkis, and Knupfer (2006). Both explore the vast geography of the forensic science community at length, well beyond the borders of a traditional crime laboratory setting. Coverage is given to everything from forensic toxicology to forensic psychology to digital evidence to criminal profiling and more.

It may also be useful to read or reread the preface of this text, where the history of the relationship between criminology and forensic science is expounded.

**The Distinguishing Feature**
Perhaps the best explanation of what a forensic scientist is comes from Dr. John Thornton, the noted criminologist mentioned in Chapter 1. He writes that the defining quality of forensic scientists is the possibility that they will be called upon to present scientific findings, under penalty of perjury, in a court of law. Subsequently, they will be asked to explain to the court what those findings mean and how they came to be. Those examiners whose work does not

This author would agree, and is of the opinion that the findings of the NAS Report, which have been incorporated into this work, have brought forensic scientists back to earth.

The purpose of this chapter is to define the nature and scope of the service of forensic scientists, their investigative and legal value, and the educational requirements within major subspecialties. It will conclude with recommendations on how forensic criminologists can best utilize the forensic scientists in their cases. In this way we will serve students by showing them career choices and pathways, while at the same time giving practitioners insight into what is available and how to assess its worth.

**FORENSIC SCIENCE DEFINED**

Forensic science is the application of scientific knowledge and principles to the resolution of legal disputes, whether criminal or civil. This definition, being generally consistent across forensic science textbooks and professional organizations, is quite broad. As defined at the beginning of this text, forensic science in its application is a subdiscipline of criminology.

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The unique role of the forensic scientist is ultimately that of an educator to within the forensic science community itself. An assessment of the discontinuity is offered in Edwards and Gotsonis (1999), (2009, p. S-5): "Not all forensic services are performed in traditional crime laboratories by trained forensic scientists. Some forensic tests might be conducted by a sworn law enforcement officer with no scientific training or credentials, other than experience. In smaller jurisdictions, members of the local police or sheriff's department might conduct the analyses of evidence, such as latent print examinations and footwear comparisons.

The "Real" Forensic Scientists

As explained in Inman and Rudin (1999), there is much confusion over who precisely the "real" forensic scientists are and who they are not. This is true even within the forensic science community itself. An assessment of the discontinuity is offered in Edwards and Gotsonis (2009, p. S-5):

The term "forensic science" encompasses a broad range of forensic disciplines, each with its own set of technologies and practices. In other words, there is wide variability across forensic science disciplines with regard to techniques, methodologies, reliability, types and numbers of potential errors, research, general acceptability, and published material. Some of the forensic science disciplines are laboratory based (e.g., nuclear and mitochondrial DNA analysis, toxicology and drug analysis); others are based on expert interpretation of observed patterns (e.g., fingerprints, writing samples, toolmarks, bite marks, and specimens such as hair). The "forensic science community," in turn, consists of a host of practitioners, including scientists (some with advanced degrees) in the fields of chemistry, biochemistry, biology, and medicine; laboratory technicians; crime scene investigators; and law enforcement officers. There are very important differences, however, between forensic laboratory work and crime scene investigations. There are also sharp distinctions between forensic practitioners who have been trained in chemistry, biochemistry, biology, and medicine (and who bring these disciplines to bear in their work) and technicians who lend support to forensic science enterprises.

Moreover, Edwards and Gotsonis (2009) found the forensic science community poorly focused and badly fragmented, with no clear practice standards, consistent terminology, or standardized means of practitioner certification. Suffice it to say that forensic science is not always practiced in a crime lab, it is not always practiced by someone working for law enforcement (nor should it be, ideally), and, unfortunately, it is not always practiced by scientists.

However, it must also be pointed out that the vast majority of full-time forensic science practitioners in the United States work in police agencies or government-funded crime labs, providing their services exclusively to law enforcement. Edwards and Gotsonis explain that (2009, p. 1–2)

According to a 2005 census by the Bureau of Justice Statistics (BJS), 389 publicly funded forensic crime laboratories were operating in the United States in 2005: These included 210 state or regional laboratories, 84 county laboratories, 62 municipal laboratories, and 33 federal laboratories, and they received evidence from nearly 2.7 million criminal cases. These laboratories are staffed by individuals with a wide range of training and expertise, from scientists with Ph.D.s to technicians who have been trained largely on the job. No data are available on the size and depth of the private forensic laboratories, except for private DNA laboratories.

This circumstance exists in no small part because forensic science in practice is an applied science (Inman and Rudin, 1999). This means that practitioners borrow from the research and principles of other established scientific disciplines and apply it to their own forensic casework. Because many forensic practitioners are not themselves scientists, especially those in direct police service, the results of their analyses can range from the exceptionally informed to the patently absurd.

Another issue is the distinction that must be made between scientist and technician practitioners of forensic science. The NAS Report goes out of its way to make a clear distinction between forensic scientists and forensic technicians. It provides, among other things, that (Edwards and Gotsonis, 2009, p. S-5)

There are also sharp distinctions between forensic practitioners who have been trained in chemistry, biochemistry, biology, and medicine (and who bring these disciplines to bear in their work) and technicians who lend support to forensic science enterprises. Many of these differences are discussed in the body of this report.
The contrast between technician and scientist is both subtle and tremendous. This situation provides an interpretation of forensic technicians to results and technicians who do little more than inject a sample and push a button without understanding—whose interpretations are left to provide interpretations to the trier of fact with scientists to construct experiments that generate the empirical consequences.

A technician is one who is trained in specific procedures, learned by routine or repetition. A forensic technician is trained in the specific procedures related to collecting and even testing evidence found at crime scenes. This is without any need for employing or even understanding the scientific method and the principles of forensic science. This describes the police technicians documenting crime scenes and collecting evidence, and more than a few of the forensic personnel working in government crime labs.

A scientist is someone who possesses an academic and clinical understanding of the scientific method and the analytical dexterity to construct experiments that will generate the empirical reality that science mandates. A forensic scientist is one who is educated and trained to examine and determine the meaning of physical evidence in accordance with the established principles of forensic science, with the expectation of presenting her findings in court. This describes fewer and fewer of those practicing forensic science in government crime labs.

As the authors have experienced on countless cases, it is technicians, investigators, and ultimately attorneys who are actually providing a majority of crime reconstructions in court, often with little understanding of forensic science or the scientific method, to say nothing of the natural limits of physical evidence. Crime lab personnel are performing any necessary laboratory analysis, but police and prosecutors are taking the final step to explain events and their relationships in court. This has the net effect of elevating the lay testimony of investigators and forensic technicians to that of the forensic scientist and of reducing the expert findings of the forensic scientist to the level of the technician.

A Culture of Science

As already mentioned, the NAS Report provides for the need to separate the current broken forensic science community from law enforcement culture. This is discussed in several sections of the report and all throughout Chapter 6, "Improving Methods, Practice, and Performance in Forensic Science," where it is explained (Edwards and Gotsonis, 2009, p. 6-1):

The majority of forensic science laboratories are administered by law enforcement agencies, such as police departments, where the laboratory administrator reports to the head of the agency. This system leads to significant concerns related to the independence of the laboratory and its budget. Ideally, public forensic science laboratories should be independent of or autonomous within law enforcement agencies. In these contexts, the director would have an equal voice with others in the justice system on matters involving the laboratory and other agencies. The laboratory also would be able to set its own priorities with respect to cases, expenditures, and other important issues. Cultural pressures caused by the different missions of scientific laboratories vis-à-vis law enforcement agencies would be largely resolved. Finally, the forensic science laboratories would be able to set their own budget priorities and not have to compete with the parent law enforcement agencies.

The NAS Committee's recognition of the incompatibility between scientific and law enforcement/prosecutorial goals, and the bias this can and has created, is perhaps its most significant contribution to the future of the forensic science community.
To correct institutional bias, which accounts for many of the unwanted observer effects discussed in this chapter, it may be time to consider separating the forensic scientist once and for all from police culture. In other words, it may be time to consider separating all state crime labs physically, philosophically, and fiscally from law enforcement and to advocate for the creation of wholly independent state divisions of forensic science that are publicly funded but available to all.

The idea is not new. Dr. Paul T. Kirk and Lowell Bradford (1965, pp. 22–23) advocated for independent crime labs four decades ago:

An independent operation, not directly a part of any other law enforcement agency, but available to all, would certainly find it easier to maintain the high degree of scientific objectivity that is so essential to good operation. It is very probable that the quality of service furnished would be higher than is now possible, because there would be no dependence on budgets of the other organization with their inevitable competition for available funds, and there would be no question of comparable rank of personnel, which is a problem in some organizations under the common American system.

Similarly, Professor James Starrs (1963) urged that the “inbred bias of crime laboratories affiliated with law enforcement agencies must be breached.” Professor Paul Gianfani (1997) also advocated for independent crime labs, stating, “These laboratories should be transferred from police control to the control of medical examiner offices, agencies that are already independent of the police.”

As forensic scientists and legal scholars agree, and the NAS Report makes clear, science of any kind cannot survive, and therefore does not belong, in the culture of law enforcement. Subsequently, there is an argument to be made that those forensic practitioners employed solely by law enforcement or the prosecution are not forensic scientists at all, but rather police practitioners. In any case, no scientist worth his or her salt wears a badge or a gun, or considers who signs his or her paycheck when rendering results. Therefore, separation of one culture from the other should be painless unless the scientist has become over-identified with law enforcement or the prosecution—which is precisely the problem that needs remedy.

### Education for Forensic Scientists

The imposition of basic educational standards is one of the greatest challenges confronting the forensic science community. A major contributing factor to our problem is, again, the alignment of forensic science with the law enforcement community. Many forensic examiners work for or within law enforcement agencies that have very low educational requirements, as do, subsequently, their in-house forensic positions. This is not something that the law enforcement community prefers to acknowledge or be reminded of. Therefore, to remain in the good graces of the many uneducated forensic examiners employed by law enforcement, most forensic professional organizations either do not impose degree requirements or provide exceptions to scientific education for law enforcement experience. This has created one of the core problems that the NAS Report identified: an overall lack of scientific education and training, let alone an absence of scientific culture, in the forensic sciences.

The NAS Report makes clear in its discussion of education reform that at the very least an undergraduate degree in the forensic sciences or some other related science (e.g., biology, chemistry, engineering) is necessary, and that a graduate degree is preferable. It also provides that mere on-the-job training is an inadequate substitute for scientific education (Edwards and Gottonis, 2009, p. 8–1):

> Forensic examiners must understand the principles, practices, and contexts of science, including the scientific method. Training should move away from reliance on the apprentice-like transmittal of practices to education at the college level and beyond that is based on scientifically valid principles, as discussed in Chapter 4. For example, in addition to learning a particular methodology through a lengthy apprenticeship or workshop during which a trainee discerns and learns to copy the skills of an experienced examiner, the junior person should learn what to measure, the associated population statistics (if appropriate), biases and errors to avoid, other threats to the validity of the evidence, how to calculate the probability that a conclusion is valid, and how to document and report the analysis. Among many skills, forensic science education and training must provide the tools needed to understand the probabilities and the limits of decision-making under conditions of uncertainty.

To correct some of the existing deficiencies, the starting place must be better undergraduate and graduate programs, as well as increased opportunities for continuing education. Legitimizing practices in the forensic science disciplines must be based on established scientific knowledge, principles, and practices, which are best learned through formal education and training and the proper conduct of research.

This basic scientific observation runs contrary to the views of many law enforcement forensic examiners who have been arguing for generations that experience trumps education and that science can be learned on the job, taught by one police officer to another. It also helps with the task of preventing law
enforcement examiners and prosecutors from arguing or suggesting that one must be in law enforcement, or work for law enforcement, to be a forensic scientist.

Additionally, the NAS Report notes that the lack of higher education in forensic science is directly associated with the lack of available scientific research in its many specialties (Edwards and Gotsonis, 2009, p. 8–11):

Many forensic degree programs are found at small colleges or universities with few graduate programs in science and where research resources are limited. The lack of research funding has discouraged universities in the United States from developing research-based forensic degree programs, which leads to limited opportunities to attract graduate students into such programs. Only a few universities offer Ph.D.-level education and research opportunities in forensic science, and these are chemistry or biology programs with a forensic science focus.

Most graduate programs in forensic science are master’s programs, where financial support for graduate study is limited. In addition, the lack of research funds means that universities are unlikely to develop research programs in forensic science. This lack of funding discourages top scientists from exploring the many scientific issues in the forensic science disciplines. This has become a vicious cycle during which the lack of funding keeps top scientists away and their unavailability discourages funding agencies from investing in forensic science research. Traditional funding agencies have never had a mission to support forensic science research.

This finding provides the argument for establishing Ph.D. forensic science programs to fund and develop much needed research in the forensic sciences. It is something that just about every other scientific discipline enjoys and benefits from. Until this happens, the education available to prospective forensic scientists will be that much less, and research in the forensic sciences will continue to suffer.

**FORENSIC SCIENTISTS**

There are many different kinds of forensic scientists, as many as there are types of evidence to examine and interpret. There are forensic psychiatrists, forensic psychologists, forensic victimologists, and even forensic criminologists—all of whom are discussed in this text. However, there are also the more traditionally regarded forensic sciences that deal directly with the examination of physical evidence collected in relation to a crime, such as criminalistics and forensic pathology.

In the following sections, we will define the role and education of other the forensic scientists that forensic criminologists are most likely to encounter in their casework. Because of the confusion regarding the certainty of forensic science conclusions, a brief discussion of the limits of some will also be provided.

**Generalist vs. Specialists**

As in the field of medicine, or any other field for that matter, there are forensic generalists and there are forensic specialists. The distinction between generalist and specialist forensic practitioners is made clearer by a discussion provided in Chisum and Turvey (2007, pp. 18–23):

Forensic generalists and forensic specialists alike are a requirement for informed forensic case examination, laboratory testing, and crime reconstruction to occur. A forensic generalist is a particular kind of forensic scientist who is broadly educated and trained in a variety of forensic specialties. They are “big picture” people who can help reconstruct a crime from work performed with the assistance of other forensic scientists and then direct investigators to forensic specialists as needed. They are experts not in all areas, but in the specific area of evidence interpretation. According to DeFoe et al. (1983, p. 17):

> Because of the depth and complexity of criminalization, the need for specialists is inescapable. There can be serious problems, however, with overspecialization. Persons who have a working knowledge of a broad range of criminalization problems and techniques are also necessary. These people are called generalists. The value of generalists lies in their ability to look at all of the aspects of a complex case and decide what needs to be done, which specialists should be involved, and in which order to carry out the required examinations.

Specialization occurs when a forensic scientist has been trained in a specific forensic subspecialty, such as an area of criminalistics, forensic toxicology, forensic pathology, or forensic anthropology. Specialists are an important part of forensic science casework, with an important role to fill. Traditionally, forensic specialists provide the bricks, and forensic generalists have traditionally provided the blueprint.

The author of this chapter, for example, was educated and trained as a forensic generalist, specializing in crime reconstruction, crime scene analysis, and criminal profiling. One of the author’s mentors, and a co-author of Crime Reconstruction (2007), W. Jerry Chisum, was also trained as a generalist by the late Dr. Paul Kirk (see Chapter 1). In contrast to the author, Mr. Chisum received his degree in chemistry and then specialized in a number of areas, including serology, crime reconstruction, and bloodstain pattern analysis.
There are fewer and fewer generalists in the forensic science community, and it is not uncommon for forensic scientists to gain employment in government service without a generalist background at all. Rather it is more common for forensic scientists to be narrowly trained as specialists of some sort without the benefit of a general forensic education, and then to learn other subspecialties once employed by a public crime lab. In fact most crime lab employees are cross-trained in multiple areas of evidence, to save having to hire additional personnel.

Criminalists
A criminalist is a particular class of forensic scientist who performs analyses and testing on physical evidence in a crime lab. Indeed, there are more than a few different subspecialties within laboratory criminalistics. As mentioned in Chapter 1, criminalistics traditionally encompasses the following subspecialties:

1. Drug Chemistry Identification and Analysis
   a. Alcohol
   b. Drugs
   c. Toxins
2. Forensic Biology
   a. DNA
   b. Serology
3. Fire Debris Analysis
4. Trace Evidence Analysis
   a. Commercial Materials Analysis
   b. Fiber Analysis
   c. Glass Analysis
   d. Hair Analysis
   e. Soil Analysis

This means that when someone refers to himself or herself as a criminalist, that person is suggesting expertise in one or perhaps more of the preceding areas. Therefore, it may also be necessary to inquire further and determine precisely what kind of criminalist that person is. Most criminalists will be eager to explain their areas of specialty along with their individual limitations.

General Education
At the forefront of the criminalistics profession is the California Association of Criminalists (CAC). This organization provides that

A criminalist is a person with a background in science, typically having at least a baccalaureate degree in an area such as chemistry, biology, forensic science, or criminalistics. Some criminalists have degrees in other, similarly related areas. Many criminalists have advanced degrees.

With the above scientific background and additional training given by his/her employer (either a government or private laboratory) a criminalist applies scientific methods and techniques to examine and analyze evidentiary items and testifies in court as to his or her findings.

The degree requirement provides for the necessity of a scholarly, science-oriented background. The CAC also provides generalist and specialist certification for criminalists. Unfortunately many "criminalists" working in public crime labs have undergraduate degrees in areas unrelated to scientific endeavor or scholarship, such as music, criminal justice, business, education, or political science. This trend is changing, however, as national hiring practices are being forced to evolve by guidelines such as those provided in the NAS Report.

Analysis
Criminalists specializing in the area of drug chemistry test for the presence of particular drugs, alcohol, or toxins. Toxicologists are specifically looking to establish their level in the human body. Drug identification comprises the bulk of government crime lab work, particularly opiates, amphetamines, cocaine, and cannabinoids associated with marijuana. The questions are related to which drugs are absolutely present, and in what quantities with respect to statutory requirements (a lesser amount may be legal to possess in some jurisdictions, more may be illegal to possess, and still more may demonstrate an intent to sell or distribute).

Forensic toxicologists work in crime labs associated with law enforcement agencies, medical examiner's offices, and private companies. They can collect and examine all manner of biological specimens for testing, including blood, urine, stomach (gastric) contents, vitreous humor (fluid from the eye), liver (and the bile which rains from it), and hair. Depending on the nature of the case, the more invasive samples are typically collected post-mortem.

As provided by the Society of Forensic Toxicologists, the educational requirements within this area of criminalistics vary depending on experience. Their membership guidelines demand that

Applicants for Full membership must have the following education degrees and experience in forensic toxicology:

- Ph.D. and 2 years experience
- M.S. and 4 years experience
- B.S. or B.A. and 6 years experience

As one can infer from these requirements, a Ph.D. is the preferred standard. However, the undergraduate degree requirement allowing for a B.A. as opposed to just a B.S. muddies the scientific water a bit. However, it is further reasonable to infer that any undergraduate degree should be related to chemistry or biology, if not held in forensic toxicology itself.
Criminalists specializing in forensic biology, such as DNA analysts and serologists (those who examine blood), are interested in forensic identification. Serologists look at blood type, proteins, enzymes, and antibodies. DNA analysts look for genetic material in blood and just about every other biological material they can get their hands on. As explained in Butler and Butler (2004, pp. 166–167):

Since every living cell contains DNA, any biological material left at a crime scene can potentially be valuable in a DNA test. The most obvious potential sources of DNA that can be obtained from a sexual assault crime scene are semen and vaginal cells. Other important sources include blood, urine, saliva, skin, hair roots, fingernails (often in a struggle a victim will scratch the perpetrator, catching his skin under her fingernails), condoms, clothing, linens, carpet, ligatures, and tape (especially good because tape and ligatures are difficult to work with while wearing gloves, possibly forcing the suspect to temporarily remove them for the task). All can provide biological material that may prove very helpful in solving a case. Even a bite mark on a victim can be swabbed to collect DNA left by the perpetrator’s saliva because saliva or “spit” often contains ample cheek cells to perform DNA testing.

DNA analysis was singled out in the NAS Report as having a more solid scientific foundation than any other forensic discipline, with statements such as this throughout (Edwards and Cototri, 2009, p. 5-3): “With the exception of nuclear DNA analysis, however, no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source.” Such statements are, of course, true.

However, there is an absence of direct criticism from the NAS regarding how DNA is databased and how DNA results are searched for, obtained, calculated, reported, and interpreted by forensic scientists—criticisms that are widely known and understood even by the general public. This includes the FBI’s pathological secrecy regarding its DNA databases. It also includes the coordinated threat from the FBI’s CODIS director to cut off access to any state that allows database searches it does not approve—which it turns out was a ruse designed to manipulate the court into denying motions from the defense (Dolan and Felch, 2008). All this to say that DNA, while being the forensic science with the most scientific underpinnings, still has a number of shortfalls.

Educational requirements for DNA analysts and other forensic biologists vary widely, but undergraduate degrees in chemistry and biology are preferred. However, these persons must also have a strong background in statistics because this is how confidence in findings is expressed in reports and then later in court. A DNA analyst who is unable to explain the statistics behind a “match,” how it was derived, and what it means, is no more than a technician. Unfortunately, this is common.

Criminalists specializing in fire debris analysis examine material collected at fire scenes for chemical and physical properties related to flammable and combustible liquids that may have been used as accelerants. This includes petroleum products such as gasoline and kerosene, primarily—not though exclusively. Fire debris must be collected in a secure, airtight container that is immune to rust or other forms of chemical erosion, such as a Mason jar, a specially lined paint can, or fire debris evidence bags. Fire debris analysis is a necessary aspect of an investigation into whether or not a fire was caused by arson (Intentional fire setting). Given the complexity of fire scene investigation, the mere presence of accelerants does not by itself prove arson (see generally DeHaan, 2007).

Criminalists specializing in trace evidence analysis seek to identify the nature of unknown samples and then to compare them with others of a similar nature to determine their origins. Trace evidence identification and comparison are accomplished by establishing the physical, microscopic, and chemical characteristics of a sample. As explained in Thornton and Kimmel-Lake (2007, p. 197):

For two reasons, the small bits of evidence may have significance beyond that which is commensurate with their size. First, their occurrence may arise from processes that the activities that generated them. Fracture, broadcasting of fine particles, and adhesion of foreign particles come to mind. Second, their size makes them inconspicuous. Any actor in the drama that we will call a crime is likely to be oblivious to the existence of this minute evidence, and even if he or she were aware, would be more or less powerless to do anything about it. These traces may provide information by means of which the factual circumstances at the time the crime occurred may be established. We call these materials trace evidence. It is an extremely broad category of physical evidence.

Because of the all-encompassing nature of this area, it is best to suggest readers seek out one or more of the learned texts which describes the instrumentation and methodology in the various forms of trace evidence examination, such as Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis by Robert Blackledge (2007); and Trace Evidence Analysis: More Cases in Muse Witnesses by Max Houck (2004).

Crime Reconstructionists

Crime reconstruction is the determination of the actions and events surrounding the commission of a crime. A reconstruction may be accomplished by using the statements of witnesses, the confession of a suspect, the statement of a
living victim, or by the examination and interpretation of physical evidence. Some refer to this process as crime scene reconstruction; however, the scene is not actually being put back together as it was—only some of the actions and sequences of events are being established.

Crime reconstruction is best conceived as the work of forensic generalists putting together theories of the crime based on the consideration of aggregated results from a variety of forensic disciplines. As explained in Chisum and Turvey (2007, p. xix):

...No one discipline can truly stand alone in a reconstruction. Each form of evidence must be in agreement with the other forms that are present. Each part must be meticulously established and then considered not just on its own but also in its place as part of the greater whole. What is it, how does it fit, and what does it mean in context—these are the questions asked by a reconstructionist.

Given this holistic approach, the authors have come to view reconstruction as the work of one who is sufficiently educated, trained, and experienced to understand the total body of forensic evidence and analysis in a case. That is, again, the forensic generalist. The generalist-reconstructionist, it must be understood, need not know how to perform all of the forensic examinations that were conducted. They need not have the ability to operate a camera to view a photograph; they need not have the ability to extract DNA and amplify it to comprehend a DNA analyst's report; they need not have the ability to perform an autopsy to understand the cause and manner of death, and appreciate the trajectory of the projectiles that passed through the body. Rather, they must be able to understand what the results of forensic examinations are, how they were reached, what they mean, and how they may be integrated to create a picture of events. Integration of findings is key because crime is best reconstructed when forged by a collaboration of the forensic evidence, and not a reliance on one single examination or discipline. To rely on one piece of evidence, or one theory, without placing it in context is not only potentially misleading but also a disservice to the justice system that the forensic scientist ultimately serves.

The reconstructionist must therefore have a formal education in the sciences and be trained as a forensic generalist with an appreciation of how the many forensic sciences inform and limit case theories.

**Bloodstain Pattern Analysis**

*Bloodstain pattern analysis (BPA)* in a subspecialty of crime reconstruction. In the context of crime and crime scenes, bloodstain patterns are the visible record of the bloodshed at a crime scene (Chisum and Turvey, 2007). As explained in Chisum (2007): "Bloodstain pattern analysis is the examination of the shapes, locations, and distribution patterns of bloodstains for the purpose of interpreting the physical events that caused them. It is based on the simple premise that bloodstain patterns are a direct result of the nature of the objects and forces that created them. As provided in the NAS Report (Edwards and Gotsonis, 2009, pp. 5–38):

Understanding how a particular bloodstain pattern occurred can be critical physical evidence, because it may help investigators understand the events of the crime. Bloodstain patterns occur in a multitude of crime types—homicide, sexual battery, burglary, hit-and-run accidents—and are commonly present. Bloodstain pattern analysis is employed in crime reconstruction or event reconstruction when a part of the crime scene requires interpretation of these patterns.

The NAS Report goes on to advise that (pp. 5–39)

Scientific studies support some aspects of bloodstain pattern analysis. One can tell, for example, if the blood splattered quickly or slowly, but some experts extrapolate far beyond what can be supported. Although the trajectories of bullets are linear, the damage that they cause in soft tissue and the complex patterns that fluids make when exiting wounds are highly variable. For such situations, many experiments must be conducted to determine what characteristics of a bloodstain pattern are caused by particular actions during a crime and to inform the interpretation of those causal links and their variabilities. For those same reasons, extra care must be given to the way in which the analyses are presented in court. The uncertainties associated with bloodstain pattern analysis are enormous.

Due to the complexity of BPA, a competent bloodstain pattern analyst will have a formal scientific education, as well as working knowledge of forensic pathology, wound pattern analysis, human biology and physiology, and physics. The NAS Report goes further, explaining (Edwards and Gotsonis, 2009, pp. 5–38)

Interpreting and integrating bloodstain patterns into a reconstruction requires, at a minimum: an appropriate scientific education; knowledge of the terminology employed (e.g., angle of impact, arterial spurting, back spatter, castoff pattern); an understanding of the limitations of the measurement tools used to make bloodstain pattern measurements (e.g., calculators, software, lasers, protractors); an understanding of applied mathematics and the use of significant figures; an understanding of the physics of fluid transfer; an understanding of pathology of wounds; and an understanding of the general patterns blood makes after leaving the human body.
It is important to note that, as described, these minimum requirements would exclude the vast majority of law enforcement bloodstain pattern analysts testifying in court today— for lack of any formal scientific education, lack of applied mathematics, and lack of knowledge regarding applied physics. Most have no science background, and have been trained in BPA by other law enforcement practitioners in a series of short courses. This is far beneath the level of education and training needed to develop expertise or even competency.

**Fingerprinting, a.k.a. Friction Ridge Analysis**

Fingerprints are used in investigative and legal settings to establish the identity of victims and suspects, and to further establish their presence at a location or their contact with a particular object. Fingerprints are often provided as the sole means of such identifications, a practice that is not as accurate as many believe. As described in the NAS Report (Edwards and Gotsin, 2009, pp. 5–7):

> Fingerprints, palm prints, and sole prints have been used to identify people for more than a century in the United States. Collectively, the analysis of these prints is known as “friction ridge analysis,” which consists of experienced-based comparisons of the impressions left by the ridge structures of volar (hands and feet) surfaces. Friction ridge analysis is an example of what the forensic science community uses as a method for assessing “individualization”—the conclusion that a piece of evidence (here, a pattern left by friction ridges) comes from a single unambiguous source. Friction ridge analysis shares similarities with other experience-based methods of pattern recognition, such as those for footwear and tire impressions, toolmarks, and handwriting analysis.

Consider also the implications of the one dissimilarity doctrine in fingerprinting with respect to how prints are “matched” (Thorton, 1977, p. 89):

> Faced with an instance of many matching characteristics and one point of disagreement, the tendency on the part of the examiner is to rationalize away the dissimilarity on the basis of improper ink ing, uneven pressure resulting in the compression of a ridge, a dirty finger, a disease state, scarring, or superimposition of the impression. How can he do otherwise? If he admits that he does not know the cause of the disagreement then he must immediately conclude that the impressions are not of the same digit in order to accommodate the one-dissimilarity doctrine. The fault here is that the nature of the impression may not suggest which of these factors, if any, is at play. The expert is then in an embarrassing position of having to speculate as to what caused the dissimilarity, and often the speculation is without any particular foundation.

The practical implication of this is that the one-dissimilarity doctrine will have to be ignored. It is, in fact, ignored anyway by virtue of the fact that fingerprint examiners will not refrain from effecting an identification when numerous matching characteristics are observed despite a point of disagreement. Actually, the one dissimilarity doctrine has been treated rather shabbily. The fingerprint examiner adheres to it only until faced with an aberration, then discards it and conjures up some fanciful explanation for the dissimilarity.

Regarding friction ridge analysis, the NAS concludes that it is not an error-free result, nor should it be treated as 100% conclusive with respect to identifications (Edwards and Gotsin, 2009, pp. 5–12, 5–13):

> Historically, friction ridge analysis has served as a valuable tool, both to identify the guilty and to exclude the innocent. Because of the amount of detail available in friction ridges, it seems plausible that a careful comparison of two impressions can accurately discern whether or not they had a common source. Although there is limited information about the accuracy and reliability of friction ridge analyses, claims that these analyses have zero error rates are not scientifically plausible....

Recent legal challenges, New Hampshire vs. Richard Langill and Maryland vs. Bryan Rose, have also highlighted two important issues for the latent print community: documentation and error rate. Better documentation is needed of each step in the ACE-V process or its equivalent. At the very least, sufficient documentation is needed to reconstruct the analysis, if necessary. By documenting the relevant information gathered during the analysis, evaluation, and comparison of latent prints and the basis for the conclusion (identification, exclusion, or inconclusive), the examiner will create a transparent record of the method and thereby provide the courts with additional information on which to assess the reliability of the method for a specific case. Currently, there is no requirement for examiners to document which features within a latent print support their reasoning and conclusions.

Error rate is a much more difficult challenge. Errors can occur with any judgment-based method, especially when the factors that lead to the ultimate judgment are not documented. Some in the latent print community argue that the method itself, if followed correctly (i.e., by well trained examiners properly using the method), has a zero error rate. Clearly, this assertion is unrealistic, and, moreover, it does not lead to a process of method improvement. The method, and the performance of those who use it, are inextricably linked, and both involve multiple sources of error (e.g., errors in executing the process steps, as well as errors in human judgment).
Some scientific evidence supports the presumption that friction ridge patterns are unique to each person and persist unchanged throughout a lifetime. Uniqueness and persistence are necessary conditions for friction ridge identification to be feasible, but those conditions do not imply that anyone can reliably discern whether or not two friction ridge impressions were made by the same person. Uniqueness does not guarantee that prints from two different people are always sufficiently different that they cannot be confused, or that two impressions made by the same finger will also be sufficiently similar to be dismissed as coming from the same source. The impression left by a given finger will differ every time, because of inevitable variations in pressure, which change the degree of contact between each part of the ridge structure and the impression medium. None of these variabilities—of features across a population of fingers or of repeated impressions left by the same finger—has been characterized, quantified, or compared.

Subsequent to the publication of the NAS Report, the International Association for Identification (IAI) overturned a century of forensic practice and declared to its members in a memo that, when responding to challenges during testimony (Garrett, 2009):

- It is suggested that members not assert 100% infallibility (zero error rate) when addressing the reliability of fingerprint comparisons.
- Although the IAI does not, at this time, endorse the use of probabilistic models when stating conclusions of identification, members are advised to avoid stating their conclusions in absolute terms when dealing with population issues.

Apart from the NAS Report itself, this memo is perhaps the most significant revelation in the forensic science community in more than 100 years. It should be noted that the current state of this particular form of analysis exists and has persisted largely because of the fact that the majority of analysts work in law enforcement and have little or no scientific background. Subsequently, it has been accepted uncritically by the courts until recently, and suffered little if any scientific assessment. One hopes this will soon change as a result of the IAI's new mandate.

**Firearms and Tool Mark Identification**

Firearms and tool mark examiners "use microscopic comparisons of markings to associate an item of evidence with a particular source" (Rowe, 2003, p. 327). Edwards and Cotsonis (2009) explain that (pp. 5–18):

Toolmarks are generated when a hard object (tool) comes into contact with a relatively softer object. Such toolmarks may occur in the

commission of a crime when an instrument such as a screwdriver, crowbar, or wire cutter is used or when the internal parts of a firearm make contact with the brass and lead that comprise ammunition. The marks left by an implement such as a screwdriver or a firearm's firing pin depend largely on the manufacturing process—and manufacturing tools—used to create or shape it, although other surface features (e.g., chips, gouges) might be introduced through post-manufacturing wear. Manufacturing tools experience wear and abrasion as they cut, scrape, and otherwise shape metal, giving rise to the theory that any two manufactured products—even those produced consecutively with the same manufacturing tools—will bear microscopically different marks. Firearms and toolmark examiners believe that toolmarks may be traced to the physical heterogeneities of an individual tool—that is, that "individual characteristics" of toolmarks may be uniquely associated with a specific tool or firearm and are reproduced by the use of that tool and only that tool.

However, the NAS Report offers little enthusiasm for the current state of firearms and toolmark identification efforts, warning that (Edwards and Cotsonis, 2009, pp. 5–21):

Because not enough is known about the variabilities among individual tools and guns, we are not able to specify how many points of similarity are necessary for a given level of confidence in the result. Sufficient studies have not been done to understand the reliability and repetability of the methods. The committee agrees that class characteristics are helpful in narrowing the pool of tools that may have left a distinctive mark. Individual patterns from manufacture or from wear might, in some cases, be distinctive enough to suggest one particular source, but additional studies should be performed to make the process of individualization more precise and repeatable.

A fundamental problem with toolmark and firearms analysis is the lack of a precisely defined process. As noted above, AFTE (Association of Firearm and Toolmark Examiners) has adopted a theory of identification, but it does not provide a specific protocol. It says that an examiner may offer an opinion that a specific tool or firearm was the source of a specific set of toolmarks or a bullet striation pattern when "sufficient agreement" exists in the pattern of two sets of marks. It defines agreement as significant "when it exceeds the best agreement demonstrated between tool marks known to have been produced by different tools and is consistent with the agreement demonstrated by tool marks known to have been produced by the same tool." The meaning of "exceeds the best agreement" and "consistent with" are
As with friction ridge analysis, the state of this particular form of analysis exists and persists largely because of the fact that the majority of analysts work in law enforcement, and have little or no scientific background. The results of such examinations are therefore to be treated with great caution, as they are too often accepted as firm and final when in fact there is very little if any science behind such opinions (Schwartz, 2005). Again, it is the hope that this will soon change.

Digital Evidence Analysis

Digital evidence analysis refers to the examination of (Casey, 2004, p. 12) "any data stored or transmitted using a computer [or other personal electronic device] that support or refute a theory of how an offense occurred or that addresses critical elements of the offense such as intent or alibi." It includes all kinds of digitally stored data, such as text, images, audio, and video. There are many challenges to collecting digital evidence, as the very act of collection can permanently alter it. For this reason and more, digital evidence is among the least understood and most complex forms of evidence that can be collected in association with a crime.

Law enforcement agencies are only just getting into the habit of collecting digital evidence as a routine matter. However, many agencies lack the expertise or ability to do so. Worse, even when digital evidence is collected, it often goes unexamined unless a private examination is requested by the defense.

As with other areas of forensic examination, many law enforcement officers have taken it upon themselves to become in-house experts with highly varied results. Most, it is fair to say, do not have enough of a background in science or technology to understand the complexity of such evidence, let alone interpret its meaning objectively. Digital evidence analysis requires a high degree of education and training in the very specialized tasks of collection, processing, and examination/interpretation (Casey, 2004). Consequently, these jobs are often separate, and should be separately credentialed. However, an undergraduate degree in computer science, engineering, or a related subject, is preferred.


Forensic Accountant

A forensic accountant is a particular kind of accountant who examines, or audits, financial records to answer investigative questions and help resolve legal disputes. Forensic accountants have a high degree of value to investigative and forensic inquiries. They may be used to answer questions regarding economic losses and financial damages, to resolve issues related to income and lifestyle in disputes over alimony and child custody payments, or to establish the nature and extent of financial fraud and asset ownership in cases where financial crimes are suspected, or those involving organized criminal enterprise.

While there are no firm educational requirements in forensic accounting specifically, it is recommended that practitioners have at least an undergraduate degree in accounting, economics, or a related area, with coursework and further specialized training in auditing, fraud, and forensic accounting. The variety of methods for assessing expertise in forensic accounting are explained in Levanti (2009):

Experience requirements of Forensic Accountants

Unlike many other professional fields, there are no experience requirements necessary to call oneself a Forensic Accountant. When looking for an experienced professional, the length of time someone has spent conducting actual accounting and auditing engagements should be strongly considered. However, accounting and auditing experience is not necessarily enough to qualify one as a Forensic Accountant; one must look at the professional experience of conducting investigations as well. Experience conducting investigations can be gained in many ways, including working in a forensic practice at an accounting firm or working in a law enforcement capacity. Academia can also provide professionals who have conducted research into fraud-related fields.

Education credentials of Forensic Accountants

Although there are no educational standards for Forensic Accountants, there are standards for other professionals, such as CPAs. When choosing a professional Forensic Accountant, one should be guided by the same professional standards used for other services be it accountant, doctor, or attorney. Lack of education, however, should not be considered solely as a disqualifying factor for a candidate. A candidate may not have an advanced degree, but instead may have many years of experience in auditing, accounting or investigations that makes up for the lack of advanced educational credentials. When hiring a professional from a large, well-known firm, it is highly likely that the person's educational credentials have been verified and that he or
she comes with the backing of the firm. When looking at a candidate without backing of a large firm, a request to an educational institution to verify educational credentials may provide needed clarity to make an informed decision. Beware of diploma mills issuing mail-order degrees when inquiring about educational credentials.

**Professional credentials of a Forensic Accountant**

One of the most effective ways to verify the credentials of a Forensic Accountant is by checking the references that are provided. The Internet is another good source of information, as well as Google, Ask.com and other search engines that offer thousands of sources of information on all types of professionals. Individuals belonging to established professional organizations may be confirmed as active members in good standing.

Regarding professional organizations themselves, there are several organizations that provide accreditations to Forensic Accountants. Some of these organizations have little or no education or experience requirements for their members or established professional standards for their members to follow. When inquiring about professional affiliations, one should seek out the requirements to become a member and/or receive a professional certification. For those organizations that lack satisfactory requirements, it is important to remember that deceptive organizations and certifications exist in every profession, including accounting and fraud investigations.

The lack of educational requirement in this subdiscipline of forensic science makes clear the need for belonging to professional forensic organizations with clearly defined educational requirements, standards of practice, and enforced codes of ethics. When an examiner is unwilling to submit to these, belonging only to those organizations that are essentially large social clubs, this unwillingness telegraphs a lack of professionalism and even a lack of confidence in the examiner's own work.

For guidelines and practice standards, see generally the Journal of Forensic Accounting: Auditing, Fraud, and Risk at http://www.redwards.com/journals/jfa.

**Forensic Anthropologist**

Forensic anthropologists apply the science of physical anthropology and human osteology (the study of the human skeleton) to investigative and legal questions. Primarily, they assist in the discernment of human bones from those of animals. If a bone or any set of remains is found to be human, forensic anthropologists proceed to assist with their identification. They are often employed in cases in which human remains are beyond physical recognition as occurs in mass disasters or those cases in which there is advanced decomposition. Forensic anthropologists can also assist with determinations of age, sex, stature, and ancestry, and assess remains for trauma and possible disease. Practitioners are usually educated at the master's level, if not holding their Ph.D. in anthropology.

For more information, see the American Board of Forensic Anthropology at http://www.theabfa.org.


**Forensic Odontology**

Forensic odontology, also referred to as forensic dentistry, "is the application of the arts and sciences of dentistry to the legal system," Glass (2003, p. 61). It involves the identification of individuals by comparison of their teeth with established dental records. This occurs most commonly in cases of accidental death or homicide when human remains are discovered and their identity is unknown. It also involves the comparison of suspect dentition patterns with suspected bite mark patterns for the purposes of helping to establish identity.

Practitioners will typically have a private dental practice of some sort, with forensic work and expertise being something they develop on the side. This means that they must possess a D.D.S., a D.M.D., or the equivalent dental degree from an accredited institution.

For more information, see the American Board of Forensic Odontology, which provides specific standards of forensic practice and uniform terminology for its membership, at http://www.abfo.org.


**Forensic Pathologists**

Forensic pathologists are those charged with determining cause and manner in cases of violent or unexpected death. They are meant to attend the death scene, gather a history, perform the autopsy, and then assess the nature in which the deceased interacted with the environment in such a manner as to cause his or her demise. They also collect decedent clothing, document injuries, and collect biological samples in accordance with sexual assault kit protocols, as well as those needed for forensic toxicological analysis. Very often, their assessments will determine whether or not a death is the result of crime and also provide the foundation for much of the reconstruction work that may be done regarding the crime. The results of their findings are used in civil and criminal litigation alike.
With respect to the divergent Medical Examiner/Coroner (ME/C) systems that operate in the United States, the NAS Report concluded (Edwards and Gotsuis, 2009, pp. 9–19)

ME/C systems function at varying levels of expertise, often with deficiencies in facilities, equipment, staff, education, and training. And, unfortunately, most systems are under budgeted and understaffed. As with other forensic science fields, there are no mandated national qualifications or certifications required for death investigators. Nor is medical expertise always required. In addition, there is no one recognized set of performance standards or best practices for ME/C systems or are there incentives to implement one recognized set. Also lacking are universally accepted or promulgated methods of quality control or quality assurance. It is clear that the conversion of coroner systems to medical examiner systems as recommended by many studies has essentially halted and requires federal incentives to move forward.

The shortage of forensic pathologists speaks to the need to provide incentives for young physicians to train in forensic pathology. Systems with authorized positions cannot fill them, because of this shortage and budget deficits.

Practitioners of forensic pathology will have an M.D. and board certification in forensic pathology—that is, unless they are coroners. In which case they need only be 18 and possess a valid driver’s license, which can and does happen in some jurisdictions.

For more information, see the National Association of Medical Examiners, which provides specific standards of forensic practice and uniform terminology for its membership, at http://thename.org.

Consulting with Forensic Scientists

As we have learned, forensic scientists come in many forms, and their numbers include exameers who do not work in crime labs or directly with physical evidence at all. They also lack uniform standards in education and methodology; their conclusions often lack scientific rigor and are overly confident; and they are often marked by improper alignment with law enforcement and prosecutorial agencies. As a consequence, the forensic science community is fragmented and broken, and does not speak with a single voice. It is also awash with the inept and the biased.

When working with the results of physical evidence examination, forensic criminologists are encouraged to do the following:

1. Check the resumes of purported forensic scientists. Do they actually have the education that they claim? Do they have a formal scientific education? Or does their "science" derive from a series of law-enforcement-sponsored short courses?

2. Learn the practice standards and protocols that individual examiners are operating under when rendering their conclusions. Assess whether their reporting comport with them.

Learn the ethical codes governing the forensic practitioners that you encounter—if there are any at all. If you learn of unethical conduct, report it. This may not result in any action or sanctions, but it may, and it will at least make a record.

3. Be eager to get a second opinion. Real scientists like having the work checked because they know the validity of their methods and are proud of their efforts.

4. If you have questions regarding a forensic examiner's report (and you will), ask about it. If the examiner refuses to speak with you, that in itself is an answer.

5. Remember that forensic scientists are not equal; especially true of specialists, they may know only their small piece of the puzzle. Do not assume that they know more or less than they do.

6. Work toward a generalist's level of forensic knowledge. This degree of education is a process rather than a result, so be prepared to make a commitment that is at least the same length as your intended career in forensic service.

7. Develop an extensive forensic library. If a forensic examiner's report doesn't sound right, is overly vague, or seems to lack good science, read up. Repeating this process over and over again on each new case will make you a better forensic examiner.

8. Do not give more weight to scientific findings than they deserve and become proficient with the limits of good science in their areas you routinely encounter.

Forensic scientists have value to investigative and forensic efforts in that they can clearly define the limits of the evidence they have examined—assisting
with the support or refutation of case theory. Further still, they can express those limits in both intelligible writing and comprehensible testimony. If they are unable to perform these tasks, then their value is limited. Forensic practitioners who overestimate the significance of their findings or conceal any weaknesses are to be avoided. Whether incompetent or frauds, they place any work which incorporates their findings at risk of being misleading or just plain wrong. Forensic criminologists must therefore become adept in recognizing competent and incompetent forensic practice alike, to maintain the integrity of their own findings.

SUMMARY

Clearly, there are many different types of forensic scientists, with various investigative and legal value and educational experience. The defining quality of forensic scientists is the possibility that they will be called upon to present scientific findings, under penalty of perjury, in a court of law. Scientists then should be prepared to explain to the court what their findings mean and how they came to them. Anyone who cannot or does not do this is not a forensic scientist. The distinction between a forensic scientist and a technician must also be made, where a scientist is educated in the scientific method and uses it to interpret results.

As is clear from the previous discussion, there is a strong argument to be made that those forensic practitioners employed solely by law enforcement or the prosecution are not forensic scientists at all, but rather police practitioners; this is especially true with certain subtypes of forensic scientists, for whom little or no education related to the sciences is necessary.

Although the importance of forensic generalists cannot be understated, it is much more common for forensic scientists to be narrowly trained as specialists of some sort without the benefit of a general forensic background and then to learn other sub-specialties once employed by a crime lab. These specialists can take the form of criminalists involved in one area or many: bloodstain pattern analysts, fingerprint or friction ridge analysts, firearms and tool marks identification specialists, forensic anthropologists, forensic odontologists, and forensic pathologists. Each of these specialists will have a different level of education in various fields, each may or may not have a pro-law enforcement bias, and each has the potential to make egregious errors based on lack of scientific knowledge and background education. It is the job of forensic criminologists utilizing these experts to educate themselves on the error rates, problem areas, and necessary qualifications to carry out these examinations and to assess the forensic scientists accordingly.

Review Questions

1. True/False: Technicians and scientists are generally viewed as equivalent when it comes to evidence analysis.
2. Describe the different areas of criminalistics and the educational requirements of each.
3. True/False: The term trace evidence is used to describe a very specific type of physical evidence.
4. Explain what is involved in a crime reconstruction.
5. Name the requirements necessary to be a bloodstain pattern analyst. Where does this leave law enforcement trained pattern analysts?
6. Describe the one-dissimilarity doctrine. What does this mean for the fallibility of fingerprint evidence?
7. Why is it a problem that tool mark and firearms examiners do not have a specific process which they are meant to carry out to determine whether an identification can be made?
8. True/False: There are no mandated qualifications or certifications for death investigators in the United States.

REFERENCES


Garrett, R.J., 2009. Memo from the President of the International Association for Identification to the Membership, February 19.


