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 (Chisum, 2007).

Bloodstain Patterns: The visible record of the blood shed at a crime scene.

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 combustible 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 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 origins by establishing the physical, microscopic, and chemical characteristics.

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 crime fighters. 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 impression in the minds of those studying and working in the criminal justice system. The media portrayal of infallibility has created a community populated by many who believe themselves to be infallible. In part, this self-perception is sustained for lack of experience with being effectively challenged. As discussed in Cooley (2007, p. 508–509):

For much of the 20th century, judges, prosecutors, and attorneys infrequently scrutinized the individualizing and reconstructive claims and qualifications of forensic experts. Although various reasons subsist 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 attesting 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 Gotsonis, 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; Risinger, Saks, Thompson, and Rosenthal, 2002; Schwartz, 2005), the ongoing 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,2 and the publication of Chisum and Turvey (2007),3 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.4 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.
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.

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 criminology 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, Saukko, and Knupfer (2000). 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 criminalist 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 them. Those examiners whose work does not
bring them into contact with the legal system are not “forensic” in nature. As provided in Thornton and Peterson (2002, p. 148):

What then, of the forensic scientist? The single feature that distinguishes forensic scientists from any other scientist is the expectation that they will appear in court and testify to their findings and offer an opinion as to the significance of those findings. The forensic scientist will, or should, testify not only to what things are, but to what things mean. Forensic science is science exercised on behalf of the law in the just resolution of conflict. It is therefore expected to be the handmaiden of the law, but at the same time this expectation may very well be the marina from which is launched the tension that exists between the two disciplines.

The unique role of the forensic scientist is ultimately that of an educator to attorneys, judges, and juries. Trust extended to them as an expert by the court under these circumstances is not trivial. The results of their examinations and any related opinions can greatly influence the outcome of a legal proceeding. In civil matters, reputations and fortunes may be lost or won. In criminal matters, nothing less than the life and liberty of the accused is at stake. A convincing forensic scientist can be terribly compelling to a judge or jury, and thus tip the scales of justice for one side of a dispute over the other.

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. 5-5)

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.
With the greatest distinction being that of testing versus interpretation (p. 2–4):

Because of the distinctly different professional tracks within larger laboratories, for example, technicians perform tests with defined protocols, and credentialed scientists conduct specialized testing and interpretation.

The contrast between technician and scientist is both subtle and tremendous. Currently, the trend is to populate government-funded crime labs with forensic technicians who do little more than inject a sample and push a button without knowing the science beneath their analysis. This saves money in terms of having to hire fewer of those with advanced degrees. This also limits the testimony of forensic technicians to results and prevents them from being able to explain the meaning of those results with competence.

This situation provides an interpretative windfall for the police and prosecution—who are left to provide interpretations to the trier of fact with scientists carefully in their pocket or moved entirely to the side. As explained in Chisum and Turvey (2007, pp. xvi–xvii):

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.
The position taken by the NAS is that science must be part of both the methods and interpretations of forensic scientists. A technician can collect a sample, extract DNA, or test for the presence or absence of substances. But it takes a scientist to interpret the results of that test in the context in which it was run, with respect to the limits of good science. If others are interpreting evidentiary findings on their behalf or without a scientific background, then there is increased room for misrepresentation and error.

To recap, forensic science is not always practiced in a crime lab, is not always practiced on behalf of law enforcement, and is not always practiced by actual scientists. That is to say, there are an undocumented number of independent forensic scientists in private practice working to provide balance within the criminal justice system. It is, after all, a justice system that is awash with variously qualified law enforcement employed forensic practitioners bound to serve the prosecution and no other. Moreover, the education, training, and experience of forensic practitioners is not fixed or mandated by any one agency or organization. This has resulted in many government and police lab employees who are trained on the job, heralding experience as their only qualification.

**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. This is consistent with the discussion found in Cooley and Turvey (2007, p. 79):

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 lab systems 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 L.] 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 (1993) urged that the “inbred bias of crime laboratories affiliated with law enforcement agencies must be breached.” Professor [Paul] Gianelli (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 a scientific education (Edwards and Gotsonis, 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. ix–x):

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 DeForest et al. (1983, p. 17):

Because of the depth and complexity of criminalistics, 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 criminalistics 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 blueprints.

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.

*See [http://www.cacnews.org/membership/criminalistics.shtml](http://www.cacnews.org/membership/criminalistics.shtml)*
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.

**Analyses**

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 examiners’ 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.

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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 root, 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 Gotsonis, 2009, p. 8-5): “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—though not 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 describe 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 Mute 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