Educational Pathways to Careers in the Forensic Sciences

R. E. Gaensslen, Ph.D.
Professor emeritus, Forensic Science
University of Illinois at Chicago

1. The scope of forensic sciences

Taken in the broadest sense, the forensic sciences consist of a broad, interdisciplinary group of applications of medical, biological and physical sciences, and various technologies, to issues in civil and criminal justice and regulatory matters.

For purposes of this paper, we will adopt the widest scope of major disciplines that fall under the forensic sciences rubric. As will become clear, the educational preparation necessary for entry into the forensic sciences is diverse, ranging from high school diploma to doctoral degrees.

Thus, the forensic sciences consist of pathology, dentistry (odontontology), psychiatry, psychology, nursing, toxicology, entomology, physical anthropology, human biological evidence (blood, semen, saliva, etc.) analysis, the analysis of other types of biological materials, such as plant materials, pollens, etc., analysis of hair, fibers, and all types of materials, analysis and comparison of patterns and pattern evidence (fingerprints, documents, firearms, tool marks, etc.), engineering, the investigation and analysis of computer crime, crime scenes, and crime scene patterns and the investigation and analysis of digital devices and computer crime.

The specialties are discussed individually in more detail immediately below, along with the educational and training requirements for each one. In Table 1, the forensic specialties are grouped under what is generally regarded as the minimum academic degree needed for its practice.

Later in the paper, educational program accreditation and practitioner certification is briefly discussed as well. It is worth noting here that this discussion is limited to education and training programs relevant to practice in the United States.

2. Terminal academic degrees, additional specialized training, and employment opportunities in forensic specialty areas

Table 1 organizes all the forensic specialty areas discussed here under what is generally regarded as the minimum terminal degree required for them.

In addition to academic degrees, almost every specialty requires additional training. This may be formal or informal, but is generally under the tutelage and/or supervision of an experienced practitioner.

2.1 Crime scene investigation and/or analysis

Contrary to popular myth, engendered by popular television programs, the majority of crime scene investigators are sworn police officers.
Larger departments may have sufficient resources to support special crime scene investigation units. They are not scientists by training, and there is no forensic laboratory that has all sworn personnel who are equally adept at police and lab work. A major part of crime-scene work involves documenting scenes and evidence, and collecting and packaging evidence that is to be submitted to a forensic laboratory. In more recent years, there has been a trend toward requiring more formal education for police, but the majority of departments do not require college degrees. Federal law enforcement service does require a college degree in order to apply.

It has been argued persuasively that crime scene investigation would be more effective if criminalists (see below in section 2.2) could be regularly involved in it. By “more effective” is meant that more relevant evidence would be recognized and collected, less irrelevant “evidence” would be collected, and physical evidence would be used more often for reconstruction. In a word, the task would be more efficient.

Table 1.

<table>
<thead>
<tr>
<th>High School or A.S.</th>
<th>B.S.</th>
<th>B.S. or M.S.</th>
<th>Ph.D.</th>
<th>M.D. or D.M.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crime scene investigation and/or processing</td>
<td>Forensic engineering</td>
<td>Criminalistics</td>
<td>Criminalistics (especially DNA, and forensic chemistry)</td>
<td>Pathology</td>
</tr>
<tr>
<td>Digital forensics (extraction of information from digital devices)</td>
<td>Digital forensics (crimes involving sophisticated computer use)</td>
<td>Digital forensics</td>
<td>Toxicology (sometimes M.S.)</td>
<td>Odontontology (Dentistry)</td>
</tr>
<tr>
<td></td>
<td>Forensic nursing (sometimes Ph.D. or N.D.)</td>
<td></td>
<td></td>
<td>Psychiatry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Entomology</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Anthropology (sometimes M.S.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Psychology (sometimes M.S.W.)</td>
</tr>
</tbody>
</table>

While it is hard to disagree with this assessment, we are a long way from its implementation. Resources are simply insufficient in most places. There is a difference between crime scene processing and crime scene analysis.
The former describes documentation and evidence collection from a crime scene in an orderly way. Crime-scene analysis is more about reconstruction, the use of the physical evidence record and analytical findings to help reconstruct past events. Reconstruction is often included as being part of “criminalistics” (2.2 below). Crime scene investigation is an integral part of reconstruction based on the evidence and especially patterns. A few specialty areas, blood pattern analysis is a good example, are primarily aimed at reconstruction.

It may be noted here that some specialties not discussed in this paper are focused on reconstruction. Reconstruction is simply using current physical evidence and/or data to try and reconstruct the actions or events that gave rise to them. The National Transportation Safety Board, for example, investigates airplane and other transportation related accidents. One hears about forensic archaeology, or even forensic accounting, and others.

Among all the specialty areas discussed, employment opportunities are probably greatest in the crime scene investigation arena, provided it is understood that almost all these jobs are held by sworn law enforcement personnel. Thus, one must meet the requirements for joining the law enforcement agency, usually attend and make it through a police academy, then vie for a position in a crime scene investigation unit. In many departments, there may not be crime scene investigation units per se, and crime scene investigators may have other law enforcement duties. In a handful of jurisdictions, there are specialized, civilian crime scene investigators attached to the forensic science laboratory. These individuals may also be specialists in one of the laboratory examination areas as well.

2.2 Criminalistics

There is no generally accepted definition of what is encompassed by the term “criminalistics.” The term came into English from German and generally includes: forensic biological evidence testing, including genetic typing; forensic materials testing (sometimes called “trace evidence” analysis); forensic chemistry, including controlled substance analysis; and microscopy. Some people would also include fingerprints, questioned documents, and firearms and tool mark identification. These are sometimes called pattern evidence specialties, and footwear, tire tracks, and similar types of markings are also part of that specialty. Under some definitions, crime scene (forensic) photography and crime scene investigation, especially reconstruction aspects (2.1 above) might be part of criminalistics. One way to think of criminalistics is that it includes most or all of the activities in most public, full-service forensic science laboratories.

A B.S. degree is a minimal requirement for any of the criminalistics specialties today, except perhaps the crime-scene aspects. Many practitioners also have M.S. degrees. A few people in operational laboratories have Ph.D.s, but they are primarily supervisors or technical leaders. Academic degrees must be in the hard sciences (typically chemistry, biochemistry, or biological science) or in forensic science to qualify as preparation for a forensic laboratory position. A B.S. or B.A. degree in a non-hard-science subject does not meet the requirements for criminalistics. There are people in the profession with B.S. degrees in medical laboratory sciences, physics, or some other science, but this is becoming less common. Most educators would advise young people interested in criminalistics to emphasize chemistry in their educational preparation.
It is common today for students to earn B.S. degrees in one of the traditional sciences, then perhaps an M.S. in forensic science at one of the academic programs available. There are very few Ph.D. programs in forensic science as such. There is also not much demand for Ph.D.s in forensic science laboratories. The majority of these Ph.D.s are in DNA units or sometimes in supervisory positions, and most of the Ph.D.s are in traditional disciplines such as chemistry or molecular biology.

Besides formal education, every criminalistics specialty requires additional training before a person is casework-ready. Traditionally, the lengthiest training has been for questioned documents analysts. There is a relatively small number of entry-level positions in the criminalistics specialties every year, and it is fair to say that the existing forensic science programs overproduce graduates relative to the actual labor market. It is unlikely that the nation’s forensic science labs absorb more than a few hundred new people a year, and in some years it could be fewer than that.

Forensic science programs may require or make available internship opportunities to provide students with a close-up look at forensic lab operations and perhaps some hands-on experience. Most of the post-graduate training, however, takes place in operational laboratories after someone is hired. The idea of following a medical model as part of a graduate forensic-science program has been proposed, but resources and organizational arrangements to implement such an idea have never been realized. Under such a model, students would carry out an extensive “residency” in a specialty area as part of their degree program. The term “residency” was used to distinguish it from “internship,” which is typically much less rigorous.

Criminalistics has a certification board, and offers certification in most of the major specialty areas. Although board certification is surely a praiseworthy goal, it is not required for criminalistics employment in most laboratories. Until it is required, it is not likely to become widespread.

It should be noted that the pattern evidence areas (fingerprints, questioned documents, firearms, and tool marks) have their own professional organizations, their own professional journals, and their own certifications, separate from criminalistics. It is also worth noting that employment opportunities in the fingerprints specialty, including both latent prints and automated fingerprint identification system (AFIS) specialists, are typically greater than those in other areas of criminalistics. It may also be noted here that many questioned document examiners are self-employed.

Fire investigation may be considered a part of criminalistics. The laboratory analysis of fire debris is unequivocally forensic chemistry and thus part of criminalistics. Fire investigation is generally separate from fire debris analysis, however, and done by different specialists. Fire debris analysis is aimed at finding flammable liquid residues suggesting arson. Similarly, bomb debris analysis is aimed at finding the component explosives, and possibly detonators and/or device construction that might be characteristic of an offender or a group. The investigations of the scenes are done by specially trained individuals who generally don’t work in forensic labs. Fire investigation has long been the purview of firefighters with specialized training. They may be called fire marshals. The goal of the investigation is to determine the cause and point of origin of the fire. The fire debris analysis results can help with these determinations. Certification programs for fire investigators are available.
Some fire investigation specialists are in private practice.

As noted above, one way to think about criminalistics is that it encompasses most or all the activities in a forensic science laboratory, or crime laboratory. It is probably fair to say that there are three types of forensic labs, broadly speaking: full-service, partial service, and specialty. A full-service lab typically serves a larger population such as a large city or a whole state. It will have a large drug chemistry (drug identification) section, a somewhat smaller biology/DNA section, and sections that handle “trace” and materials evidence (hair, fibers, glass, soil, etc.), fingerprints, questioned documents, and firearms and tool marks. Such a lab might also have computer science specialists, evidence technicians, photographers, and possibly crime scene and/or reconstruction specialists, and toxicology services. A partial-service lab has fewer personnel than a full-service lab, and tends to have examiners in the specialties that receive the most cases (drug chemistry, biology/DNA). Some states (New York, New Jersey, Florida, Georgia, Illinois, Texas, Arizona, California, among others) have established laboratory systems. A lab system enables the state to provide laboratory services to a more localized geographical area, thus helping establish productive relationships between investigators and laboratory personnel. In addition, every lab in the system does not have to be full-service, because cases can be moved around internally within the system. Specialty laboratories are just that. Most of them specialize in drug chemistry (the federal DEA labs are the prime example) or in DNA. There are a number of private, commercial DNA laboratories today. Within a state system, one of the laboratories might be devoted to one specialty, such as DNA typing. The majority of scientists (or examiners as they may be called) in forensic science labs have job titles such as “criminalist” or “forensic scientist,” and there are usually several levels, going from entry-level bench scientist up to section supervisors and laboratory administration.

2.3 Forensic engineering

Forensic engineers are specialists in using the engineering disciplines to help inform legal questions. They may be civil, mechanical, electrical, aeronautical, or perhaps even computer engineers (see below at 2.4). A B.S. degree in engineering is required at minimum. Most are licensed as professional engineers (P.E.) and this license may be required for some practices. Some forensic engineers have M.S. or Ph.D. degrees as well. Most full-time practitioners are in private practice or work in small, private firms. Some forensic engineers are academics who do consulting as time permits. There are several hundred forensic engineers in practice nationwide. Many forensic engineers are involved in transportation accident reconstructions (automobile, train, plane, etc.). They may also be involved in some materials failures cases involving product liability, building or other structure failures and collapses, and the like. These cases are generally civil rather than criminal. Board certification is available in forensic engineering.5

2.4 Computer crime investigation, forensic computer science

The application of digital device analysis and computer science and to forensic investigations and security matters is a relatively recent development.
Criminal investigators have come to realize that computers, tablets, and other devices with memory chips, such as cell phones can provide useful investigative information, or be directly used in criminal activity. Accordingly, some investigators have begun to specialize in investigations of computer-based crime (an example would be luring purveyors of child pornography or pedophiles into the open where they can be arrested and prosecuted), or in extracting information from computers as part of other investigations. The majority of these investigators have learned these specialties by experience, self-instruction, and short training courses or seminars.

Investigation of true computer crime, hacking and data breach incidents, and the like, requires significant knowledge and training in the designs and inner workings of computers, operating systems, software, and networks. A minimum of a B.S. in computer science or computer engineering would be required for this type of work, and many such people would also have an M.S. degree. Although there is not a very large number of these specialists in the nation’s law enforcement agencies at present, the specialty is growing rapidly. Many people with advanced knowledge and training work in private data and national security protection positions. It may be expected that significant opportunities will exist in this specialty area at the local, state and federal levels.

This specialty area is sometimes called “computer forensics.” The term is not correct, since “forensics” is, strictly speaking, debating, and although the Latin root words are the same, forensic science should not be called “forensics.” Popular culture and media’s relentless insistence on doing so, however, probably means that the language is here to stay.

Certification is available from the International Association of Computer Investigative Specialists. There are about 1750 certified forensic computer examiners from this program.

2.5 Forensic toxicology

Forensic toxicologists are specialists in the effects of drugs on the human body, and in drug detection and quantitation in human blood, body fluids, and sometimes other matrices (such as hair). They have M.S. degrees at minimum, and many have Ph.D.s. These Ph.D.s can be in toxicology, pharmacology, medicinal chemistry, or related biopharmaceutical disciplines. There are almost no Ph.D. programs in forensic toxicology per se. Practitioners with M.S.-level training might have their degrees in the subjects mentioned just above, or in forensic science from a program that has an emphasis or a concentration in toxicology and additional training. It is probably fair to say that most toxicology lab directors or heads of large toxicology sections are Ph.D.s. A considerable part of forensic toxicology is analytical. Thus a strong chemistry background is essential, and many students contemplating a toxicology career earn B.S. degrees in chemistry. A B.S. degree in biochemistry could also be suitable if the student made certain to get appropriate courses in analytical and physical chemistry.

Toxicologists handle a variety of questions, through analysis of post-mortem specimens or of specimens from living individuals. Post-mortem specimens are typically screened for commonly encountered drugs of abuse, possibly for ethanol, and for toxins if indicated, to assist the medical examiner in determining cause and manner of death (see below at 2.8).
Drugs and toxins can contribute to a death and in sufficient doses can actually cause death. Specimens from living persons are generally submitted for drug screening. Drug screening is required as pre-employment screening for certain types of positions requiring security clearances or high levels of trust and responsibility. Random drug screening is required in certain occupations, and to verify compliance in treatment programs.

Some toxicology laboratories devote considerable attention to driving-while-intoxicated or driving-under-the- influence enforcement. This effort can involve actual testing of blood or breath specimens, or responsibility for breathalyzer calibrations. In the last few years, toxicologists have had to become involved in some sexual assault cases where drugging of victims was an issue. Toxicologists can be involved in compliance matters (such as with methadone-maintained patients) and with the testing of newborns for evidence of drug exposure due to maternal drug abuse. Among the biomedical forensic specialties, there are probably more opportunities for employment in toxicology than in any of the others. There are toxicology services (and thus toxicologists) in a number of large forensic science laboratories, as well as in every medical examiner’s office. In addition, there are a number of private and government laboratories engaged in drug-free workplace compliance, pre-employment screening, etc.

There is a specialty certification board for forensic toxicology, the American Board of Forensic Toxicology and as of mid-2018 there were about 180 Fellows and 260 diplomates. Although certification is a highly desirable credential, quite a few individuals working in the toxicology field have not obtained certification. Certain degrees or certifications may be required for certain directors of laboratories that are subject to federal supervision.

2.6 Forensic entomology

Entomology is the science of insects. Forensic entomologists focus on insect activity connected with death and dead bodies. Generally, forensic entomologist have Ph.D.s in entomology and some additional specialty training in forensic applications gained through non-academic courses and/or direct experience under the tutelage of a more senior specialist. Their B.S. degrees might be in biological sciences or in entomology.

There is a certification board for this specialty, but only about a dozen individuals are certified. There are also categories for “members” and “technicians.”

Most forensic entomologists are academics who do forensic cases on a consulting basis. There are generally not enough entomology cases in a jurisdiction to warrant a full-time forensic entomologist. Most of the time, forensic entomologists go to death scenes to collect insect evidence, or they may receive insect evidence collected by other investigators. Analysis of egg, larvae (maggots), or pupae of insects can be helpful in determining time since death. Forensic entomologists may also help the pathologist to interpret insect or other animal bites.

2.7 Forensic (physical) anthropology

Forensic anthropologists are classically physical anthropologists, that is, specialists in human osteology (skeleton), as against cultural anthropologists.
Like the forensic entomologists, the majority of these specialists are academics who consult on forensic cases as necessary, although there are more forensic anthropologists than there are forensic entomologists. A small number have full-time positions involving human identification, and there are some in full-time positions who have other duties (such as medico-legal death investigation) in addition to anthropology cases. Forensic anthropologists have M.S. or M.A. degrees at minimum, and many have Ph.D.s. Their B.S. or B.A. degrees could be in physical anthropology or in biological sciences. Forensic anthropologists are essential in examining skeletal remains. They can extract considerable information about a person from skeletal remains, including but not limited to estimates of age, stature, gender, skeletal diseases or abnormalities, and information about skeletal trauma.

Physical anthropologists have traditionally been interested in human evolution. As DNA analysis methods have evolved and developed in ways that can be used to shed light on evolutionary questions, these applications have been pursued. These investigators are typically Ph.D.s with backgrounds in molecular biology and/or molecular genetics, and might be called “molecular anthropologists”.

Specialty board certification is available in forensic anthropology.\(^9\) Candidates for ABFA certification generally must have a Ph.D. as well as meeting other requirements. Around 80 individuals in the nation are active diplomates of this board.

2.8 Forensic pathology

Forensic pathologists are physicians who have specialized in pathology. An appropriate college degree and graduation from medical school with a MD are the first steps into this specialty.

An internship and a pathology residency generally follow medical school. Finally, specialized training in forensic pathology completes the preparation. This may take the form of a one-year fellowship in forensic pathology at one of the nation’s medical examiner offices that engages in training. This education and training can take 15–16 years from high school graduation.

Forensic pathologists are often medical examiners, whose duties under the law generally consist of determining cause and manner of sudden, unexpected, or questioned deaths – usually any death that occurs outside medical supervision. Medical examiner offices are established by municipal, county, or state laws. Forensic pathologists must have a state license to practice medicine and board certification in pathology and forensic pathology.\(^10\) There are around five hundred fully board-certified active forensic pathologists throughout the nation, most serving in medical examiner or coroner offices.

It is worth noting that the number of board-certified forensic pathologists is considered too low – many more would be required to meet the needs of proper death investigation. Both the National Research Council committee,\(^11\) and the specialized medicolegal death investigation committee\(^12\) have emphasized this point.
2.9 Forensic psychiatry

Forensic psychiatrists, like forensic pathologists, are physicians and follow a course of education and training similar to that described above for a forensic pathologist, except that their residency is in psychiatry, and they may complete their training with a fellowship in forensic psychiatry. Forensic psychiatrists evaluate suspects and offenders for the courts, can be involved in evaluating children and victims, and may get into criminal and behavioral profiling. They also treat certain offenders.

Forensic psychiatrists must have a state license to practice medicine and board certification in psychiatry. Certification is offered in the forensic psychiatry specialty by the American Board of Psychiatry and Neurology. Many forensic psychiatrists are in private practice, but they may also be employed by corrections, probation and parole, or law enforcement agencies.

2.10 Forensic odontology (forensic dentistry)

Forensic odontologists are educated and trained first as dentists. After completing appropriate college course requirements for entry into dental school, they complete the professional D.D.S. or D.M.D. degrees. Some dentists take additional specialty training and may earn M.S. degrees in specialty areas.

Training in forensic odontology is typically gained through non-academic courses, and/or by direct experience under the tutelage of a senior forensic odontologist. There are several institutions where forensic odontology training is available.

Specialists in this field do human identifications through comparisons of dentition and dental X-rays (in accidents, mass disasters, etc.) and also compare bitemarks with test impressions from suspects. Forensic odontologists must have a state license to practice dentistry and many have board certification in forensic odontology. The American Board of Forensic Odontology certifies forensic odontologists. There are around 95 active board-certified odontologists in the nation. The vast majority of them have regular dental practices, and work on forensic cases as needed, often as consultants to medical examiners, law enforcement agencies, or hospital emergency departments. Many are also active in DMORTs (Disaster Mortuary Operational Response Teams).

2.11 Forensic nursing

Forensic nursing is a relatively recent specialization for trained nurses who are interested in certain aspects of forensic practice. The specialty revolves around the treatment of sexual assault complainants, and collection of evidence and information from them. Sometimes, the forensic nurses have specialized clinics just for this purpose. This practice has given rise to the Sexual Assault Nurse Examiner (SANE) specialty, and to the formation of Sexual Assault Response Teams (SARTs) in many places. Forensic nurses may also be involved in emergency department operations involving injury or death that is a result of criminal actions.

Forensic nurses start out as nurses, often with a B.S.N. degree. Some have M.S.N. or N.D. (doctoral) degrees. Certification is available through the International Association of Forensic Nurses.
2.12 Forensic psychology

Forensic psychologists are not medical doctors (physicians), but most will have met state requirements for clinical practice. Most states require that a person have earned a Ph.D. in psychology (some states have at times accepted the M.S.W. – Master of Social Work – as well) complemented by an appropriate clinical internship. A forensic psychologist’s work is similar to that of a forensic psychiatrist.

Certification is offered through the American Board of Professional Psychology. Certification generally requires a Ph.D. from an appropriately accredited academic program in addition to other requirements and training. A small number of forensic psychologists, who may or may not be licensed for clinical practice, do criminal profiling.

It should perhaps be noted that there are very few opportunities for full-time criminal profiling across the whole country.

3. Certification and Accreditation

Throughout the discussion of specialties, certifications have been mentioned. Certification is widely considered a valuable credential if it is obtained from a legitimate certifying body. Generally, certifying boards are accredited by oversight committees or agencies such as the Council for Higher Education Accreditation or the Forensic Specialties Accreditation Board.

Certification is for individuals, while accreditation is for organizations or service entities. Although certification is available in many forensic science specialties as noted, it is not necessarily required for employment or for practice. Certification is valuable for the public and for consumers of the specialty knowledge, as it provides assurances that certain minimum standards have been satisfied by the practitioner. Most certification programs require periodic re-certification.

Accreditation is worth mentioning in this paper because universities are generally accredited, and so can be many of the programs they offer. In the forensic sciences, the Forensic Science Education Programs Accreditation Commission accredits academic programs in criminalistics, including forensic biology and forensic chemistry, and digital forensic science programs, at both the B.S. and M.S. levels. The FEPAC web site provides a list of programs that have received accreditation.

4. Concluding Remarks

An outline of the scope and educational requirements for the major forensic science specialties has been presented. Depending on the specialty area, the education/training pathway may be relatively short and informal (such as in crime scene investigation) or it may require more than one degree and be quite lengthy (such as in forensic pathology). The employment opportunities markets in the different specialty areas have also been briefly described.
Most of the “forensic science” programs in colleges and universities provide education and training in criminalistics and/or toxicology. Some are highly specialized (for example, they may only offer training in DNA analysis), while others are more general in their approach. A recent trend is the effort to try to integrate training with graduate education, and to thus shape some graduate programs in criminalistics more toward professional degrees (similar in objectives to medical, dental, public health, pharmacy, and similar degrees that prepare someone for a specific profession).

Ubelacker\textsuperscript{18} and Williams et al.\textsuperscript{19} have discussed directly and indirectly many of the subjects in this paper.

Acknowledgements

I thank the late Dr. Ladi Berka of Worcester Polytechnic Institute for first inviting me to write about this subject for the New England Association of College Teachers Journal. That article was later revised and published in Anal Bioanal Chem (2003) 376 : 1151–1155. I thank Dr. Jack Kenney, Dr. Dwight Adams, and Dr. Kurt Nolte for recent valuable discussions.

References

8. American Board of Forensic Entomology [Internet] Available from: forensicientomologist.org, retrieved July, 2018
10. American Board of Pathology [Internet] Available from: http://www.abpath.org, retrieved July, 2018
12. Scientific Working Group for Medicolegal Death Investigation, Increasing the supply of forensic pathologists in the United States, Dec 5, 2012 [The SWGMDI has been supplanted by the OSAC Subcommittee on Medicolegal Death Investigation operating under the auspices of the National Institute of Standards & Technology]
15. International Association of Forensic Nurses [Internet] Available from: https://www.forensicnurses.org, retrieved July, 2018