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What is Forensic Science?

The word *forensic* comes from the Latin word *forensis*. A relevant, modern definition of *forensic* is: *relating to, used in, or suitable to a court of law* (Merriam Webster Dictionary, www.merriam-webster.com). Any science used for the purposes of the law is a *forensic* science.

The forensic sciences are used around the world to resolve civil disputes, to justly enforce criminal laws and government regulations, and to protect public health. Forensic scientists may be involved anytime an objective, scientific analysis is needed to find the truth and to seek justice in a legal proceeding. Early on, forensic science became identified with law enforcement and the prosecution of criminal cases — an image enhanced by books, television, and movies. This is misleading because forensic science is objective, unbiased, and applies equally to either side of any criminal, civil, or other legal matter.

Forensic science is a rewarding career where the love of science can be applied to the good of society, public health, and public safety.

What is a Forensic Scientist?

A forensic scientist is first a scientist. When a scientist’s knowledge is used to help lawyers, juries, and judges understand the results of scientific tests, the scientist becomes a forensic scientist. (Sherlock Holmes was a forensic scientist).

Forensic science is a vital tool in the search for the truth in any legal proceeding. In criminal matters, scientific analyses and tests conducted by qualified forensic scientists can exonerate as well as convict an accused person. In civil cases, such as a lawsuit for damages from a vehicle accident or from a medical problem, testing and analysis by a qualified forensic scientist may be used by either side to address the validity of the allegations in the suit. Regardless of the type of legal proceeding or which side uses scientific evidence, the forensic scientist must be able to write a report and testify under oath about: what facts or items of evidence were analyzed or tested; what tests or analyses were used; how valid or reliable those tests or analyses have been found to be by other courts; why and how the forensic scientist was qualified to
conduct those tests or analyses; and, what the results of the tests or analyses were and how those results are relevant to the issues in dispute.

What Do Forensic Scientists Do?

Because the work of a forensic scientist is intended to be used in court and because scientific evidence can be very powerful, the forensic scientist must be accurate, methodical, detailed, and above all, unbiased. The ability to keep detailed notes and to write clear, concise, and accurate reports is vital.

The forensic scientist must be able to determine which facts or items of evidence are relevant. In most cases, that’s easy – the item or items are provided to the forensic scientist for examination and analysis. In other cases, the forensic scientist may need (or want) to personally go to the scene to conduct an on-site analysis, gather evidence, or document facts for later analysis. Having been provided or having gathered the relevant information, the forensic scientist then has to decide which examinations, tests, or analyses are appropriate – and relevant – to the issue(s) in dispute. (Is that powder cocaine or not? Did a defect in the road surface cause the crash?). Then, the forensic scientist must conduct the most appropriate tests/analyses and document the process. Afterward, the forensic scientist must interpret the results and write a clear, concise report documenting the steps followed to reach this conclusion or opinion of the forensic scientist.

The forensic scientist will, at some point, have to testify. Testimony is the verbal statement of a witness, under oath, to the judge or jury. Forensic scientists are “expert” witnesses as opposed to ordinary or “fact” witnesses. Expert witnesses are permitted to testify not just about what the results of testing or analysis were (“facts”), but also to give an opinion about what those results mean. For example, a forensic scientist may testify about the observed, factual results of a chemical drug analysis and that, in their expert opinion, the results show that the tested substance is a specific drug, such as cocaine or heroin.

To qualify as an expert witness, the forensic scientist must have a solid, documented background of education, training, and experience in the
scientific discipline used to conduct the examinations, testing, or analyses about which the forensic scientist wants to testify.

Sometimes in court, the work or qualifications of the forensic scientist are challenged. A party to a court case may challenge whether the scientist performed the tests correctly; whether the scientist interpreted the results accurately; or, whether the underlying science is valid and reliable. Finally, a party to a court case may challenge whether the scientist is properly qualified to render an expert opinion or question the scientist’s impartiality.

“If the law has made you a witness, remain a man of science. You have no victim to avenge, no guilty or innocent person to convict or save — you must bear testimony within the limits of science.”

— Dr. P.C.H. Brouardel
19th-Century French Medico-Legalist

How Do I Become a Forensic Scientist?

You will need:

• A bachelor's degree – get a degree in science (chemistry, biology, physics, etc.), but also take courses in math, statistics, and writing skills.
• An advanced degree – some jobs, such as psychiatrist, anthropologist, or pathologist require advanced degrees and specialized training.
• Good speaking skills – take public speaking; join the drama club, toastmasters, or the debate team.
• Good note-taking and observation skills – take laboratory courses.
• The ability to write an understandable scientific report
• The ability to be unbiased
• Intellectual curiosity
• Personal integrity
How Much Money Will I Make?

Income in the forensic sciences varies greatly depending on the type of job, the employer, and the work requirements. Forensic science careers provide comfortable, but not necessarily “high dollar,” salaries. Forensic scientists work different hours, depending upon what they do. Most scientists in forensic laboratories work 40 hours per week, Monday through Friday. Others work in the field and their work hours may vary. Still others are “on call” and the work hours vary widely. Every branch of forensic science offers opportunity for personal growth, career advancement, and increased financial compensation.

Where Will I Work?

Forensic scientists work in laboratories, at crime scenes, in offices, in classrooms, and in morgues. Their responsibilities may include field work – domestically or abroad, in various locales and in varying climates. They may work for federal, state, and local governments; international organizations; public and private laboratories; medical examiners offices; hospitals; universities; police departments; or as independent forensic science consultants.

Disciplines Within the American Academy of Forensic Sciences

The American Academy of Forensic Sciences (AAFS), the largest forensic science organization in the world, has over 6,000 members (scientists and lawyers), representing different disciplines within the forensic science community. Information concerning careers in each of the eleven sections of the AAFS will be provided:

- Anthropology
- Criminalistics
- Digital & Multimedia Sciences
- Engineering Sciences
- General
- Jurisprudence
- Odontology
● Pathology/Biology
● Psychiatry & Behavioral Science
● Questioned Documents
● Toxicology
Imagine a scenario where a decomposed, mostly skeletonized body is found under some bushes along a remote road. Large bones are clearly present and what appears to be a human skull can be observed under some leaves. Tattered clothing is located in close proximity. It is this type of situation where a forensic anthropologist would likely be called to assist. The skills of a forensic anthropologist will be critical in the recovery and documentation of the skeletal remains and associated evidence at the scene as well as in the subsequent laboratory analysis of the bones to identify the person and determine how they died. With expertise in archaeological methods and an extensive background in human osteology (the study of the human skeleton), a forensic anthropologist can help solve even the most challenging cases.

Recovery of skeletal remains from a crime scene.

Scope of Work

“Anthropology” is a very broad field that includes many sub-disciplines such as cultural anthropology, archaeology, linguistics, and physical (biological) anthropology. Most commonly, forensic anthropologists specialize in physical anthropology and archaeology. It is from physical anthropology that a forensic anthropologist learns the skills of human osteology and interpretation of the human skeleton. It is from training in archaeology that a forensic anthropologist learns the proper methods of
excavation and mapping to apply during the recovery of buried or scattered human remains.

Meticulous scene recovery procedures will ensure that all evidence and remains are properly collected and that the spatial relationships between them are documented. Scene recoveries can include cases such as a skeleton scattered on the surface, buried remains, fire scenes, and mass fatality incidents such as plane crashes or explosions.

Through the study of the skeleton, forensic anthropologists attempt to reconstruct as much as possible about a person’s life and death. Laboratory analysis can develop the “biological profile” of the person (including whether they are male or female, their age at death, ancestry, and living height) based on specific features observed on their bones. Components of the biological profile are critical to the identification process. In addition, previous skeletal pathologies (such as healed broken bones), diseases, and other skeletal features can help provide further information about an individual’s life and help identify them. Every piece of information potentially narrows the pool of missing individuals who could be a match to the remains. Skeletal analysis will also reveal clues on the bones that could suggest how the person died, such as cut marks from a knife and fractures resulting from gunshot or blunt force trauma. The stage of body decomposition, in combination with information about environmental conditions, can help estimate how long the individual has been dead.

**Education and Training**

Forensic anthropologists usually earn a PhD in anthropology with an emphasis on the study of human osteology and anatomy. Although the course of study will vary, each forensic anthropologist is broadly trained in physical or biological anthropology with an emphasis in skeletal
biology. Archaeology is also an important component and valuable experience is gained from attending archaeological field schools and excavating actual sites. Whether the archaeological excavations are ancient or modern, the student gains an understanding of excavation methods and site formation processes through “hands-on” experience.

The American Board of Forensic Anthropology (ABFA) was created for the purpose of certifying experts in the field of forensic anthropology. For board certification, it is necessary to demonstrate proficiency in all aspects of forensic anthropology. This is accomplished through training, case analysis, and rigorous examinations. Requirements for certification may be found at the ABFA website (www.theabfa.org).

**Career Opportunities**

Forensic anthropologists work in various organizations. Today, many forensic anthropologists are university professors who perform casework on a part-time basis by consulting for local medical examiner/coroner offices. Some large medical examiner offices employ full-time forensic anthropologists on staff. Other forensic anthropologists work for human rights organizations and federal government agencies (e.g., FBI and the U.S. Department of Defense). It is not uncommon for forensic anthropologists to also serve additional roles such as medicolegal death investigators or identification specialists. Full-time work in forensic anthropology is limited and positions are typically very competitive.
“Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as silent evidence against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen that he deposits or collects - all these and more bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence. Physical evidence cannot be wrong; it cannot perjure itself; it cannot be wholly absent. Only its interpretation can err. Only human failure to find it, study and understand it, can diminish its value.”

— Paul L. Kirk, PhD
“Father of Criminalistics”

Crime Investigation: Physical Evidence and the Police
Laboratory Interscience Publishers, Inc., New York, NY 1953
Chapter 1, page 4.

Scope of Work

Criminalists analyze, compare, identify, and interpret physical evidence, then report results for use in the justice system. Forensic laboratories have two primary functions: (1) identifying evidence; and, (2) linking individuals, objects, and locations through physical evidence. The main role of the criminalist is to objectively apply standard, scientific processing techniques of the physical and natural sciences to examine physical evidence. Physical evidence may be anything. It may be as subtle as a whiff of a flammable gas at an arson scene or as obvious as a pool of blood at a homicide scene. The enormous range of material challenges the ingenuity of the criminalist who examines and identifies hair, fibers, blood, seminal and other body fluid stains, drugs, paint, glass, botanicals, soil, flammables and safe insulating material; restores obliterated, smeared or smudged markings; and identifies firearms and compares fired bullets, tool markings, and footwear impressions. In most cases, the amount of the evidence to be tested is very small, such as a drop of blood, a hair, or a piece of glass, but can be a vehicle or other large object.
Using specialized training, analytical skill, and practical experience, the criminalist separates evidence from items having little or no value. Next, the criminalist sorts, compares, and identifies the evidence, using chemical tests and instruments to develop useful information for investigation or at trial. The criminalist may find, for example, that a bullet has been fired from a particular gun, the DNA profile from a bloodstain inside a suspect’s car is the same as the victim’s DNA profile, or that a fragment of paint from the scene of a hit-and-run accident has come from a particular car. These types of analyses are rarely routine; they require an eye for detail, a broad practical scientific background, and the ability to apply these skills in the laboratory.
Perhaps the most important task of the criminalist lies in interpreting the results of the tests to help determine the facts. The results may help to determine the circumstances at the time a crime occurred or to provide details supporting a witness’s statement. Reconstructing the events of a crime can be very difficult. It requires an understanding of the meaning of results from the analysis of physical evidence, of the physical laws and processes involved, and the recognition of how they interact. Finally, any results and conclusions made by the criminalist must be conveyed to the others in the criminal justice system, such as officers, attorneys, and jurors. This is done by written reports and expert testimony. The criminalist must express conclusions so that technical details are understood by the non-scientist jury, attorneys, and judges.

Criminalists must be able to think critically and use scientifically valid methods to analyze anything and everything submitted to the laboratory. They must be familiar with many different types of equipment and techniques in order to conduct the necessary testing. They must know basic chemistry concepts as well as have advanced knowledge of instrumental techniques that include polarized light microscopy (PLM), gas chromatography/mass spectroscopy (GC/MS), Fourier Transform Infrared Spectroscopy (FTIR), Raman IR, and scanning electron microscopy (SEM) to name a very few.

Education and Training

The minimum educational requirement for a criminalist is a bachelor's degree in chemistry, biology, physics, molecular biology, forensic science, or a related physical science. For some positions, a master’s degree is required. Many colleges and universities offer degrees and courses in forensic science. When choosing a forensic science program,
It is important to determine whether the program is accredited by the Forensic Science Education Programs Accreditation Commission (FEPAC). (www.fepac-edu.org). Accredited programs offer the necessary amount of science and math required to be a criminalist.

In deciding whether to get a degree in chemistry, biology, or forensic science, study the courses offered. At least 24 semester hours of either chemistry or biology is required and math is a must. Knowledge of statistics is becoming increasingly important. The title of the degree is not as important as the courses taken.

The education of a criminalist never stops. Because forensic science is an ever-evolving field, criminalists must continually increase their knowledge in their discipline. To keep up with the many advances in science, the criminalist must take continuing education courses. After successfully completing an examination, the criminalist may become certified by the American Board of Criminalistics (www.criminalistics.com) in a variety of specialties. Entire forensic laboratories may prove their competence by becoming accredited to the International Organization for Standardization (ISO) standards. ISO accreditation demonstrates best management practices coupled with the best science practices with the competency of the scientific staff. Currently, there are four U.S. accrediting bodies recognized by the International Laboratory Accreditation Cooperation (ILAC) that provide ISO forensic accreditation. Forensic laboratory accreditation is required by law in a number of states.

**Career Opportunities**

Criminalistics is a diverse profession and criminalists usually specialize in one or more of the many sub-disciplines, such as firearms and toolmark identification, biology/DNA, controlled substance analysis, or fire and explosion debris analysis. Criminalists work in forensic laboratories in police departments, sheriff offices, district attorney offices, regional and state agencies, medical examiners’ offices, private companies, colleges and universities; and for federal agencies such as the Drug Enforcement Administration (DEA); Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF); Federal Bureau of Investigation (FBI); United States Postal Service; the military forces, and the United States Fish and Wildlife Services. Criminalists assist the United States
Department of Justice in helping other countries create or update forensic science services.

The criminalist may start as a “bench” scientist after graduating from college and, through education and dedication, work up to forensic laboratory director. There are many opportunities to teach at community colleges and universities training future criminalists. As forensic science advances, more criminalists will be needed to perform new tests in an ever-expanding field of evidence.

**Biology/DNA**

A criminalist specializing in DNA must have a solid scientific foundation and be flexible and willing to routinely implement newly-validated testing reagents, customized laboratory consumables, enhanced automation and instrumentation methods, and new DNA genetic markers. Interpretation of DNA evidence is one of the most challenging aspects of forensic DNA analysis especially as it relates to statistical calculations for DNA profile rarity and new software programs are constantly improving this task. Forensic DNA analysis continues to evolve into new technologies, including Rapid-DNA where forensic DNA results are obtained within about an hour. DNA analysis may be conducted in government and private DNA laboratories, criminal booking agencies, mass disaster sites, and international areas of conflict. Another progressive technology is Next Generation Sequencing (NGS) in which massive amounts of genetic information are obtained through the rapid synthesis of target DNA achieving greater statistical reporting power. DNA testing will always be evolving for the criminalist who chooses DNA as a forensic profession.

**Controlled Substances**

Drug chemistry is one of the many forensic disciplines in a typical forensic laboratory. The drug chemist uses a wide variety of techniques and methods including color and microcrystal tests, chromatography (thin layer, gas, liquid, and high-pressure liquid), spectrophotometry (ultraviolet, visible, infrared).

*Cocaine – drug, bongs, test results.*
raman), spectrometry (mass spectrometry), X-ray spectroscopy (X-ray diffraction), and nuclear magnetic resonance spectroscopy. Many of these tests are considered preliminary in nature as they do not identify a specific compound but a general class of compounds. Techniques that are considered confirmatory are those which actually determine the structure of a compound and thus identify a specific compound instead of a class of compounds. The most common confirmatory instruments are infrared (FTIR), mass spectrometry (MS), nuclear magnetic resonance (NMR), and X-ray diffraction (XRD). The drug chemist may have large quantities of drug materials to analyze or just milligrams of a material. The drugs may be pure or mixed with other substances which then require the chemist to extract the drugs for analysis. Drug analysis normally has the highest number of analyses in forensic laboratories due to the high incidence of drug abuse around the world.

Fire
In fire debris analysis, it is necessary to know how flammable liquids are made and how they burn in order to recognize both the flammable liquids and their breakdown products (i.e., combustion products) that may be found in the fire debris.

This cabin exploded because of a leak in a poorly installed propane gas line. Accumulated gas was set off by a loose electrical connection at the furnace. Criminalists often combine multiple skills or work with other disciplines. Determining the cause of the explosion that destroyed this log cabin required collaboration among chemists, metallurgists, and engineers.

Fire investigation was once practiced largely by non-scientists using “rules of thumb.” New research into the production of fire patterns has revealed that much of what the profession thought it “knew” about fire behavior was not accurate. Determining the origin (where the fire started) is not as easy as it was once thought. Several high-profile cases of wrongful conviction have made it clear that there is a need for more scientists with knowledge of chemistry and physics to enter the field.
Trace evidence testing covers a wide area of materials to be analyzed such as explosives, gunshot residue, hairs, and fibers. In many cases, criminalists must understand the physics of how evidence is produced.

Criminalists must not only understand the composition of trace evidence but also understand the dynamics that create or alter physical evidence. For example when an explosion occurs, it is very rare that the explosive or device that explodes is completely consumed or destroyed. Rather, they are transformed into residues and very small pieces. It is up to the criminalist to analyze these residues and recognize these small pieces for what they are (i.e., explosive device components) and how they relate back to the original explosion.

Wildlife Forensic Science
Poaching violations, the development of state and federal hunting regulations, the Endangered Species Act of 1973, and the United Nations Convention on International Trade in Endangered Species (CITIES) are some of the factors which helped create this new field.

The major difference between criminal forensic science and wildlife forensic science is that the victim (and occasionally the suspect) is an animal.

The identification of wildlife evidence can be complicated because wildlife enforcement officers rarely seize whole animals which can be readily identified by a museum or zoo expert. More typically parts or the products created from wildlife will be recovered as evidence. The characteristics which define an animal species are rarely present in those parts or products.

Wildlife forensic scientists are often required to develop new ways to identify species through research with carefully documented known specimens before they can examine evidence in a case and testify in court. An additional complication is that, while human forensics deals with only a single species (homo sapiens), wildlife forensic scientists must be prepared to identify evidence from any species in the world that is illegally killed, smuggled, poached, or sold through an illicit market.
Examples of wildlife evidence items might be blood on an illegal hunter’s clothing; fresh, frozen, or smoked meats; loose hair; fur coats; reptile leather products, such as purses, belts, and shoes; loose feathers and down; carved ivory objects; sea turtle oil (suntan lotion); shell jewelry; and powdered rhinoceros horn. While it might seem that wildlife forensic scientists face an overwhelming task in developing new and reliable ID techniques, they do have one advantage over other forensic scientists: sample size is rarely a problem. Example seizures of wildlife evidence have included 20,000 pounds of suspected sea turtle meat, 10,000 pounds of ivory, and 300,000 suspected rhinoceros horn pills.

**Suggested Additional Reading**

Butler, John M., Forensic DNA series by (Elsevier)


*Advanced Topics in Forensic DNA Typing: Methodology*, 2011.


Digital & Multimedia Sciences

Digital data are all around us and are collected routinely in most investigations. More likely than not, someone involved in a crime operated a computer, used a mobile phone/device, or accessed the Internet. Additionally, digital audio, photography, and video recording devices are nearly everywhere; most businesses and many local and state governments have security cameras/devices that can yield a surprising amount of photos/video. To meet this growing demand, there are several specialties in Digital & Multimedia Sciences. Digital & Multimedia Sciences professionals not only perform and conduct digital forensic examinations, they also help develop the scientific foundations for the practice of digital forensics, including research and publication, and they may manage digital forensic laboratories.

Digital evidence examinations require very specific hardware and software tools to find numerous types of digital evidence. Examiners, depending upon their specialties, may discover evidence and provide testimony concerning the following:

- Digital device examinations
- Network analysis
- Examination and comparison of digitized numerals, images, analog/digital audio and video (which includes examinations such as authenticity, photogrammetry, and enhancement)

Computer forensics used to involve simply looking at individual computers which may have some connection to criminal activity. With the ready availability of access to the Internet, intrusions to gain access to or corrupt information on other computer systems by criminals have become widespread. Network forensics is required to properly investigate and determine what happened. This extends to mobile devices with the explosion in smart phone and tablet systems that provide fully networked computing technology in the palm of your hand.

The analysis of audio recordings requires techniques and procedures which continue to be evolving areas of research. Forensic speaker comparison, acoustic analysis and enhancement, and audio authenticity examinations are all important activities which can aid investigations and assist in the settlement of disputes. With capabilities to disguise voices as well as easily manipulate digital audio with off-the-shelf technology,
the investigation of underlying acoustic patterns has become one of many important areas of both technological and linguistic research.

The advent of digital photography provides the potential to aid in the documentation of crime scenes and injuries. Digital photography also provides a source of images from witnesses, victims, and subjects due to the widespread availability of digital cameras in laptops, tablets, and smart phones. An extension of the explosion of technology is the widespread availability of video recording capabilities. Nearly every mobile device can record video, providing more sources of evidence than ever before. Over 100,000 photographs and 13,000 digital videos were reviewed in the Boston Marathon Bombing investigation, which added the complexity of sheer volume to the traditional issues in digital image and video examinations. Deriving important information from digital photographs and videos relies on the ability to authenticate such images as well as enhance and conduct analysis to extract meaningful evidence.

The work in a digital and multimedia examination might address some of the following questions:

- What files have been deleted from the digital device?
- What other digital devices have been connected to this system?
- Was this system attacked or modified by someone over the network?
- Can a remote system or user be located or identified?
- What sites on the internet were visited by this system?
- Was this audio recording altered?
- Can this video recording be enhanced to help identify someone?
- Can the physical characteristics of an object in a photograph be determined?
- Can individuals an offender targeted or victimized be determined?
- Can unknown victims be located or identified based on phone number, email, etc.?
- Can patterns of offender activity related to the investigation be reconstructed?
Photographic analysis using photogrammetry.

Media analysis of a computer can recover deleted files.

Video analysis to enhance an image.

Spectrographic analysis of an audio recording.

Education and Training

Candidates for an apprenticeship program in digital and multimedia sciences should possess a minimum of a bachelor’s degree, preferably in computer science, information technology, or engineering. In the United States, there are undergraduate degree programs with emphasis in digital forensics, computer forensics, and media forensics. There are also graduate degree and graduate certificate programs in these fields. Digital forensic examiners also may have various types of certifications. A certified professional not only possesses technical competency but also adheres to a strong code of ethics.

Career Opportunities

Digital forensic examiners are employed in both the public and private sector. Private practice consultants can be found in most major cities. Many large police organizations as well as most state and federal law enforcement agencies, generally employ digital forensic experts. Scientists who specialize in the field of digital & multimedia sciences work or practice in the following forensic areas: computer-related crime investigator; computer specialist; image analyst/examiner; audio
analyst/examiner; video analyst/examiner; speech scientist; and, facial identification/biometrics.

Many qualified practitioners are members of the American Academy of Forensic Sciences (www.aafs.org), International Association of Computer Investigative Specialists (www.iacis.com), the High Technology Crime Investigation Association (www.htcia.org), the International Society of Forensic Computer Examiners (www.isfce.com), the Audio Engineering Society (www.aes.org), the International Association of Identification (www.theiai.org), the Law Enforcement & Emergency Services Video Association (www.leva.org), the Institute of Electrical and Electronics Engineers (www.ieee.org), and other professional groups and societies.

Suggested Additional Reading


Farmer, D. and Venema, W., Forensic Discovery, Addison-Wesley, Boston, MA, 2009.


Who Are Forensic Engineering Scientists?

Forensic engineering scientists make up perhaps the most varied group of forensic practitioners. Collectively, their interests extend across all of the engineering fields as well as the underlying sciences such as physics and chemistry. They are problem solvers and problem definers who are often brought into an investigation with no clear definition as to what they are going to do but with the expectation that they will do *something* useful. For example, Caltech Physicist, Richard B. Feynman, was asked to address the Challenger disaster not because of his quantum field theory work that brought him the Nobel Prize but because he represented the epitome of a field known for its problem-solving genius.

In broad terms, these individuals perform research and design services in addition to building, manufacturing, and maintaining structures and devices that sustain and improve our modern way of life. They deal with mechanisms, heat, sound, electricity, fluids (gases and liquids), the environment, weapons systems, transportation, the biosciences, food production, and communications. In short, just about everything you see around you every day and some things that you do not see (such as pacemakers, groundwater, and artificial joints). Above all else, human health and safety are overriding concerns for the forensic engineer.

Scope of Work

The forensic scientist or engineer applies the tools and techniques of science and engineering to resolve questions relating to civil, criminal, and regulatory issues. Forensic scientists and engineers typically investigate accidents, product failures, environmental contamination, and criminal acts. Incident investigations may involve bridge or building collapses, automobile collisions, air and rail accidents, explosions, shootings, and stabbings. Practitioners of forensic engineering sciences may be involved in helping to apprehend and convict criminals on the one hand or exonerating and protecting the innocent on the other. They may also provide support in lawsuits based on claims that negligent acts caused personal injury. Other cases may use forensic engineers to correctly assign blame for environmental harm, to evaluate claims that
product flaws resulted in injury to the user of the product, and to show whether patent rights have been infringed.

Many requests for forensic engineering services involve criminal and civil suits in which the forensic scientist or engineer will be asked to render expert opinions regarding the results of examinations. These opinions may receive further scrutiny in a deposition or during a trial. In most legal disputes involving science and engineering issues, each party will have their own experts who will evaluate the credibility of the proffered forensic analysis.

**Education and Training**

Before becoming a forensic scientist or engineer, you must first become a scientist or an engineer. Student engineers/scientists require a good grasp of the basic sciences of mathematics, physics, chemistry, geology, and biology. An individual specializing in any one of these disciplines should have a broad-based education that will provide a good understanding of all other disciplines. The forensic engineer or scientist should become an expert at one or more component disciplines. Examples might involve becoming an expert in environmental data collection and analysis including use of the mass spectrometer and gas chromatograph. As another example, the forensic engineer/scientist might become an expert in electronic components and system design to enable the diagnosis of system failures and design flaws. In still another example, the investigator of an accident involving military munitions should have become expert in non-destructive, non-invasive evaluation using advanced imaging techniques such as gamma radiography, ultrasound, and MRI scans in order to ascertain what went wrong.

The minimum education required is a bachelor’s degree in engineering or science. Depending on the field chosen, an advanced degree, MS or PhD, may be recommended. Work experience in the chosen field is a plus. Other essential capabilities include writing and speaking skills. Knowledge and understanding of legal procedures and standards of proof are often important. Some engineers acquire a Professional Engineer (PE) license; however, a PE is not required. Active participation in professional organizations and continuing education are highly recommended. The forensic engineer or scientist must be highly competent, ethical, credible, and should have extensive professional experience in the subject matter under consideration.
Career Opportunities

Job opportunities for forensic engineering scientists track those for other types of forensic practitioners—crime labs at the federal, state, and local levels; law enforcement agencies; research laboratories; insurance companies, and small or large corporations.

An opportunity for private consulting practice exists for many forensic engineering scientists once they are well into their professional lives. Far more than in any other sections of the American Academy of Forensic Sciences, Members and Fellows in the Engineering Sciences Section operate their own consulting firms that range in size from a single practitioner to multiple individual experts. The primary clients for these small consulting firms are attorneys with civil and criminal practices, corporations, states, municipalities, as well as prosecutors at all levels of government. Some engineers and scientists are choosing to pursue forensic engineering sciences as a first career, which adds a younger contingent to this growing community.
“There is literally no end to the number of disciplines that become ‘forensic’ by definition. Nor is there an end in sight to the number of present or future specialties that may become forensic. The examples are many.”

— Anthony Longhetti, BA
AAFS Past President
Editorial, Journal of Forensic Sciences
1983;28:3-5

The General Section was founded in 1968 and is the third largest section in the Academy. It is the home of established areas of forensic science not fitting into the more narrow definitions or membership requirements of the other sections, newly emerging forensic scientific specialties, or those forensic specialists whose numbers are not sufficient to support a separate section.

The goal of every section of the Academy is to promote professionalism, integrity, competency, education, foster research, improve practice, and encourage collaboration. Membership in the General Section provides opportunities for professional development, personal contacts, and recognition of achievements. Additionally, members can advance their scientific proficiencies by learning from and consulting with scientists with broader experiences and similar interests.

Scope of Work

Members of the General Section represent forensic specialties in the areas of laboratory investigation, field investigation, clinical work, education and research, and other emerging forensic science disciplines.

These individuals are employed or practicing in the following disciplines of forensic activity:

- Accounting
- Archaeology
- Art and Sculpting
- Aviation/Land Vehicle Accident Investigation
- Consulting
- Credibility Assessment
- Death and Crime Scene Investigation
- Education or Research
New areas of forensic study result from a combination of adaptation, unique problem solving, and advances in natural and social sciences. Other well-established disciplines, such as Anthropology, Odontology, Engineering Sciences, and most recently, Digital & Multimedia Sciences were nurtured in and emerged from the General Section of the AAFS.

The General Section is the Academy’s gatekeeper, always willing to consider accepting new disciplines that develop in response to the needs of the justice system. Our latest accepted discipline is Forensic veterinary sciences, concerned with the health and welfare of animals through the recovery, identification, and examination of material evidence of inhumane destruction, treatment, abuse, neglect, or illicit trade in animals or animal parts for legal purposes. Veterinary technologists and technicians perform medical tests under the supervision of a licensed veterinarian to treat or to help veterinarians diagnose the illnesses and injuries of animals.

One of our larger subgroups includes forensic nurses specializing in areas such as sexual assault examination, clinical forensic medicine, and death investigation. Forensic nurses also participate on elder and child abuse teams, mass fatality planning/response, and provide consultation on many other topics of medicolegal significance. These specially trained nurses contribute to any manner of investigations involving human injury or illness.
Education and Experience

All members of the General Section must have at least a bachelor's degree. Many of the disciplines represented require a master’s or doctorate degree. Work experience requirements vary with educational levels and specific field of interest. Almost all agencies that support forensic science personnel provide opportunities for continuing in-service training and many offer additional advanced training. Student mentoring is an especially important component of education for disciplines such as bloodstain interpretation, medicolegal death investigations, and forensic artistry, for which specific college degree programs have yet to be developed.

Career Opportunities

Many of the forensic scientists within the General Section work for universities, police agencies (state, city, and local agencies), federal agencies (such as DEA, ATF, and FBI), and criminal investigation arms of the military forces and their support laboratories. Others work for coroners, medical examiners, hospitals, and District Attorney’s offices. Private companies and independent forensic specialists are consultants to either the prosecution or defense. Income is dependent on specialty and geographical area and is generally increasing for the well-trained forensic scientist. Career advancements are available in many agencies and are dependent on the discipline.
As crime continues to evolve with technology and society, forensic scientists will be challenged to respond by adapting established technologies and, where necessary, developing new ones. These emerging forensic science disciplines will continue to be of vital importance to the courts and society in general.
“Forensic” is defined by *Black’s Law Dictionary* as “belonging to courts of justice.” Forensic science is “the application of scientific knowledge to legal problems” (*Merriam-Webster Dictionary*) such as criminal trials, civil disputes, and arbitration proceedings to assist courts in resolving questions of fact. Many of the forensic sciences - such as fingerprint analysis and document examination - originally developed from the need for lawyers to explain the significance of physical evidence to a case, often to identify a perpetrator of a crime. All forensic science is evidence used by lawyers in presenting and explaining their cases in court.

Rapid advances in scientific knowledge during the last century resulted in scrutiny by attorneys and courts of the validity of then-current scientific analytical techniques. Consequently, many areas of forensic science—defined by the laws of evidence as “technical or other specialized knowledge” — are being evaluated by courts under changing standards of reliability, validity, and admissibility. A forensic scientist will frequently be asked to provide testimony as an expert witness who has conducted a scientific analysis of the evidence in a legal proceeding. Consequently, forensic scientists must be aware of the process involved in being qualified as an expert and the evidence standards that will be applied to the scientific analysis performed by the forensic scientist. Expertise comes from education, training, or experience and can be based on the scientific method or on specialized training.

**Scope of Work**

Counsel on both sides of a matter being tried in court, as well as the judge presiding over the trial, are lawyers. They are the main players in the drama of the courtroom. A lawyer who uses expert testimony in a criminal, civil, or other legal proceeding must know the laws that govern the admissibility of scientific evidence and be able to apply these laws when submitting or challenging scientific evidence in depositions and court proceedings. The judge, also, must understand the issues concerning the validity and admissibility of scientific evidence and must ensure the legality of the entire process. Much depends on the knowledge, training, education, and experience of the forensic scientist whom a lawyer seeks to qualify as an expert witness since an expert
witness, and only an expert witness, is permitted to testify to an opinion based on analyses performed by the expert.

Although each deposition, hearing, or court appearance is a unique experience, forensic scientists testifying in a legal proceeding may reasonably expect questioning to cover at least a few key areas before the scientist is qualified as an expert by the judge. Either lawyer may ask about the field of specialization in which the witness claims to be an expert, the reliability of analyses based on that specialty, and the witness’s qualifications in that specialized field. Education in the field of specialized knowledge in which the witness claims to be proficient will be most relevant and may cover any and all formal education the witness has — or has not — completed. Any publications or educational materials written or edited by the witness or by others in the field may be used to either support or challenge the witness’s qualifications, opinions, and conclusions. Professional or technical training in the specialty, the witness’s performance during that training, as well as certifications or other credentials related to the specialty, may also be addressed.

The expert’s experience in the field of specialized knowledge may be covered, together with any issues related to the expert’s performance in the field. The witness’s performance at work — including written and oral performance evaluations, disciplinary proceedings, and any other evidence relevant to competence — may be scrutinized. Testimony by the witness in prior proceedings may be used to support or undermine the reliability or validity of the expert’s opinion in the current matter.

After the forensic scientist has been accepted as an expert either by agreement of the parties or by the judge, direct examination by the lawyer retaining the expert is intended to allow the expert to favorably state the expert's education, training, and experience in the field of specialized knowledge; the facts relied upon when preparing reports, summaries, or opinions for the case; the theories, techniques, methods, or procedures applied by the expert to analyze the facts; and any conclusions or opinions the expert reached as a result of this process. Direct examination is typically a smooth, comfortable exposition of the witness’s qualifications, reasoning, and opinion.

Cross-examination by opposing counsel is typically more challenging. A primary goal of an expert witness’s cross-examination is to identify any weaknesses that may undermine the relevance, reliability, and/or validity
of the expert’s conclusions. Although the witness has already been accepted as an expert, cross-examining counsel may try to discredit the expert’s testimony and opinions before the “trier of fact,” usually the jury, by questioning the expert’s qualifications; knowledge of the scope, limits, validity, and reliability of the witness’s area of specialization; application of that specialized knowledge to the facts of the case; and/or relevance of the evidence to the issues in the case. There are limits to all scientific disciplines. Experts well-versed in their discipline should be aware of those limits and be able to testify with ease about what can – and cannot – be known regarding a given piece of evidence.

**Education and Training**

Members of the Jurisprudence Section must possess a law degree, have passed a bar examination, and be licensed members in good standing of the bar in one or more states. Full-time law school students are eligible to join the section as student affiliates. Continuing education is essential for lawyers to stay current as forensic science advances and legal standards adapt to these advances. Judges are lawyers who have been appointed or elected to the bench. Since judges serve as “gate-keepers” for the admissibility of scientific evidence and of expert witnesses, they too, should take continuing education courses to remain fully aware of the issues surrounding the admissibility, reliability, and validity of scientific evidence and of the experts testifying to its use.

The Jurisprudence Section works to provide this knowledge to scientist and lawyer alike through workshops and presentations during the AAFS Annual Scientific Meetings held in February.

**Career Opportunities**

Lawyers working with forensic science issues may be employed in a variety of broad fields or specialties and by a broad range of employers and organizations. Some are in private practice; others work in District Attorney’s offices, State Attorney’s offices, Public Defender’s offices, or for federal, state, or local government agencies. Some are employed by large private companies; still others teach in colleges and universities. Hours of work and income are dependent on geographical area; place of employment; experience; status and reputation; and, type of practice.
Forensic dentistry (odontology) is a vital branch of forensic science that involves the application of dental knowledge, primarily for the identification of human remains. The forensic dentist’s work includes:

- the comparison of remains with dental records
- the comparison with dental records
- the evaluation of bitemarks (animal or human)
- the comparison with suspect dentitions;
- the aging of individuals by the dentition to determine chronological age both in the living and in the deceased;
- the evaluation of an individual’s dental/oral injuries to resolve civil (compensation, etc.) or criminal matters (assault, etc.);
- resolving dental malpractice or negligence issues.

All of these areas involve evaluation, report writing, and/or court testimony.

Scope of Work

Forensic dentists deal with a range of medicolegal problems, but the most common issue addressed is identification of human remains. Often no fingerprints are on file or are destroyed by decomposition, fragmentation, or by fire as occurred in 9-11 and in most air disasters. Natural disasters such as tsunamis, hurricanes, and volcanoes can involve an enormous number of deceased. Buried bodies may even need to be
re-identified if caskets are washed out of the ground by flooding or avalanche.

The identification of an unknown or confirmation of an identity is performed at the request of the coroner or medical examiner. Fragments of a jaw or a single tooth can be sufficient to make an identification providing antemortem (pre-death) dental X-rays are available for comparison. A postmortem (after-death) oral examination includes intraoral and extra oral photographs, dental X-rays, and dental charting. A “smiling” photograph of the suspected deceased can be used for comparison if the anterior teeth are still present in the remains. In the absence of a missing person match, the dental characteristics of an individual can give law enforcement clues to identity. Postmortem dental data can be rapidly compared to antemortem data using a database such as WinID (www.winid.com) to provide a list of the best matches for an odontologist to compare for a potential identification. In the case of an unknown deceased or a missing person, the data can be entered into NAMUS (National Missing and Unidentified Persons System) (www.namus.gov), a national centralized repository and resource center database maintained by the U.S. Department of Justice.

![Antemortem dental cast compared to the deceased’s dentition.](image)

Another important area of forensic dentistry is bitemark analysis. Bitemarks can occur during a variety of human activity including assault, domestic violence, rape, elder abuse, self-defense, sports, accidents, infanticide, or other homicide. The American Board of Forensic Odontology (www.abfo.org) has developed rigorous guidelines and standards for analysis and Board Diplomates (DABFO) require additional education, training, and experience in this subject matter. New odontologists would be wise to work with experienced mentors.
certified by ABFO when doing their first few cases. Experience with digital imaging and Photoshop® is often a requirement during the evaluation and comparison phase of bitemark analysis. DNA collection at autopsy or in the living is part of the bitemark protocol.

Dental injuries or dental neglect may be critical information in the investigation of domestic partner, child, and elder abuse. Odontologists also evaluate, consult, and/or testify in civil litigation resolving malpractice, negligence, personal injury, immigration (aging issues), and workers’ compensation cases.

**Education and Training**

A graduate dental education leading to the DDS (Doctor of Dental Surgery), DMD (Doctor of Dental Medicine), or equivalent degree is a basic requirement. Some dental schools may offer electives or other continuing education courses in forensic dentistry. The American Academy of Forensic Sciences (AAFS) offers annual forensic dental programs in the form of workshops, presentations, and posters sessions. The AAFS-affiliated FSAB (Forensic Specialties Accreditation Board) and the recognized certifying body, the American Board of Forensic Odontology (www.ABFO.org), have a certification program in forensic dentistry that is based upon a candidate’s personal and professional record of education, training, experience, and achievement as well as the results of a formal examination.
The American Society of Forensic Odontology (www.ASFO.org) meets during the AAFS Annual Meeting and holds a daylong course on forensic dental themes. It is the entry-level organization, and anyone with an interest in forensic odontology can apply for membership. There are week-long courses offered biennially at the University of Texas Health Science Center in San Antonio (Southwest Symposium on Forensic Odontology) and in alternate years at the University of Detroit Mercy School of Dentistry in conjunction with the Wayne County Medical Examiner’s office. There are longer and more extensive programs such as the fellowship program at the University of Texas HSC in San Antonio, the certificate program at McGill University in Montreal, and the Bureau of Legal Dentistry at The University of British Columbia in Vancouver. Other institutions in Europe and Australia also have programs available. These courses are highly recommended because they specifically concentrate on forensic dental education. The objective of these courses/programs/fellowships/certificates is to provide advanced training in current approved techniques and methods in forensic dentistry taught by highly qualified and experienced mentor odontologists in real situations and providing subject matter for research.

*Intra oral ultra-violet [UV] photograph. Note the fluorescent dental fillings.*
Severely charred natural dental crowns.

**Career Opportunities**

There are opportunities for a forensic odontologist to have a formal appointment or consulting relationship with a coroner, medical examiner, state and/or local government agencies, the police and/or military services, and the insurance industry. Insurance companies, legal firms, hospitals, and child/senior protection agencies often seek additional private consultations. Reimbursement is usually on a fee-for-service or contractual basis.

Once a commitment is made to enter this field, the forensic dentist needs to be current in the most accurate methods available, be aware of ethical values and conflicts, and possess the dedication to render an impartial opinion in a timely and professional manner.
The diverse fields of forensic biology and the life sciences and forensic pathology play important roles in forensic science. This section of the AAFS comprises a diverse group of members, all with important roles in forensic investigations.

Forensic Pathology
Forensic pathology is the practice of medicine concerning injury analysis and performance of autopsies to determine cause and manner of death. Although forensic pathologists cannot perform all of the miracles seen on television shows such as “CSI” and “NCIS,” it is an interesting and exciting field and is a popular and competitive career choice.

Pathology is a medical specialty—the study of disease. Pathologists study disease by performing a type of surgery called an autopsy. Tissues and organs removed during an autopsy are examined for evidence of disease and injury and may also be examined under the microscope. Analysis of fluids taken from the body, such as blood or urine, also provides information about disease to the pathologist.

Forensic pathology is the application of the principles of pathology, and of medicine in general, to the legal needs of society. Forensic pathologists perform autopsies to determine what caused a person's death. They are also involved in the investigation of the circumstances surrounding the death. Knowing about these circumstances allows them to determine the manner of death—natural, accident, suicide, homicide, or undetermined.

Although there is much emphasis on violent deaths, forensic pathologists and biologists also investigate sudden deaths of seemingly healthy individuals, deaths of people who have never seen a doctor, deaths occurring in police custody, suspicious or unusual deaths, deaths resulting from surgical or diagnostic procedures, or some deaths that occur in public institutions. The law of the specific jurisdiction where the death occurs determines which deaths must be reported to the medical examiner (often a forensic pathologist) or, in some states, the coroner. Then the medical examiner, or coroner, is responsible for deciding if an autopsy is necessary to determine the cause and manner of death. A forensic biologist will assist these individuals, along with other
investigators, as well as provide insight into the postmortem interval (time elapsed since death) and the location of bodies that have yet to be discovered.

A forensic pathologist begins an autopsy with a thorough external examination of the body.

Forensic Biology
Forensic biology is the application of the life sciences to legal and regulatory investigations. Forensic biology comprises all of the life sciences including, but not limited to, entomology, genetics, microbiology, ecology, and botany. A forensic biologist studies organisms or cells of organisms that are associated with criminal activity. Many organisms, including insects, bacteria, plants, and fungi can be used as evidence because they indicate the time at which an event took place, or they associate a particular person with an object or a location. Genetics are regularly used to confirm the identity of these organisms. In many instances, forensic practitioners of these disciplines have a broad application for their discipline with a wide range of job opportunities (e.g., casework, research, and teaching).

Scope of Work

Forensic Pathology
The forensic pathologist’s involvement and investigation may include visiting the scene of death. Forensic pathologists and/or their investigators gather information concerning what happened at the time of death, what the person was doing at the time, and the medical history of the individual.
The forensic examination of a body includes examining the clothing on the body, the body itself, and an internal examination of the decedent’s organs, which is the autopsy. The body is usually photographed and diagrammed with a detailed written report describing any injuries or disease process. The autopsy usually includes microscopic examination of the tissues of the body. X-rays may also be taken to look for bullets, broken bones, or other abnormalities.

Microscopic examination of tissues and consultation with colleagues is an important part of some autopsies.

The forensic pathologist works with other branches of the forensic sciences. The forensic pathologist may collect evidence from the body, such as blood and hairs in an assault case, swabs for examination for semen in rape cases, and fibers from the decedent's clothing and body. These are sent to the forensic laboratory for examination by a criminalist—a scientist trained in the examination of physical evidence. The forensic pathologist also collects specimens, such as blood, urine, bile, stomach contents, and body tissues, for toxicology analysis. The toxicologist looks for the presence of alcohol, drugs, and other chemicals or poisons in these specimens. If bullets, shotgun pellets, or wadding are recovered at autopsy, they are also sent to the forensic laboratory for examination. A firearms examiner analyzes these specimens and is often able to match them to a specific weapon.
Forensic pathologists collect a variety of evidence, such as bullets, hairs, fibers, and fluids, that may be useful to other forensic scientists working to solve a case.

Forensic pathologists also work to identify unknown deceased persons by way of medical information, dental records, and other unique features of an individual. If the body has deteriorated to a skeleton, forensic pathology may determine the race or sex of the individual. Forensic pathologists are often assisted by forensic odontologists (dentists) and physical anthropologists with the assessment of cases and the identification of deceased individuals.

Examination of the deceased may reveal whether the person received injuries, also called trauma, both prior to (antemortem) and after (postmortem) death, as well as changes to the body that occurred as a result of decomposition after death.

Each type of injury (e.g., gunshot, blunt force, or sharp force) often can be recognized by a distinctive pattern. Forensic pathologists are trained to recognize these patterns and thereby determine the cause and manner of death. Injury patterns are especially important in cases of child abuse and elder abuse.

Autopsy findings must correlate with the other known physical and circumstantial evidence. Sometimes, examination of the body may reveal that the victim died in a distant location and in a very different position from the situation in which the body was actually found. The forensic pathologist’s opinions and the autopsy results are vital components of any medicolegal death investigation. The forensic
pathologist must maintain accurate and unbiased written and photographic records. This work may lead to the conviction of the guilty or the exoneration of the innocent.

Another aspect of forensic pathology is the role this science plays in the areas of public health and disease and injury prevention. The forensic pathologist may be the first to recognize an epidemic disease or document a faulty product design that resulted in injury and death. Genetic disorders may be identified at autopsy and reported to those surviving family members who may be affected.

An emerging role of the forensic pathologist is that of clinical forensic pathology. Patterns of injury are not visible only when persons are deceased—they can also be recognized in living patients in emergency rooms and clinics. This is especially critical in cases of child and elder abuse. The interpretation of these injuries is invaluable to police or other law enforcement officials in a criminal investigation. A forensic pathologist’s training can be applied to injury analysis in both living and deceased patients.

The forensic pathologist plays an important role in communication with bereaved families as well as other physicians, attorneys, and law enforcement officers in an effort to provide all those who have need with proper, accurate, and timely information. Assistance to those who are left to deal with the loss and trauma surrounding the death of a human being is the reason for the work of the forensic pathologist.

**Forensic Biology**

Forensic Biology/Life Sciences comprises diverse fields including, but not limited to, entomology, genetics, microbiology, ecology, and veterinary medicine. A forensic biologist’s role in forensic investigations often includes visiting the scene of death. However, because forensic biology is quite diverse, the role(s) of such an individual will be field-specific. Forensic biologists typically collect evidence concerning perimortem (at the time of death) activity, postmortem interval, and location of relevant evidence. In other investigations, a forensic biologist will receive evidence collected by an investigator. A forensic biologist will analyze samples they collect or that are provided, as well as photographs and case notes prepared by other investigators including the forensic pathologist.
A forensic biologist typically serves as a forensic specialist and will be called to contribute to medicolegal death investigations when their specialty is needed. For example, a forensic entomologist will contribute expertise to a death investigation to determine the time of colonization of human remains, which in many cases represents a minimum postmortem interval (time since death). Forensic entomologists may also provide information from examining insects to help determine when trauma occurred (before or after death), if the remains had been moved from one location to another, identification of the individual (from DNA collected), and toxicology.

One emerging field of forensic biology is forensic microbiology. Forensic microbiologists use bacteria, Archaea, and microbial eukaryotes to provide insight into several aspects of medicolegal death investigation including cause-of-death, manner-of-death, identification, and postmortem interval. This is a rapidly developing field that will likely provide several new discoveries over the next few years.

Forensic biology also includes the work of botanists—those plant specialists who provide expertise in interpreting stomach contents or locating clandestine graves.

*A forensic microbiologist culturing organisms for identification.*
Forensic veterinary sciences is also an emerging field where veterinarians are called on to examine animals for documentation of trauma.

Education and Training

All forensic pathologists are medical doctors with an MD or DO degree. Therefore, the training requirements involve many years of studious effort. After four years of college and four years of medical school, an apprenticeship in pathology, known as a residency, is required. Forensic pathology is a subspecialty of pathology, so an additional one-year fellowship in forensic pathology is required. Medical board certification in anatomic pathology and forensic pathology is acquired from The American Board of Pathology.
Forensic biologists typically possess a MS and/or PhD in a biological science, such as entomology, microbiology, biochemistry, or ecology. Many biologists earn a BS in a biological science and then a MS, but some proceed directly into a PhD program from their BS. Most of these scientists conduct research in a field of biology that can be applied to a forensic investigation. Many forensic biologists also work in a non-criminal area of life science such as agriculture or conservation. Certification can be acquired in some areas of forensic biology, such as certification in forensic entomology from the American Board of Forensic Entomology.

Veterinarians must complete a four-year graduate degree program, pass a national board exam, and hold a valid license to practice veterinary medicine within a given locality. Veterinarians focusing on pathology can undertake a residency program in pathology to further their specialization.

**Career Opportunities**

Forensic pathologists are usually employed by city, county, or state medical examiner or coroner offices; hospitals; universities; and federal government agencies, such as the Centers for Disease Control (CDC) and the Armed Forces Medical Examiner. Forensic pathologists may also work for private medical groups as consultants by performing forensic autopsies.

Forensic biologists work in crime laboratories, but are more often associated with universities, museums, or other government agencies. These scientists typically serve as consultants to medical examiners and coroners while conducting research in an area of forensic biology.

All the forensic specialties play an important role as expert witnesses for attorneys in criminal (both prosecution and defense) and civil cases.
Forensic psychologists and psychiatrists address a broad range of legal issues when they work on criminal cases, civil cases, and other areas such as family/domestic relations law. In criminal law, the focus is on issues such as competence (e.g., competence to stand trial, to testify, to waive legal representation, or to be executed) and the assessment of mental illness as it relates to criminal responsibility (e.g., not guilty by reason of insanity (NGRI) or diminished capacity). Civil cases typically require assessment of issues such as involuntary psychiatric commitment, the right to refuse treatment, competence to make medical decisions, and appropriate disability compensation (if any). Family and domestic relations cases may include juvenile delinquency, child custody, parental fitness, domestic abuse, adoption, and foster care evaluations.

Scope of Work

Forensic psychiatrists and psychologists often spend a significant amount of time working with attorneys and judges and are trained in giving effective expert testimony.

In organizing the components of a forensic psychiatry assessment, a four-step series of questions is often used:

- What is the specific psychiatric-legal issue to be addressed?
- What are the legal criteria that define this issue (e.g., a state’s statutory definition of insanity)?
- What are the psychiatric-legal data that pertain to this issue?
- What is the data and reasoning process that the expert uses to reach his/her opinion?

An attorney or other retaining party may ask the expert to opine on several psychiatric-legal issues in a single case or referral and each issue should be addressed separately. For example, a criminal defendant might be evaluated to determine the following:

- Whether a confession to law enforcement officers was voluntary
- Competence to stand trial
- Criminal responsibility/culpability for the offense
• Capacity to abide by the terms of probation (if applicable), and/or
• Future dangerousness if discharged to the community

Some of these questions require retrospective analysis (e.g., mental functioning and behavior at the time of the alleged offense or at the time of the alleged confession), some are “here and now” determinations (e.g., competence to stand trial), and some require predictions of future behavior (e.g., likelihood of abiding by the terms of probation). The data collected and utilized to formulate opinions obviously will differ depending on the issue the psychiatrist or psychologist is asked to address. Therefore, there is no such thing as a “general” forensic psychiatric or psychological evaluation.

**Education and Training**

Psychiatrists are medical doctors who generally have completed twelve years of education and training, including undergraduate, medical school, and residency training in general psychiatry. Forensic psychiatrists also may have additional training and experience in subspecialties relevant to the evaluations they conduct (e.g., addiction psychiatry, child and adolescent psychiatry, geriatric psychiatry).

Many forensic psychiatrists complete an additional one or two years of post-residency training in psychiatry-and-the-law/forensic psychiatry. Others pursue a career of independent study and on-the-job training. The American Board of Psychiatry and Neurology certifies competence in psychiatrists who have completed an accredited fellowship and passed an examination. The Accreditation Council on Fellowships in Forensic Psychiatry and the Accreditation Council of Graduate Medical Education certify the quality of post-residency, subspecialty fellowship training programs.

Forensic psychologists generally major in behavioral science during their four years of college, complete an additional one to two years of training for a master’s degree, and spend an additional four to six years in graduate school to obtain a PhD in psychology. Some psychologists complete post-doctoral fellowship training in forensic psychology. Other psychologists study independently and obtain on-the-job-training in forensic psychology. These specialists then apply to the American Board of Professional Practice in Psychology for certification in the specialty of forensic psychology (through an examination process).
Career Opportunities

Forensic psychiatrists and psychologists may be employed in private practice; by private hospitals; by state hospitals; by city, county, or state governments; or by the federal government. For example, they may work in a state prison or a state hospital setting. Alternatively, they may have their own private practice and serve as consultants to a broad range of organizations that interface with psychiatry, the behavioral sciences, and the law.
Questioned document examination, also referred to as forensic document examination, is the branch of forensic science best known for the determination of authorship of signatures and handwriting but, in fact, involves much more comprehensive analyses of writing instruments, writing mediums, and office machine products.

**Scope of Work**

Subject matters analyzed by document examiners include the following:

- Authorship of signatures
- Authorship of handwriting and hand printing
- Examination of documents for presence of alterations
- Decipherment of obliterated or erased entries
- Restoration of burned or liquid soaked documents
- Classification and identification of typewriters and computer printers
- Classification and identification of other office products such as staplers or check writers
- Page substitution, and,
- Presence of indented writings

A document examiner will accomplish the analyses of the above-referenced forms of examination requests by utilizing state-of-the-art equipment in conjunction with standard methodologies. Most document examiners limit their examinations to nondestructive methodologies. In instances in which destructive tests for purposes of ink analysis or paper analysis may yield beneficial results, document examiners will refer that specific testing to an appropriate ink or paper chemist for destructive analysis.
Education and Training

Published standards for training, in line with common practices used in the profession for many decades, require that forensic document examiners should have: (1) corrected or natural vision of 20/20; (2) no evidence of color or form blindness; (3) a baccalaureate degree or higher in forensic science, sciences, or related subjects; and, (4) successful completion of a minimum 24 month structured training program under the direct and constant supervision of a qualified primary training officer. This training is the cornerstone of a forensic document examiner’s proficiency. Appropriate training can be obtained from government laboratories or qualified document examiners in private practice, such as those certified by the American Board of Forensic Document Examiners or members of organizations such as the Questioned Documents Section of AAFS. Although available publicly, correspondence courses are not a substitution for a direct two-year training period.

Physical match of a robbery note that was left at the scene (bottom) with a piece of paper found in a suspect’s car. Document examiners can also conduct handwriting comparisons and indented writing examinations in these instances.
A form entry that appeared as “08” (left) was actually altered from what originally was “15” (right).

Microscopic view of a simulated (copied) signature.

Staple hole patterns can be used to determine whether certain staplers could have been used in the fastening of documents together or to determine whether there is evidence that a page has been removed and another reinserted in its place.

Career Opportunities

Forensic document examiners are employed in both the public and the private sector. Private examiners can be found in many major cities in the United States. Large police agencies, along with most state and
federal law enforcement agencies often employ document examiners in their crime laboratories.

Lists of qualified document examiners are provided through membership lists of the certification organization the American Board of Forensic Document Examiners (www.abfde.org) and national professional organizations, such as the Questioned Document Section of the American Academy of Forensic Sciences (www.aafs.org), and the American Society of Questioned Document Examiners (www.asqde.org). There are also several regional organizations with members who are most willing to assist in your quest into the fascinating realm of questioned document examination.
TOXICOLOGY

Toxicology is the study of adverse effects of drugs and chemicals on biological systems. Forensic toxicology involves the application of toxicology for the purposes of the law, or in a medicolegal context. A forensic toxicologist answers questions such as:

- Did prescription or illegal drugs cause or contribute to this person’s death?
- Was this person impaired by drugs or alcohol while they were driving? or,
- Was a drug used to facilitate a criminal act?

Answering questions like these often requires forensic toxicologists to work with, and share information with, law enforcement, forensic pathologists, death investigators, crime scene investigators, clinicians, other forensic scientists, and legal professionals.

Scope of Work

The field of forensic toxicology involves three main sub-disciplines: postmortem forensic toxicology, human performance toxicology, and forensic drug testing. These specialized fields offer a variety of exciting career paths. In postmortem forensic toxicology, forensic toxicologists work with pathologists, medical examiners, and coroners to help establish the role of alcohol, drugs, and poisons in the causation of a death. The forensic toxicology laboratory identifies and quantifies the presence of drugs and chemicals in biological fluids and tissues that are taken from the body during the autopsy. A wide array of specimens may be encountered in postmortem toxicology investigations including blood, urine, vitreous fluid from the eye, liver, brain, and other tissues, as well as hair and nails. Once the testing is complete, a forensic toxicologist then interprets these findings. This information helps a forensic pathologist determine the cause and manner of death.
The forensic toxicologist uses state-of-the-art analytical techniques, such as those used in hospital or research laboratories, to isolate and identify drugs and poisons from complex biological specimens. This requires knowledge of analytical chemistry procedures and instrumental analysis. Forensic toxicology laboratories use a variety of different techniques, including gas and liquid chromatography, mass spectrometry, spectrophotometry, and antibody-based immunoassays. Qualitative and quantitative methods of analysis are used to determine which drugs or poisons are present, and at what concentration. Forensic toxicologists must have an inquiring mind and the ability to apply their knowledge of chemistry and pharmacology to solve real world puzzles.

Human performance toxicology deals with the effects of alcohol and drugs on human performance and behavior. Drug and alcohol use can have serious medicolegal consequences and is involved in an array of criminal investigations, ranging from impaired driving, to vehicular assault and homicide, to drug-facilitated crimes such as sexual assault. Criminal investigation analysis involves the same application of techniques as in the death investigation setting, but specimens are typically collected from living persons. Blood and urine are commonly encountered, but oral fluid, hair, and other specimens are also used. Forensic toxicologists are frequently asked to determine the timing and extent of impairment resulting from different patterns of drug and alcohol use. The interpretation of the test results in this area is
the greatest challenge, requiring the application of knowledge from clinical and medical studies and experience in the field, to give an opinion about the effects of a drug or combination of drugs on an individual at the time of a crime or accident.

Forensic drug testing is performed in a wide variety of other settings including the workplace, doping control in sports, probation and parole, as well as compliance monitoring and testing. The use of drugs by people in the workplace has significant safety and economic consequences. This is particularly important for people employed in hazardous or safety-sensitive industries such as transportation and the military. The scope of drug testing is often limited however, compared with human performance or postmortem toxicology, but the throughput of testing can be greater. Workplace drug testing laboratories may perform tens of thousands of tests per day and many times require specialized configurations of equipment such as multiplexing, which decreases analysis time and improves productivity. Urine is the most common specimen tested but oral fluid, hair, sweat, and other matrices are also used. As with all of the forensic disciplines, there is a strong emphasis on record keeping, chain-of custody documentation, stringent quality control, and data management.

In forensic toxicology, the interpretation and communication of the results can be more challenging than the analysis itself. The results obtained are often determined using scientific tests and procedures that are complex and difficult for most juries and lawyers to understand. Therefore, a toxicologist must have strong communication skills so the information can be presented fairly and clearly in court.

**Education and Training**

A bachelor’s degree in the life or physical sciences is the first step towards pursuing a career in forensic toxicology. A solid background in chemistry and coursework in pharmacology and toxicology are needed. Many forensic toxicologists have masters or doctoral degrees. Some enter toxicology after working in, or pursuing education in, other areas such as medicinal chemistry, pharmacology, or clinical chemistry. While relevant educational requirements are necessary to enter the field of forensic toxicology, training in the laboratory furthers an individual’s knowledge, experience, and ability to provide interpretation of the results. The American Board of Forensic Toxicology (www.abft.org)
offers professional certification to scientists working in the area of forensic toxicology.

**Career Opportunities**

Forensic toxicology is an exciting and rewarding profession, where science intersects with medicine and the law. It offers the opportunity to interact with other professionals with wide-ranging backgrounds and expertise. Forensic toxicologists may work in medical examiner laboratories, crime laboratories, military, government, or private sector facilities. Other career opportunities exist in hospitals, universities, and industry.

The Society of Forensic Toxicology (www.soft-tox.org) is a leading professional society for toxicologists in the United States. The International Association of Forensic Toxicologists (www.tiaft.org) is another excellent source of international reference materials. Similarly, there are regional professional organizations that can provide additional resources including the California Association of Toxicologists (www.cal-tox.org) and the Southeastern Association of Toxicologists (www.sat-tox.org). These websites provide many additional details concerning career opportunities and advances in the field of forensic toxicology.
Resource List

American Academy of Forensic Sciences
www.aafs.org

American Academy of Psychiatry & the Law
www.aapl.org

American Board of Forensic Anthropology
www.theabfa.org

American Board of Criminalistics
www.criminalistics.com

American Board of Forensic Document Examiners, Inc.
www.abfde.org

American Board of Forensic Odontology
www.abfo.org

American Board of Forensic Psychology
www.abfp.com

American Board of Forensic Toxicology
www.abft.org

American Board of Medicolegal Death Investigators
www.abmdi.org

American Board of Pathology
www.abpath.org

American Institute of Forensic Education
http://taife.com/

American Polygraph Association
www.polygraph.org

American Society of Crime Lab Directors
www.ascld.org

American Society of Forensic Odontology
www.asfo.org
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<th>Organization</th>
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<tr>
<td>American Society of Questioned Document Examiners</td>
<td><a href="http://www.asqde.org">www.asqde.org</a></td>
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<td>Association of Firearm and Tool Mark Examiners</td>
<td><a href="http://www.afte.org">www.afte.org</a></td>
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<td>Australian and New Zealand Forensic Science Society</td>
<td><a href="http://www.anzfss.org.au">www.anzfss.org.au</a></td>
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<td>California Association of Toxicologists</td>
<td><a href="http://www.cal-tox.org">www.cal-tox.org</a></td>
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<tr>
<td>Canadian Society of Forensic Science</td>
<td><a href="http://www.csfs.ca">www.csfs.ca</a></td>
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<tr>
<td>Forensic Science Society</td>
<td><a href="http://www.forensic-science-society.org.uk">www.forensic-science-society.org.uk</a></td>
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<tr>
<td>High Technology Crime Investigation Association</td>
<td><a href="http://www.htcia.org">www.htcia.org</a></td>
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<tr>
<td>Institute of Electrical and Electronics Engineers</td>
<td><a href="http://www.ieee.org">www.ieee.org</a></td>
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<tr>
<td>International Association for Identification</td>
<td><a href="http://www.theiai.org">www.theiai.org</a></td>
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<tr>
<td>International Association of Bloodstain Pattern Analysts</td>
<td><a href="http://www.iabpa.org">www.iabpa.org</a></td>
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<tr>
<td>International Association of Computer Investigative Specialists</td>
<td><a href="http://www.iacis.com">www.iacis.com</a></td>
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<tr>
<td>International Association of Coroners and Medical Examiners</td>
<td><a href="http://www.theiacme.com">www.theiacme.com</a></td>
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<tr>
<td>International Association of Forensic Nurses</td>
<td><a href="http://www.iafn.org">www.iafn.org</a></td>
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<tr>
<td>International Institute of Forensic Engineering Sciences</td>
<td><a href="http://www.iifes.org">www.iifes.org</a></td>
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International Society of Forensic Computer Examiners
www.isfce.com

International Society of Forensic Radiology and Imaging
www.isfri.org

International Veterinary Forensic Sciences Association
www.ivfsa.org

National Association of Forensic Accountants
www.nafanet.com

National Association of Medical Examiners
www.thename.org

Scientific Working Group for Medicolegal Death Investigation
www.swgmdi.org

Scientific Working Group for Wildlife Forensics
www.wildlifeforensicscience.org/swgwild/

Scientific Working Group on Bloodstain Pattern Analysis
www.swgstain.org

Society of Forensic Toxicologists
www.soft-tox.org

Southeastern Association of Forensic Document Examiners
www.safde.org

Southeastern Association of Toxicologists
www.sat-tox.org

Southwestern Association of Forensic Document Examiners
www.swafde.org
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