Here We Stand: What a Forensic Scientist Does

Jon J. Nordby

... thou shalt far more easily and happily attain to the knowledge of... Natural Philosophy... by long use and much exercise than by much reading of books or daily hearing of teachers.

Ambroise Paré (1510–1590)

Introduction

I'm grateful for Danner boots (Figure 1.1). Eleven hours of standing, with maybe three or so to go, helps me appreciate the finer things. Fourteen days straight should cure anyone's romantic illusions about forensic science. I'm thankful too for gloves, the blue ones with no powder, as I examine an A bag labeled human tissue to find the number. I must ensure that the number in the bag and the number on the bag equate. As I place the contents in a new bag, my partner twists the top, while someone else seals it with an Office of Chief Medical Examiner (OCME) label. In a perfect world, the numbers all match. The item moves down the line as an OCME investigator writes in a notebook, a New York City Police Department (NYPD) officer signs a pink form, and a Fire Department of New York City (FDNY) officer repeats the process, making photocopies. And so it goes for 12 straight hours. When we wear out, the night shift plugs in — 24/7, with no end in sight. This is life in the forensic factory, invisibly toiling for a grieving public which is quietly being served.

If the Danner Company ever made something to comfort the human mind, I'd be the first to buy it. At least my feet feel good even when the numbers fail us. Even if the numbers always matched, in a perfect world, we wouldn't be doing this in the first place.

I am here as a member of DMORT, which stands for Disaster Mortuary Operational Response Team (Figure 1.2). This is a
Figure 1.1 First pants, followed by socks, and only then, boots. (Photo courtesy of Jon J. Nordby.)

Figure 1.2 Region 10 of the Disaster Mortuary Operational Response Team (DMORT) covers Washington, Oregon, and Alaska. (Photo courtesy of Jon J. Nordby.)

difficult job. Despite the blue filtering mask, the smells will not leave me – I carry the taste of death, mixed with concrete dust, jet fuel, and Necro-EaseTM. I know that returning home means moving through all the normal post-traumatic stages, including the profound grief with its unreasoning anger. I will settle back among neighbors and acquaintances, even some friends, who don’t understand. I’ve accepted dealing with this as a part of a career choice made long ago. Most of us have been there before. We’ll be there again.

It’s impossible to come away from an event of this magnitude and retain the detachment that keeps us sane. Feeling deeply sad for the victims of the World Trade Center attack and their families, while feeling morally outraged by their deaths, seems rational, normal, and common to all of us working together in this assembly-line setting of the body identification center. The job of a forensic scientist can be exciting; but we must be aware that, often dealing with death, it is indeed a serious business that can, on occasion, be emotionally draining (Figure 1.3).

To be a forensic scientist requires the appropriate integration of basic human emotions with basic rational enterprise, what the ancient Greeks called reason. Their term did not carry the unfortunate contemporary connotation of mere mechanical calculation. Forensic science, as science, demands cognitive skills, but more, it demands reason in the ancient Greek sense — it demands of us a rational soul, with emotive and cognitive elements operating in harmony. It demands for my mind what the Danner Company provides for my feet. Dealing with life’s grimmest realities dispassionately while never losing sight of the feelings that keep us human. This is what a forensic scientist does.

For ancient Greek thinkers, the highest human calling involved what they termed
addressing public safety questions about high-rise office buildings or issues of building design may teach us how to build safer tall structures in the future. Questions concerning the safety of the site itself and the extent of damage to surrounding structures also requires careful analysis from many different scientists working to address these and other questions of public significance. Perhaps the most obvious public safety issues concern identifying the perpetrators and preventing them from committing further acts of violence. The results of any investigation must also anticipate future questions by supplying facts relevant to many yet-to-be formulated inquiries. Clearly such enterprises require the expertise of scientists from many different backgrounds, and the knowledge gained through many specialties. Chemists, engineers, psychologists, and computer technicians are among those who will be asked to apply their knowledge in the forensic context.

While our U.S. Courts became involved in the first terrorist attack on the World Trade Center in 1993, some legal issues arise from the September 11 attack that may block the court’s involvement with “acts of war.” Yet many investigative results will help point toward the identity, origin, and location of both conspirators and co-conspirators who may indeed fall under one or more court’s jurisdictions.

When the results of such investigations establish criminal intent, justice demands punishment for the perpetrators of crime, as well as society’s protection from further nefarious acts. But as former Attorney General of the United States Ramsey Clark put it, “There are few crueler injustices directly inflicted on an individual by government than conviction for a crime one did not commit.” Through their contribution of scientific reliability, the forensic sciences must help the court ensure that the guilty receive punishment and that the innocent remain free. It is important to consider that, contrary to what movies portray, large numbers of the accused have been exonerated by forensic science.
do them. It's what a forensic scientist does. One important characteristic of forensic scientists is adaptability, and a willingness to advance the common good.

Of course, the extreme situation surrounding the World Trade Center attack does not illustrate the everyday nature of unique forensic sciences discussed in the following chapters of this book, nor does it describe the role of specialized scientists operating within their specific areas. It does, however, illustrate the unifying element of scientific work to be presented in courts of law to help resolve legal disputes. The forensic sciences uniquely share their applications to legal issues for resolution in a public forum. Without courts of law, there would be no forensic sciences; without the Polis, there could be no law. Forensic sciences operate inextricably in the service of the public, represented through the rule of law by the courts. Different functions, but all necessary for the common good.

**Lawyers and Scientists**

All men are liable to error; and most men are, in many points, by passion or interest, under temptation to it.

John Locke (1632–1704)

Lawyers and forensic scientists enjoy a close, yet often uneasy, relationship. Forensic scientists must not forget that lawyers have moral and legal obligations that often generate conflict and misunderstanding among those with scientific minds. For example, defense lawyers have an obligation to conduct a spirited defense of the accused, especially if they are guilty. Like it or not, the fundamental purpose of the criminal justice system is to protect the rights of the accused.

Lawyers work in adversarial situations where the clear objective remains winning a favorable decision for one's client through knowledge of the law. The adversarial system depends for its success upon the vigilance of opposing counsel, who also works toward the same objective. In this sense, law is outcome based. In law, a judge or a jury determines the truth. What juries or judges say, through their verdicts, is what is so. This legal goal has nothing whatever to do with proper, logical, scientific practice.

In sharp contrast to the practice of law, science remains justification based. Reaching the truth, or as close as one can come to it, depends upon the available evidence combined with a reliable method and not upon the rhetoric of persuasion. Scientists remain dependent upon data and present their conclusions as tentative, conditional, or probable in nature where appropriate. Lawyers, however, represent one of two rival positions arguing for acceptance. They may be operating with a different set of facts. The scientist may present the data, but the lawyer may argue that the data is inadmissible and prevent the data from becoming evidence. Where a scientist may see a complex issue consisting of many related parts whose interactions may be unclear to varying degrees, a lawyer may see the issue simply as yes or no, black or white, on or off, true or false. In other cases, what the scientist sees as black and white data may become more complex in the law's view.

In this sense, at least, forensic scientists and lawyers speak different languages with different objectives, unfortunately using many of the same words. The words truth, fact, certainty, possible, and probable can mean very different things in law and in science. These points remain to be considered later in the book.

**Theoretical Natural Sciences and Practical Forensic Sciences**

It is one thing to show a man that he is in error, and another to put him in possession of truth.

John Locke (1632–1704)
Law and Science

The philosophical foundation of the criminal justice system remains to protect the innocent and to ensure that the truth emerges for any matter before the court, thereby ensuring that justice is done. Given the number of cases to be heard, however, the criminal justice system has the potential to sacrifice values of truth and justice to organizational efficiency. While crime laboratory scientists may pride themselves as being “independent finders of fact,” most operate under police jurisdiction or administration, and many scientists, perhaps unconsciously, develop the attitude that they work exclusively for the best interests of the police or the prosecutor.

When emotions overcome reason, a zealous forensic scientist may intentionally or inadvertently deny real justice. Results are misrepresented, or worse, falsified. Such flawed science may not be easy to spot, since it can only appear through the results of the scientific investigation. While no one can ever attain anything close to a perfect harmony of reason with emotion, forensic scientists at least have a political duty to strike the best balance possible under life’s most difficult circumstances. Of course, completely satisfying this duty remains both difficult and elusive. The commitment to ethics should be stressed in the education of a forensic scientist. The values inherent in “good science,” including both these moral elements and the nonmoral elements distinguishing reliable from unreliable scientific practice, should be a part of official forensic scientific curricula.

In some tiny jurisdictions, coroners may also work as sheriffs, prosecutors, or funeral directors. Some medical examiners work under the administrative umbrella of prosecutors’ offices, and, in some rare cases, the sheriff also moonlights as both coroner and district attorney. At the very least, such organizational structures risk potential conflicts of interest. The potential exists for overseers to influence reports, compromising appropriate objectivity. In the practical world, only the competence and rigorous honesty of the individuals holding such perilous positions preserve the philosophical basis of the criminal justice system designed to protect the innocent and expose the truth about complex actions. Under these organizational structures, the system works if, and only if, morally honest individuals hold key positions of power.

Without the underpinnings of high ethical standards, forensic scientists may become what is known in the profession as hired guns. The student considering this profession should resist the temptation of selling whatever opinion is needed by defense or prosecution. Not all hired guns become forensic frauds merely through nonexistent or meaningless credentials. Properly educated, experienced scientists may also act as gunslingers through ignorance or misapplication of method. This might involve purposefully omitting relevant tests or suppressing relevant results. Many such experts may develop an entirely unjustified sense of their own scientific abilities and observational powers. Generally, such experts offer firm, certain, and conclusive opinions designed to fit the relevant courtroom advocate’s agenda. Such a forensic expert may even resort to defining scientific error as any interpretation that disagrees with his or her own.

In the real forensic sciences, individual scientists always work as members of a larger team, perhaps with other specialized scientists, law enforcement investigators, prosecutors, defense attorneys, judges, juries, and the media, each contributing his or her efforts toward the bigger picture of a public trial, or an investigation capturing the public interest. The job of a forensic scientist is not one of glamorous celebrity.

If Sherlock Holmes, the detective invented by Sir Arthur Conan Doyle, worked a shift with us at the Manhattan medical examiner’s office, he might be assigned to pick up trash in the parking lot at Memorial Park. He might have to check the fuel levels and the temperature gauges on the refrigerated trucks, or to water the potted plants decorating the entrance to each trailer. In this situation, it’s not a waste of time or talent if those tasks need to be done, and Holmes has time and ability to
Unlike theoretical natural scientists, forensic scientists have an obligation to become familiar with both lawyers and the law. And while all scientists are required to uphold a high ethical standard, as mentioned earlier, forensic scientists are particularly bound to combine scientific skills with a sworn duty to the public good. It is for this reason that forensic science has been called a public science. Forensic scientists must be prepared to battle dubious cultural expectations, either inappropriately elevating or denigrating the powers of science. Such expectations are usually generated through crime novels, popular theatre, movies, and television. These inappropriate expectations when found among jurors, lawyers, and even judges can negate conservative scientific testimony. From crime scene to conviction, a good forensic scientist will be teaching others, an ability that requires patience and the communication of complex principles in simple terms. This, too, is what a forensic scientist does.

Currently, legal challenges to many established forensic science techniques, such as fingerprint and hair comparison, are being made. The law is questioning whether such evidence is truly scientific. The natural sciences from this adversarial position remain theoretical, while the forensic sciences remain pejoratively practical. The forensic scientist must work to counteract this misguided view without appearing defensive. The following table summarizes the contrasts usually developed by applying such a view of the sciences:

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<tr>
<th>Misguided View</th>
<th>Forensic Sciences are said to be:</th>
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<tr>
<td>Natural Sciences are said to be:</td>
<td>Practical</td>
</tr>
<tr>
<td>Theoretical</td>
<td>Applied to problems</td>
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<tr>
<td>Pure knowledge</td>
<td>Disorderly</td>
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<tr>
<td>Orderly</td>
<td>Contaminated</td>
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<tr>
<td>Pristine</td>
<td>Chaotic</td>
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<tr>
<td>Controlled</td>
<td>Specific</td>
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<tr>
<td>General</td>
<td>Approximations</td>
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<tr>
<td>Covering Laws</td>
<td>Conjectures</td>
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<td>Predictions</td>
<td>Uncertain</td>
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If forensic science is conjectural, operating in chaotic situations where data are likely to become contaminated, can we trust the fingerprint as evidence? The so-called covering law model of natural science accounts for expectations of scientific certainty which no forensic science allegedly approximates: epistemically certain laws of nature cover and, thereby, through deduction, explain cases. There are many examples of these certain deductions, such as Fick's law for diffusion, Fourier's law for heat flow, Newton's law for shearing force, and Ohm's law for electric current. But these laws assume that a single cause explains a single specific given effect. Laboratory conditions or observational situations artificially manipulate phenomena to fall within the parameters of the law under investigation. Hence, they are ceteris paribus laws, that is, they hold only with "other things being equal" or "other things being right," such as with situations in an artificially controlled laboratory environment. In contrast, the crime scene is anything but a controlled setting.

Of course, almost all cases requiring explanation in the forensic setting involve many combinations of so-called causes all mixed together in the world existing outside of the laboratory. Without the ceteris paribus clause, such laws become manifestly false; with the clause, they cover only artificially limited and trivially unrealistic cases. General laws, however, describing complex interactions of such ceteris paribus laws in concrete cases are unavailable. There is simply no body of theory or law readily available to cover particular, unique, complex phenomena such as the World Trade Center attack and collapse on September 11, 2001.

Yet such events demand some kind of scientific explanation. Our ability to supply the best explanation of the World Trade Center attack and collapse precedes our knowledge of any scientific law that may, in fact, cover the unique situation. At best, the existence of various scientific specialties helps us to break the vague request for an explanation into its various specific components. The search for some single covering law becomes sheer myth. Until we discover some such law,
it is up to science to supply acceptable explanations in the absence of any so-called certain knowledge. In practice, the forensic sciences have an important element in common with the natural sciences. While their scientific goals obviously differ, their scientific common ground rests within an identical method of inquiry.

The aims of the so-called scientific method remain solidly within a procedural scope, focusing on scientific reliability. Follow these steps and the results will be consistent. With this methodological focus, illusive certainty becomes attainable reliability; natural laws and causes disappear in favor of explanatory connections, and the quest for comprehensive theory is replaced by relevant experience.

Laws of thermodynamics aside, bodies tend to cool at generally predictable rates given ambient temperature and other environmental factors. Logical methods, rather than some unattained body of accepted laws and proposed theories, characterize reliable scientific explanations in either theoretical or forensic contexts. This distinction can be summarized in the following table:

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<th>Reliable Method of Inquiry: The Common Ground of Theoretical and Forensic Science</th>
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<td>Reliable Methods Possess Characteristics of</td>
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<tr>
<td>Integrity</td>
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<td>Competence</td>
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<td>Defensible technique</td>
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<td>Relevant experience</td>
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Forensic Experts

An expert is someone knowing more and more about less and less, eventually knowing everything about nothing.

Attributed to Sir Bernard Spilsbury, MD

Neither natural scientists nor forensic scientists start from theories or laws when facing the need to explain some puzzling phenomenon. They start from data. And not from commonplace data, but from the surprising anomalies raising the puzzles requiring explanation. Unusual observations suggest explanatory connections to pursue and test. Such connections define evidence and distinguish data that are evidence from data that remain merely coincidental. In that effort, the natural scientist and the forensic scientist share a fundamental approach belying any simplistic distinction between real science and forensic science.

As a forensic scientist, whether working an average case or one as catastrophic as the World Trade Center investigation, it never becomes my job to convict or punish the perpetrators. The job description only includes ensuring the best data collection and control, or determining the clearest relevant scientific explanations supported by reliable methods, always limited to the available data. I aim for methodological reliability, even if that notion remains limited to matching up numbers on the inside and the outside of plastic pouches.

An Expert's Role

Regardless of one's role in an investigation, no one can accurately claim to be an expert witness by profession. Expert witnesses, by law, can only be declared such by a judge. There are experts who are not scientists; for example, experts in office design, river rafting, school bus driving, fashion design, art history, or scuba diving. Of course, there are also experts in the natural sciences and medicine, as well as those with forensic practices. But only the court creates expert witnesses. Forensic scientists first and foremost must remain scientists. Those practicing forensic medicine remain, first and foremost, medical professionals. Forensic scientists and forensic pathologists may or may not be declared expert witnesses by the court.

Usually scientific or other experts offered by attorneys to the court as potential expert witnesses give opinions only within their areas of expertise. Sometimes, lawyers hire
an expert simply because the other side hired one first. But, usually, lawyers engage experts when the facts of a case remain unclear, when analytical procedures in some field might help clarify those facts, or when specialized training can help educate the jury in turn to help the jurors make better informed decisions. The goal remains to apply some reliable method to those facts to help the court render its decisions. For forensic scientists, it’s all about reliable scientific methods.

Scientific Method

Attempting to characterize reliable scientific methods, as if describing some lifeless non-existent abstraction, remains doomed to failure. There simply is no such generalized abstraction available to describe. At most, we can point toward a simple list detailing some of the many features reliable methods implement, enabling the productive scientific investigation of facts before the court. Reliable methods

- Help distinguish evidence from coincidence without ambiguity.
- Allow alternative results to be ranked by some principle basic to the sciences applied.
- Allow for certainty considerations wherever appropriate through this ranking of relevant available alternatives.
- Disallow hypotheses more extraordinary than the facts themselves.
- Pursue general impressions to the level of specific details.
- Pursue testing by breaking hypotheses (alternative explanations) into their smallest logical components, risking one part at a time.
- Allow tests either to prove or to disprove alternative explanations (hypotheses).

In the forensic sciences, we reason from a set of given results (a crime scene, for example) to their probable explanations (hopefully, a link to the perpetrator). The aims of forensic science and medicine rest with developing justified explanations. But obviously not all forensic explanations are alike. Some involve entirely appropriate statistical assessments and degrees of error suitably dependent on accurate mathematical models and accurate population studies. The reader will meet such explanations, for example, when studying DNA and other population-based sciences presented in this text. However, not all forensic scientific explanations involve such statistical issues. Instead, individual, non-repeatable events with no statistical characteristics may demand scientific explanation.

A medical diagnosis, for example, involves selecting the best explanation of abnormalities in the observed data from among the clinically available alternatives. Clinical diagnosis may involve prior probabilities in the Bayesian sense, but ultimately the diagnosis concerns what’s wrong with one individual, not just what affliction correlates to some population group. In forensic medicine, the diagnosis focuses on the cause and manner of an individual’s death. Mathematics rightly plays no statistical role in these explanations or their possibilities for error. The accused may have known the victim, but cannot be logically convicted on the basis that statistically most murderers know their victim.

In either clinical medicine or in the forensic sciences, how one’s opinion is constructed determines its certainty. The certainty of forensic explanations is measured by assessing their explanatory justifications. This, in turn, involves showing, first, that the explanation is justified, and second, that the explanation is better justified than any available alternative explanation.

In this forensic setting, certainty assessments address the scientific explanation’s rational justification, leaving the question of the explanation’s truth and role in legal deliberations to the court. This allows for a clearer understanding of requests for certainty assessments when scientists are
asked by attorneys to attach some degree of certainty to their work product. First, omitting the larger issues of truth leaves out the difficult determination of how frequently justified opinions could be false. Second, it leaves the entirely inappropriate precision of mathematics and probability theory entirely out of this sort of nonstatistical certainty assessment.

All reliably constructed scientific explanations are best viewed by their creators as works in progress. We could always learn additional facts that may alter our views. Sometimes, however, no additional information would be relevant. In either case, our opinions must be held with what American philosopher and scientist Charles Sanders Peirce called contrite fallibilism — an awareness of how much we do not know, and the humility to acknowledge the possibility of making mistakes. He describes this intellectual stance to a friend in personal correspondence.

The development of my ideas has been the industry of thirty years... For years in the course of this ripening process, I used for myself to collect my ideas under the designation fallibilism; and indeed the first step toward finding out is to acknowledge you do not satisfactorily know already; so that no blight can so surely arrest all intellectual growth as the blight of cocksureness; and ninety-nine out of every hundred good heads are reduced to impotence by that malady — of whose inroads they are most strangely unaware!

Indeed, out of a contrite fallibilism, combined with a high faith in the reality of knowledge, and an intense desire to find things out, all my philosophy has always seemed to grow. 19

This basic intellectual stance remains necessary both for essential humility and for the very possibility of scientific advance. Forensic scientists must develop an intellect not too sure of what must remain uncertain, not too uncertain about what must remain sure. In the spirit of intellectual honesty and judicial prudence, the best advice for the forensic scientist to carry from the scene to the lab and into court throughout a long career comes from a 20th century Viennese philosopher, Ludwig Wittgenstein: "Whereof one can not speak," he said, "thereof one must remain silent."

Endnotes

1 DMORT falls under the National Disaster Medical System, in turn a part of the U.S. Public Health Service. Ten DMORT units make up 10 regions covering the United States. Each unit consists of medicolegal death investigators, forensic odontologists, forensic pathologists, other forensic scientists, and assorted specialists all suited to form a single team to help local officials continue to conduct their operations during a mass disaster involving a large number of casualties.

2 Necro-EaseTM is a product designed to remove, or at least to ease, the smell of decomposition. There are many death investigation professionals who find this helpful in treating this powerful odor. I am not among them. It is best used in cases involving, at most, one body. It was not designed to work in refrigerated trucks filled with human remains. In my opinion, it contributes its own unique smell that must be endured alongside the already present odor of decomposition.

3 Of course, how we deal with those feelings takes on a rational component when considering the ethical dimensions of being a forensic scientist.

4 Aristotle formulates his entire moral theory on an understanding of this basic human harmony or balance. His student, Plato, also develops this view into a robust moral theory based on functions proper for humans.

5 Such views have been associated with Aristotle's notion of eudaemonia, loosely meaning "living well," "fulfillment of proper function," or "happiness." This notion remains at the heart of a U.S. Army recruiting slogan: "Be all that you can be." Aristotle, however, adds certain requirements, which eliminate obvious counterexamples.