

CRIME RECONSTRUCTION

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CRIME RECONSTRUCTION

SECOND EDITION

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Foreword

Joseph L. Peterson

The second edition of *Crime Reconstruction* is a very important addition to the forensic science and crime scene investigation literature. Editors Jerry Chisum and Brent Turvey, and their associated chapter authors for this volume, have advanced the crime reconstruction literature in three important areas: (1) they have integrated important themes of the 2009 National Academies report on forensic science into their book chapters, calling for more rigorous scientific standards and reliability in all aspects of forensic and crime scene examinations; (2) they have strengthened all chapters, particularly those addressing ethics, trace evidence, and shooting and fire scene reconstruction; and (3) they have added new chapters on forensic science, crime scene investigation, wound pattern analysis, sexual assault reconstruction, and report writing. All chapters also contain key terms, a chapter summary, an abstract, and several questions that should assist college and training instructors in preparing examinations.

I would like to take a moment to highlight several chapters that particularly impressed me in this second edition. Parts 1 and 2 of the second edition address the forensic examiner and the crime scene. Chapter 1 on forensic science sets an important theme by defining the important role of the crime scene reconstructionist as a person who needs the fundamental training in general forensic science in order to apply the methods and techniques of science to reconstruct crimes and interpret available physical evidence. The reconstructionist's primary role is to *take the side of the evidence* and to maintain that position throughout the investigation. Chapter 3 is extremely important and presents a canon of ethics that demands that the scene is interpreted correctly and that the reconstructionist "gets it right" with a minimum of error. The examiner has the professional and moral duty to "pursue the truth" of the evidence, wherever it may lead. Chapter 4 on observer effects and examiner bias is extremely important to the crime scene reconstructionist, particularly as a growing number of challenges to objectivity are recognized in the forensic science and legal literature. Cooley and Turvey rightly point out that while most forensic scientists will not fall victim to overt forms of fraud and bias, many examiners today are much less aware of more covert forms of bias that are present and the effect "context" has in influencing an investigation.

Part 3 on physical evidence provides eight chapters on a variety of evidence forms that may be encountered by the crime scene reconstructionist. Practice Standards for the reconstruction of crime scenes (Chapter 5) also set some primary rules and measures that the investigator should keep in mind regardless of the type of scene. Another extremely important consideration for the reconstructionist is to recognize those evidence dynamics (Chapter 6) that might alter, relocate, or contaminate the physical crime scene either prior to the arrival of the investigator or as a result of the crime scene investigation itself. Trace evidence (Chapter 10) addresses an area that has been pushed to the background of forensic investigation in the past several years because of the rise in DNA profiling. I believe it is important to give trace evidence its due and to encourage

crime scene reconstructionists to be aware of the multiple types of trace materials that can help determine what happened at the scene and establish the association between offenders and victims and the scene itself. The authors also stress that physical evidence is “not necessarily a certain and precise record of actions and events” and may leave an incomplete picture of the crime. All scientific and investigative personnel must recognize that physical evidence will not always answer every question. Other chapters on reconstructing bloodstain evidence (Chapter 12), investigating shooting incidents (Chapters 13 and 14), and reconstructing fire scenes (Chapter 15) are well crafted and provide insight to the new (and experienced) investigator. Part 4 on the courtroom provides solid instruction and important insight on report writing, presentation, and testimony.

Crime Reconstruction (Second Edition) is a thoroughly researched and well-written text assembled by two noted authors and practitioners in the field of forensic science. Chisum and Turvey are to be commended for their scholarship. It will soon become the standard reference for professionals and students of crime reconstruction.

Preface to the First Edition

A HOLISTIC APPROACH TO CRIME RECONSTRUCTION

W. Jerry Chisum and Brent E. Turvey

Relating to or concerned with wholes or with complete systems rather than with the analysis of, treatment of, or dissection into parts. Emphasizing the organic or functional relation between parts and the whole.

—*Holistic, Dictionary Definition*

... what is the nature of the whole, and what is my nature, and how this is related to that, and what kind of a part it is of what kind of a whole. —*Marcus Aurelius Antonius, 167 CE, Meditations, Book II*

Holistic crime reconstruction is the development of actions and circumstances based on the system of evidence discovered and examined in relation to a particular crime. In this philosophy, the whole body of evidence that comes to light in a given case is treated as interdependent; the significance of each piece, each action, and each event falls and rises on the backs of the others. More evidence gives rise to more meaning, and less evidence necessarily allows for the resolution of less meaning. The reconstruction is a function of this system and how much evidence there is and whether and how it interrelates and maintains its consistency.

A system of related evidence and any conclusions based thereon are like a mechanical engine or a biological organ, with few if any extraneous parts working judiciously, and in harmony, toward a desired end. If one of the parts fails, then the whole system suffers and may fail. With evidence and its interpretation it is precisely so. Interpretations must be compatible, working in concordance to support each other. Or at the very least not working against each other. Bloodstain pattern interpretations must not contradict the ballistic analysis; trace evidence must not contradict the conclusions of the arson investigator; DNA evidence must not contradict the conclusions of the fingerprint examiner; and so forth. A concordance of the evidence must be apparent. The reason for this is straightforward. Though it can be forgotten in a climate that seeks and rewards certain conclusions, all science, and even forensic science, especially forensic science, is grounded in skepticism. It necessarily follows that a finding out of harmony with any of the others in its system should call one or all into question.

ORIGINS: THE FORENSIC GENERALIST

The foundation for holistic crime reconstruction doctrine was introduced more than a century ago, with the 1894 publication of *Handbuch für Untersuchungsrichter als System der Kriminalistik (Criminal Investigation: A Practical Textbook for Magistrates, Police Officers and Lawyers)* by the renowned Austrian jurist Dr. Johann (Hans) Baptist Gustav Gross (Gross, 1906 and Gross, 1924). The goals of this manual were formative and ambitious: to establish principles of scientific

investigation, and to provide for the birth of the scientific investigator. The manual itself was a broad success with international appeal, achieving no less than five English editions (1906, 1924, 1934, 1949, and 1962). It also provided the basis for the practical work later undertaken by French scientist Dr. Edmund Locard when he established what is considered to be the world's first police crime laboratory in Lyon, France, in 1910. Despite the passage of time and advances in technology, the philosophies of *System der Kriminalistik* remain a touchstone of forensic knowledge and wisdom to the present day.

The approach to crime reconstruction advocated by Dr. Gross, and subsequent students of his work, was to assign such duties to a scientific investigator—what would be referred to in more modern language as a forensic generalist. The scientific investigator was to be a professional schooled broadly in the subjects of crime, criminals, and the scientific methods of their identification, apprehension, and prosecution. Their role was to understand how the system of evidence and details of a case could be established, how they could be related, and how they could be interpreted. This holistic method, branded by dispassion and an adherence to science, would ideally free the scientific investigator from the constraints of politics, cronyism, and emotional bias.

The philosophy of Hans Gross was mirrored in many subsequent published works and aspired to in numerous crime labs across the United States.

THE FORENSIC GENERALIST FADES

At present, the forensic generalist is all but a memory, and until recently ([Inman and Rudin, 2000](#); [Savino and Turvey, 2004](#)) had not made an honest appearance in forensic science textbooks since [DeForest, Gaensslen, and Lee \(1983\)](#). More curiously, some forensic professionals at present become angered when generalists are described, let alone remembered. There is more than one reason for the disappearance of the generalist and the related professional sensitivity. We will focus on the three most apparent; the first is over-specialization; the second is diminished crime lab budgets; and the third is the false paradigm of advocacy for one side over another.

The Gross Facts

Forensic generalists and forensic specialists alike are required in order for informed forensic case examination, laboratory testing, and crime reconstruction to occur. A forensic generalist is a particular kind of forensic scientist who is broadly educated and trained in a variety of forensic specialties. They are “big picture” people who can help reconstruct a crime from work performed with the assistance of other forensic scientists, and then direct investigators to forensic specialists as needed. According to [DeForest, Gaensslen, and Lee \(1983, p. 17\)](#):

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

Specialization occurs when a forensic scientist has been trained in a specific forensic subspecialty, such as an area of criminalistics, forensic toxicology, forensic pathology, forensic anthropology, or so forth. Forensic specialists provide the bricks, and forensic generalists have traditionally provided the blueprints.

In the modern forensic system, the majority of forensic scientists have become so specialized in their analytical functions that they are no longer in possession of the gross facts in the cases they work. This is a source of both angst and embarrassment to some crime lab personnel, as they would prefer that their analyses be better informed. Still others would prefer to retain the appearance of overall forensic authority that knowing the full case facts allows. Nowadays, a piece of evidence is brought to a crime lab or examiner, it is examined using a specific method, test, or procedure as the requesting agency dictates, a report of findings is written, and the overall context may or may not be known or even sought. Without the gross facts of a case, and at least some knowledge of assembling them, crime reconstruction cannot occur. Not participating in this process, for lack of skill, time, or invitation, has become a sore point for some in the community of forensic science specialists.

Underfunded and Understaffed

In terms of money, government crime laboratory budgets nationwide rarely allow for the full suite of forensic specialties, with, for example, trace evidence units vanishing in the shadow of the forensic titan that DNA has become because of its acceptance by the courts. Money, after all, is allocated for those areas of forensic science that the court has embraced. Money is not allocated for areas of forensic science that the court shows disinterest. And money for research is often a luxury that cannot be afforded at all.

Further still, government labs have faced severe budget and personnel shortages in recent years. There are several interwoven reasons for this. First, the demand for lab services has increased with the growing national profile of forensic science thanks to the popular media. More law enforcement officers are coming to understand that forensic evidence can help their cases, more juries are expecting it at trial, and as a result government crime labs are being asked to do more examinations on more evidence. Second, practice standards in many regions have evolved to meet the needs of crime lab certification. Nationwide many of the larger government crime labs and lab systems are suffering excruciating independent reviews and scrambling to meet the criteria set down by the American Society of Crime Lab Directors Laboratory Accreditation Board (ASCLD/LAB) in order claim this coveted credential in court. To meet ASCLD/LAB criteria, more of the diminishing lab budget must be spent on quality control, adequate workspace, and adequate evidence tracking and storage. Additionally, each person must complete a proficiency test on each type of evidence they analyze each year. This slows down the amount of time forensic scientists have to work on case material, and can, in extreme cases where there are staff shortages, put the examination of evidence on hold for periods of time. The accreditation process is not easy, and even requires some labs to simply start over and build entirely new multi-million-dollar facilities. This to say nothing of the requirement to hire more adequately qualified personnel, bringing front and center the problem of too few qualified candidates available with less money to pay them. Additionally, new methods of forensic analysis are not encouraged as they must be “proven methods”—refinements of methods are not

allowed. This works against the intention of the scientific method and stamps out the spark of creativity, as many of the past advances in crime lab analysis were the result of “experimentation” with actual case materials and trying something new. Third, the public funding of state crime labs constantly suffers at the hands of wary voters who tend to lack enthusiasm for raising taxes to help fund education, let alone forensic science.

With all of these factors at work, many government crime labs do not have the time, the resources, or the personnel to perform their regular analytical casework. As a consequence, backlogs have mounted in almost all areas of forensic analysis. In this environment, the extra time and commitment required for crime reconstruction is an added expense that becomes hard for administrators to justify.

The Paradigm of Sides

The paradigm of sides challenges forensic scientists on two fronts, presenting a false choice in which they are invited to abandon their chosen profession for advocacy. First, there is the obvious division between the prosecution and the defense. More than a few forensic scientists work in an environment that rewards them for thinking and behaving as though there is a morally right side of the courtroom, and a morally wrong side of the courtroom. By choosing fidelity to one side of the courtroom over another, the forensic scientist not only loses that which defines them, namely their objectivity, but they also presume a role in court that is not meant for them—that of the trier of fact. It is not the place of the forensic scientist to decide who is worthy of a defense, who is guilty, or how they should be punished. These are moral and legal conclusions, which brings us to the second part of the paradigm of sides: the division between scientific fact and legal truth. The forensic scientist is an educator to the court. It is the role of the forensic scientist to establish scientific fact and explain what it means to an investigator, attorney, judge, or jury in the context of a given case. Moreover, the scientific facts should be the same no matter which side the forensic scientist is working for. It is the role of the judge and jury, not the forensic scientist, to form legal conclusions about who is guilty of what, and what the penalty should be based on the totality of evidence.

Though often confused, scientific fact and legal truth are not the same thing. Scientific fact is established through careful examination using the scientific method. Legal truth is determined by the trier of fact based on their understanding of the law. This is made abundantly clear in cases of wrongful conviction, where a person may be found legally guilty of a crime without having actually committed it. Subsequently, the abilities of a forensic scientist are not measured in arrests, convictions, or even acquittals, as will be made evident throughout this work. Forensic science, though a servant to court, must serve itself first in order to have any intrinsic value. When science chooses a side other than itself in any conflict or dispute, it is no longer science but advocacy.

The majority of forensic scientists have no trouble understanding the gravity involved in navigating the paradigm of sides on this level, and would rather resign from a case or an agency than sacrifice their objectivity and integrity. The true forensic scientist knows that their first onus is to their profession, and that if there is no science, there can be no forensic science.

This community understanding is all well and good until it is remembered that a fair number of forensic scientists work in government crime labs that are housed within, or directly supervised by, police agencies or district attorney’s offices. In terms of the actual reconstruction of

crime, police and prosecutors are faced with the reality that the scientists they employ may not always agree with their theories regarding a case. In fact, in some instances, the evidentiary findings of the crime lab may hamper or even disprove an important point upon which a police or prosecution theory is built. For some government agencies, this internal evidence based self-correction is a welcome adjustment to the course of a criminal investigation and any future prosecution. However, history has shown that this is not always so. Not all government crime labs enjoy an open or healthy relationship with their law enforcement and prosecutorial supervisors. And a significant number of government agencies remain hesitant to put their scientists in a position where they can reconstruct the crime in its entirety and then be called by the defense as witnesses against them.

The paradigm of sides presents the forensic scientist with a false choice between prosecution or defense; between scientific fact or legal truth. Pressure to choose can be brought to bear in many ways—personal, professional, and financial. Furthermore, the pressure on a forensic scientist in such environments, to be part of the “team” and help “get the bad guys,” can be seductive and overwhelming to the point of assimilation. As will be discussed in future chapters, the rewards for assimilation are great, and the consequences for failing to assimilate can be equally great.

Overspecialization, diminishing budgets, and the paradigm of sides; in such ways the practice and implementation of crime reconstruction has with some exceptions faded from many crime labs and been moved into the hands of others.

The authors view this with neither frown nor favor, but rather agree to recognize that it is so. As such, the need for the development of this textbook becomes apparent. Namely, that with its departure from the crime lab, the practice of crime reconstruction is in no small danger of losing its footing on the ascending ladder that is the employment of scientific principles to casework.

MODERN CRIME RECONSTRUCTION

Modern forensic science and crime reconstruction is slowly becoming the work of police technicians trained inexpensively through short courses and lectures, as opposed to formally educated forensic scientists shepherded by mentors of quality experience. The difference between the two is significant. A forensic scientist does not just test or examine evidence and then record the results; they are meant to explore, understand, and explain its significance. [Thornton \(1997; p. 3\)](#) provides a succinct and accurate description:

The single feature that distinguishes forensic scientists from any other scientist is the certain expectation that they will appear in court and testify to their findings and offer an opinion as to the significance of those findings. The forensic scientist will testify not only to what things are, but to what things mean.

This is the very heart of crime reconstruction—not just what, where, and when, but also how and why.

The reconstruction of a crime from physical evidence is the culmination of a long and methodical process. It is the last step in the analytical journey each piece of physical evidence takes from the moment it is recognized at a crime scene. Those steps occur in roughly the same order for each item of evidence:

1. Recognition
2. Preservation
3. Documentation
4. Collection
5. Transportation
6. Identification/Classification
7. Comparison
8. Individuation
9. Interpretation/Reconstruction

Traditionally, the specific duties are broken down in this way:

Detective/Investigator/Forensic Technician

1. Recognition
2. Preservation

Forensic Technician (a.k.a. Crime Scene Technician)

3. Documentation
4. Collection
5. Transportation

Forensic Scientist/Criminalist

6. Identification/Classification
7. Comparison
8. Individuation
9. Interpretation/Reconstruction

The problem is that these forensic titles and roles are often mixed, misunderstood, or outright confused, sometimes over many generations of professionals in a given system. As a result, forensic job titles abound, with more than one to describe the same set of duties—crime scene investigator, crime scene technician, forensic investigator, evidence technician, forensic technician, laboratory technician, laboratory specialist, forensic specialist, forensic analyst, forensic scientist, criminalist, etc. What is important to remember about titles is that they are administrative, and not necessarily suggestive of a particular background, education, training, or expertise. It is the work that defines the professional. It is education, training, experience, and the quality of work products that help define expertise.

For the purposes of this text, it is important to become disentangled from this avalanche of jumbled titles and return to classic definitions for the purpose of clarity.

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

A *scientist* is someone who possesses an academic and clinical understanding of the scientific method and the analytical dexterity to construct experiments that will generate the empirical

reality that science mandates. A *forensic scientist* is one who is educated and trained to examine and determine the meaning of physical evidence in accordance with the established principles of forensic science, with the expectation of presenting their findings in court. This describes fewer and fewer of those practicing forensic science in the United States.

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

Without the proper scientific foundation, technicians and detectives performing crime reconstructions may do so without a sense of what good science is, and what constitutes the difference between assumptions, opinions, theories, and facts. They also tend to fail with regards to grasping the necessity for testing theories, and for continually attempting to falsify them against the revelations of experimentation and newly developed information. Confirmation of one's theories is easy to find, especially if that is all one seeks. Good science is not about trying to prove one's theories, but rather working tirelessly to disprove them through falsification (Popper, 1963).

HOLISTIC CRIME RECONSTRUCTION

This textbook is aptly titled *Crime Reconstruction*. It is not a manual intended to explain the technical mechanics of searching or processing crime scenes, or to delineate the rote procedures related to instrumental laboratory analysis. There are plenty of texts available which adequately cover these very important considerations, without which reconstruction would be impossible. As already discussed, *holistic crime reconstruction* is the development of actions and circumstances based on the system of evidence discovered and examined in relation to a particular crime. It is best conceived as the function of a forensic generalist. Our purpose is to educate students and prepare generalist practitioners of the forensic sciences as to the manner in which interpretations regarding evidence may be legitimately achieved and expressed.

As we have suggested, not everyone agrees with the forensic generalist model. One of the philosophical arguments against the generalist is that "one cannot be an expert in everything." We do not propose that to perform crime reconstruction one needs to be an expert in all forensic disciplines. We propose that forensic reconstructionists must become an expert in only one: *the interpretation of the evidence in context*. If students wish to pursue further knowledge about examination and analysis in a particular discipline, then there are several excellent publications that are available for that purpose. However, there has never been a textbook devoted only to the interpretation of evidence in context—the proofs, the perils, and the prevarications. Consequently, those studying and performing crime reconstruction have perhaps lacked some advanced measure of informed guidance on the subject. It is our collective goal to assist with filling that void.

Crime reconstruction, to be accurate, must be based upon a close scientific examination of the physical evidence and the surrounding environment. These examinations must be the result of

applying the scientific method. Interpretations of the meaning of subsequent results must be clearly derived by logic and critical thinking. We will try to explain these concepts so that students can understand that crime reconstruction is not just mere observation and speculation. We will also give students several ways to approach the problem of how reconstruction may be competently performed. Throughout this work we have included reconstruction techniques, interpretation guidelines, and even practice standards.

Also, students will come to appreciate that the crime scene is a dynamic location; it does not remain virginal or static, as a “frozen moment of time,” but rather it is constantly subject to change. The greater the time interval between the crime, the documentation, and examination of the scene, the greater the changes may be. These changes we have referred to as *evidence dynamics*. To be ignorant of the problems inherent in the interpretation of the evidence due to evidence dynamics can result in serious misinterpretation errors.

Different areas of physical evidence offer opportunities for reconstruction. Bloodstains, Firearms, Arson, and Trace Evidence all contribute to the whole. We have included chapters on each of these types of evidence by some of the leading experts in these fields.

Finally, there are chapters on ethics and expert testimony, so that students may understand how to comport themselves professionally, and what waits for them in the courtroom. The perspectives of the forensic scientist and the attorney are provided. As readers will come to appreciate, these considerations are far from trivial.

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

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

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Preface

THE NATIONAL ACADEMY OF SCIENCE REPORT: A MANDATE FOR SCIENCE IN FORENSIC SCIENCE

Brent E. Turvey and William “Jerry” Chisum¹

The first edition of *Crime Reconstruction* was written throughout 2005 and early 2006 as a multidisciplinary science text for advanced forensic professionals. It offered a clear rationale for returning to a forensic generalist-oriented model and provided useful tools, guidelines, and even practice standards for physical evidence interpretation. This filled an important gap in the forensic science literature.

Asserting that evidence interpretation must be a scientific process, *Crime Reconstruction* reminded the criminal justice community that this task is in the domain of forensic scientists. More specifically, the authors demonstrated collectively that the interpretation of physical evidence should remain the province of forensic scientists trained to apply the scientific method objectively without law enforcement involvement, influence, or oversight. It took a then controversial position that law enforcement investigators should be in charge of the criminal investigation and that forensic scientists should be in charge of the scientific investigation. The view that police employees are capable of acting as wholly objective scientists—while also charged with investigating crime, working with victims, interviewing suspects, and making arrests—was refuted throughout with careful citation of literature, cases, experience, and the applicable principles of cognitive psychology. Until the publication of this first edition, such views were widely held but rarely voiced out of a very real fear among those practicing forensic science—many of whom work for law enforcement agencies.

One purpose in writing *Crime Reconstruction* was to acknowledge the current status of the reconstructionist community—that it tends to be inappropriately composed of law enforcement officers and evidence technicians (a.k.a. crime scene investigators) who have, at best, undertaken a short course training model. Such practitioners, while well meaning, tend to use oversimplified reconstruction techniques with little or no actual scientific background (e.g., education in proper use of the scientific method from scientists in a nonlaw enforcement context).

This second edition of *Crime Reconstruction* has been adapted to serve both students of forensic science and professional forensic scientists charged with the task of evidence interpretation. Our primary goal was and remains the development of tools and practice standards for the forensic generalist based on the scientific method, analytical logic, and critical thinking.

¹ Mr. Chisum served as a peer reviewer for the National Academy of Science report, which also cited the first edition of *Crime Reconstruction* as a learned treatise on numerous issues.

Our second edition is also written in the still foaming wake of the National Academy of Science (NAS) report on forensic science.² This national audit of the forensic science community in the United States, commissioned by the U.S. Congress, lays out both criticisms and mandates that echo those found in our first edition. Because not all forensic science students and professionals have read the NAS report as they should and because its findings and recommendations are so vital to the future of forensic science, a review is necessary.

The purpose of this preface is to explain our support of the NAS committee on *Identifying the Needs of the Forensic Science Community* (a.k.a. the NAS report). This includes, specifically, the separation of law enforcement culture and forensic science practice; the development of an independent National Institute of Forensic Science (NIFS); the promulgation of basic scientific education requirements for forensic scientists; and the nurturing of forensic science graduate programs along with related Ph.D.-level research into new forensic methods, fraud, bias, and related error rates. These are issues that the forensic science community has had a half-century to investigate and study, but has instead chosen to ignore. We feel this must change in order that forensic science remains worthy of service to society.

THE NAS REPORT—A COMMUNITY RESPONSE

The impetus for the NAS report, which is a congressionally funded system-wide investigation and review of the forensic sciences, included the following: publication of an ongoing series of critical legal reviews regarding the tremendous bias and lack of science in forensic practice; ongoing occurrence of highly publicized forensic frauds, blunders, and crime lab scandals across the United States; ever-increasing number of DNA exonerations sourced back to flawed or misleading forensic evidence documented by groups such as the Innocence Project³; and publication of the first edition of this text. All of these are referenced in the final version of the report. The findings were prepared to inform the U.S. Congress, to help them with related legislative and budgetary decisions, per the role of the NAS.

Judge Harry T. Edwards was the cochair of the NAS committee responsible for investigating the forensic science community and the final NAS report.⁴ He testified to the Senate Committee on the Judiciary on March 18, 2009, regarding his role and perspective (Edwards, 2009)⁵:

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

² Edwards, H., and Gotsonis, C. (2009). *Strengthening Forensic Science in the United States: A Path Forward*. Washington, DC: National Academies Press; url: <http://nationalacademies.org/morenews/20090218.html>.

³ See <http://www.innocenceproject.org>.

⁴ The National Academy of Science committee on *Identifying the Needs of the Forensic Science Community*.

⁵ Edwards, H. (2009). Statement before United States Senate, Committee on the Judiciary, March 18.

Since its publication in February 2009, the NAS report has received a number of responses from the professional community. The International Association for Identification released a memo advising “that members not assert 100% infallibility (zero error rate) when addressing the reliability of fingerprint comparisons,”⁶ despite a century of advocating precisely the opposite; the American Academy of Forensic Sciences (AAFS) acknowledged that “forensic scientists should be assiduously held to Codes of Ethics,”⁷ despite the fact that in more than 50 years it has failed to develop one for its membership; and the American Society of Crime Lab Directors responded by endorsing the report’s “new paradigm” and supporting the need for “mandating ethics guidelines, ensuring quality through establishing standards for education, training, accreditation, certification, and use of common language.”⁸ These are important revelations to be sure. From these and other published accounts, the authors get the impression that forensic organizations worldwide not only endorse the report, but even go so far as to suggest that they have long been agents of the reforms it suggests.

However, anyone who has read the NAS report will be confronted by two crucial omissions from this wave of organizational endorsements. First, the NAS report makes clear the need for science in forensic science—at the very least practitioners must achieve an undergraduate degree with a formal scientific foundation. Clear organizational statements in favor of requiring a science-oriented undergraduate degree in order to serve as a practicing forensic scientist are absent, as most forensic organizations cater to a law enforcement-based membership. Many law enforcement-employed forensic practitioners lack the ability to meet any degree requirement, relying instead on an experience waiver. Second, the NAS report makes clear the need for separating law enforcement culture from forensic science. This is an issue that forensic science organizations have entirely ignored or opposed because, again, they would lose a significant portion of their membership if they were to follow this mandate.

While these issues are apparent to any scientist who has read the report, they seem less than apparent to most of the forensic practitioners and attorneys that the authors have discussed the matter with. Subsequently, it has become clear that many practitioners aren’t reading the NAS report because they think that they already know what’s in it, having read their particular organization’s supportive yet narrow responses. They don’t know what’s in it, why it’s important, or even what it means for the community.

SEPARATING SCIENTIFIC AND LAW ENFORCEMENT CULTURES

Chapter 4 of the NAS report is entitled “The Principles of Science and Interpreting Scientific Data.” This chapter makes clear what science is, what it involves, and defines it as a culture with its own philosophy, mission, and objectives. It is necessary because so much of the criminal

⁶ Garrett, R. (2009). President, *International Association for Identification*, open letter to the membership, February 19.

⁷ Bohan, T. (2009). “The American Academy of Forensic Sciences Approves Position Statement in Response to the National Academy of Sciences’ “Forensic Needs” Report,” Press Release, *AAFS*, September 4.

⁸ “ASCLD’s Comments on the Release of the NAS Report on Forensic Science,” press release, *American Society of Crime Lab Directors*, February 19, 2009; available at www.asclcd.org.

justice community is subordinate to the law, and too many forensic practitioners forget that law and science have different missions. As stated in the NAS report (2009, p. 4-11):

The methods and culture of scientific research enable it to be a self-correcting enterprise. Because researchers are, by definition, creating new understanding, they must be as cautious as possible before asserting a new “truth.” Also, because researchers are working at a frontier, few others may have the knowledge to catch and correct any errors they make. Thus, science has had to develop means of revisiting provisional results and revealing errors before they are widely used. The processes of peer review, publication, collegial interactions (e.g., sharing at conferences), and the involvement of graduate students (who are expected to question as they learn) all support this need. Science is characterized also by a culture that encourages and rewards critical questioning of past results and of colleagues. Most technologies benefit from a solid research foundation in academia and ample opportunity for peer-to-peer stimulation and critical assessment, review and critique through conferences, seminars, publishing, and more. These elements provide a rich set of paths through which new ideas and skepticism can travel and opportunities for scientists to step away from their day-to-day work and take a longer-term view. The scientific culture encourages cautious, precise statements and discourages statements that go beyond established facts; it is acceptable for colleagues to challenge one another, even if the challenger is more junior. The forensic science disciplines will profit enormously by full adoption of this scientific culture.

This is a welcome acknowledgment that the mandates of good science need to be written out and explained, as they are so poorly understood both within the forensic science community and among its end users—the courts and law enforcement. The NAS report also makes clear at multiple points that forensic science is often developed and practiced outside of scientific culture and by nonscientists. Subsequently, the forensic science community has yet to fully embrace fundamental scientific mandates for lack of understanding that they actually exist, let alone that science does not result without them.

This echoes warnings expressed in Thornton and Peterson (2002), that forensic scientists are rarely trained in the scientific method, do not understand its implications, and that this ignorance leads to abuse.⁹ Similarly concerned, the authors wrote (Chisum and Turvey, 2007, p. 85): “most practicing [forensic examiners] would probably have a great deal of enthusiasm for strict adherence to standards that embrace diminished bias, analytical logic, and the scientific method, if only they understood what these things are.”

The NAS report further provides for the need to separate the forensic science community from law enforcement culture. This is discussed in many sections, and all throughout Chapter 6, “Improving Methods, Practice, and Performance in Forensic Science,” where it is explained (2009, p. 6-1):

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

⁹ The work of Dr. Joseph L. Peterson, criminalist practitioner, researcher, and educator, is referenced multiple times in the NAS report. He also presented before the NAS committee as part of their inquiry.

The NAS committee's recognition of the incompatibility between scientific and law enforcement/prosecutorial goals, and the bias this can create and has created, is perhaps its most significant contribution to the future of the forensic science community. This is consistent with specific recommendations for separation found in Cooley and Turvey (2007; see also Chapter 4 of this work),¹⁰ which cites back to Giannelli (1997),¹¹ Starrs (1993),¹² and Kirk and Bradford (1965).¹³

Forensic scientists perform objective analysis on evidence in order to educate the triers of fact. As such, their methods and means should not be biased by, aligned with, or subordinate to the law enforcement mission. They must not be measured by arrests assisted or convictions secured. They must also not compete with police budgets, with lab equipment set against patrol car maintenance. They must be under the management of other scientists and be evaluated and promoted by virtue of their scientific competence.

If readers take nothing else from the NAS report, let it be that science cannot survive, and therefore does not belong, in the culture of law enforcement. This means that every government-funded crime lab must be removed from law enforcement oversight or affiliation and made an autonomously run government entity.

THE FORENSIC SCIENCE COMMUNITY CANNOT REFORM ITSELF

As explained in the NAS report, the forensic science community is fragmented and broken; it cannot identify, let alone fix, its own problems, and does not speak with a single voice about what is best for its future. Moreover, it has proven incapable of holding itself accountable for anything that it does—with a history of failing to correct identifiable errors and scientific deficiencies.

Consider the following two examples:

The American Academy of Forensic Sciences: The AAFS is often touted as a forward-thinking, science-minded professional organization, with respect to promoting good practice and educational development in the forensic sciences. In reality, the AAFS is primarily a professional networking organization with many nonscience and law enforcement members, including a jurisprudence section for attorneys and judges and a general section for law enforcement employees unable to join other sections. It does not mandate a science degree for membership or advancement, offers no general knowledge exam or certification, and has no specific ethical guidelines for members save those that protect the interests of AAFS. Also, numerous AAFS members remain in good standing despite having been determined by the courts to have

¹⁰ Cooley, C., and Turvey, B. (2007). Observer effects and examiner bias: Psychological influences on the forensic examiner. In *Crime Reconstruction* (W.J. Chisum and B. Turvey, eds). Boston: Elsevier Science.

¹¹ Giannelli, P.C. (1997). The abuse of scientific evidence in criminal cases: The need for independent crime laboratories. *Virginia Journal of Social Policy Law*, 4:439–470.

¹² Starrs, J. (1993). The seamy side of forensic science: The mephitic stain of Fred Salem Zain. *Scientific Sleuthing Review*, 17:1–8, Winter.

¹³ Kirk, P., and Bradford, L. (1965). *The Crime Laboratory: Organization and Operation*. New York: Charles C. Thomas.

provided false and misleading credentials, testimony, or findings under oath. The value of any professional organization is found in the degree to which it credentials and regulates its membership, and the AAFS fails both of these tests.

American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB): ASCLD-LAB is the laboratory accrediting body founded by ASCLD. It is governed by lab directors drawn from the very labs that it accredits. This means that it is run by laboratory stakeholders and is not an independent, impartial credentialing body. They do not see it as useful to revoke the credentials of members. Nor do they see it as beneficial to make audit results public. The FBI lab did not lose their ASCLD/LAB accreditation after the fingerprinting errors revealed in the Brandon Mayfield case nor were they sanctioned; DNA Security Inc. didn't lose their ASCLD/LAB accreditation after its senior (and sole) analyst committed forensic fraud in the Duke-Lacrosse rape case. In fact, no known penalties were levied. These are anathema to good scientific practice.

Moreover, ASCLD/LAB requires that accredited labs set laboratory procedures in stone. Deviations from established procedures are not allowed—reducing any scientist to a technician's role. This sounds good unless the procedure is dated or uninformed, as may be the case. It also goes against the spirit of the scientific method (developing, testing, and eliminating all possibilities). Forensic scientists are not free to try new methods published in scientific journals and analyze evidence within the constraints of a particular case under the ASCLD/LAB “must be in the lab manual” model. That is, unless they have the time develop new standards and protocols, which most labs do not with their caseloads and backlogs. Subsequently, they are compelled to stick with old methodologies and are generally unable to innovate.

These examples, taken from many, show how self-interested and unscientific the forensic science community can be when governing itself. However, the most compelling argument that the forensic science community cannot reform itself is that after more than 50 years it hasn't. The NAS report is clear on this issue, and its findings have the virtue of being both informed and impartial.

THE ADVERSARIAL PROCESS CANNOT REFORM THE FORENSIC SCIENCE COMMUNITY

Contrary to arguments made by those advocating against forensic reform, judges and lawyers have not held the forensic science community accountable for identifiable errors and scientific deficiencies. As explained in the NAS report (2009, p. S-19):

The adversarial process relating to the admission and exclusion of scientific evidence is not suited to the task of finding “scientific truth.” The judicial system is encumbered by, among other things, judges and lawyers who generally lack the scientific expertise necessary to comprehend and evaluate forensic evidence in an informed manner, trial judges (sitting alone) who must decide evidentiary issues without the benefit of judicial colleagues and often with little time for extensive research and reflection, and the highly deferential nature of the appellate review afforded trial courts' *Daubert* rulings. Given these realities, there is a tremendous need for the forensic science community to improve. Judicial review, by itself, will not cure the infirmities of the forensic science community.

The point, which cannot be stressed enough, is reiterated later in the NAS report with less diplomacy (2009, p. 1-14):

The bottom line is simple: In a number of forensic science disciplines, forensic science professionals have yet to establish either the validity of their approach or the accuracy of their conclusions, and the courts have been utterly ineffective in addressing this problem. For a variety of reasons—including the rules governing the admissibility of forensic evidence, the applicable standards governing appellate review of trial court decisions, the limitations of the adversary process, and the common lack of scientific expertise among judges and lawyers who must try to comprehend and evaluate forensic evidence—the legal system is ill-equipped to correct the problems of the forensic science community. In short, judicial review, by itself, is not the answer.

We agree that judicial review is not and never has been the answer to quality forensic science for the following reasons—beyond the lack of scientific expertise among jurists.

Scientific fact and legal truth are not the same, despite their confusion by some. *Scientific fact* refers to information and events that have been established based on a broad factual record to a reasonable degree of scientific certainty by scientists using the scientific method. *Legal truth* refers to information and events that have been established by a court ruling based on a narrow factual record—at the discretion of either a judge or a jury. Scientific fact is the result of objective and analytical deliberation; legal truth is the result of something else entirely, as explained in Thornton and Peterson (2002, p. 149)¹⁴:

Scientific “truths” are established when the validity of a proposition is proven to the satisfaction of a prudent and rational mind. Legal “truths” are not established by the exercise of the scientific method, but by the processes of the adversary system.

The role of physical evidence in the administration of justice may reasonably be described as follows: Science offers a window through which the law may view the technological advances of our age. Science spreads out a smorgasbord of (hopefully) valid facts and, having proudly displayed its wares, stands back. The law now picks out those morsels that appear most attractive to it, applying selection criteria that may or may not have anything to do with science. These selection criteria may appear sensible, even obligatory to the law, but may appear illogical or even whimsical to science.

Scientific fact and legal truth are therefore very different propositions. Not only are they established by entirely different means, they are also sought for what can be incompatible ends. Science seeks to find out what happened and why; the law seeks just resolution of legal conflict.

Moreover, judicial players have their own agendas and cultures to satisfy. None of this is a secret, but it will not be heard from beneficiaries of the current law enforcement-dominated forensic science community. In plain language, too many prosecutors are focused on obtaining convictions, not justice or fact finding; too many defense attorneys lack sufficient motive, education, or resources to really question law enforcement employed or affiliated forensic personnel; too many attorneys on both sides are content to hire “experts” who are either ignorant of science or ignore it in their interpretation of evidence; and too often judges are former prosecutors with the agenda of protecting law enforcement-employed or -affiliated forensic personnel from scrutiny—serving as back-up prosecutors rather than neutral interpreters of the law.

¹⁴ Thornton, J., and Peterson, J. (2002). The general assumptions and rationale of forensic identification. In *Modern Scientific Evidence: The Law and Science of Expert Testimony* (D.L. Faigman, D.H. Kaye, M.J. Saks, and J. Sanders, eds.). St. Paul, MN: West Group.

Because there is a need to separate forensic science from law enforcement culture, because the forensic science community cannot reform itself, and because the adversarial process is not suited to the task developing and regulating scientific practice, we wholly support the NAS report's recommendation for the development of a National Institute of Forensic Science (NIFS). This would be an "independent federal agency" that is not "in any way committed to the existing system" and not "part of a law enforcement agency," with "a culture that is strongly rooted in science" and must be wholly endorsed (2009, p. S-13). It must be created separate from DOJ, separate from any law enforcement oversight, and separate from any law enforcement budget priorities.

The authors hope that the NIFS would not be composed of members drawn from ASCLD or ASCLD/LAB, the FBI, or those strongly affiliated with the AAFS, as this would perpetuate the very problems it should seek to alleviate. Instead, the NIFS should be run by a strong leader from the forensic science community with no political loyalties or employment ties to its end users (e.g., law enforcement and prosecutorial agencies). It should be governed by a body composed of scientists from various applied and research backgrounds who are also not compromised by an employment or funding relationship with end users. It would be best composed of scientists, and for scientists, to serve the justice system most effectively.

FORENSIC SCIENTISTS MUST MEET BASIC EDUCATIONAL REQUIREMENTS: THEY MUST BE EDUCATED AS SCIENTISTS

The imposition of basic educational standards is one of the greatest challenges confronting the forensic science community. A major contributing factor to the problem is, again, the alignment of forensic science with law enforcement. Many forensic examiners work for or within law enforcement agencies that have very low educational requirements—where a vocational criminal justice degree is viewed as an acceptable substitute for a scientific education. This is not something that the law enforcement community prefers to acknowledge or be reminded of. To retain membership of the nonscientific forensic examiners employed by law enforcement, most forensic organizations either do not impose degree requirements or provide exceptions for law enforcement experience. This has created one of the most serious problems identified by the NAS report: an overall lack of scientific education and training, let alone a culture of science, in the forensic sciences.

The NAS report makes clear in its discussion of education reform that an undergraduate degree in the forensic sciences, or some other related science, is necessary and that a graduate degree is preferable. It also provides that on the job training is an inadequate substitute (2009, p. 8-1):

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

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

This runs contrary to the views of many law enforcement forensic examiners who argue that experience trumps education and that science can be learned on the job. It also helps with the task of preventing law enforcement examiners and prosecutors from suggesting that one must be in law enforcement, or work for law enforcement, in order to be a scientist. In fact, precisely the opposite is true.

FORENSIC SCIENCE GRADUATE PROGRAMS AND SCHOLARLY RESEARCH MUST BE FEDERALLY SUPPORTED

Currently, many forensic science programs operate out of schools of criminal justice aligned with or taught by current and former law enforcement. The model is vocational rather than scholarly. In other words, these programs are designed to produce police officers, correctional officers, crime scene technicians, or bench criminalists for government crime labs. This is reflected by the types of instructors employed—too many are criminal justice practitioners, not objective scientists or academic scholars. In this environment, research is not supported, funded, or viewed as necessary within forensic science. The NAS report offers that (2009, p. 8-11):

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

Most graduate programs in forensic science are master's programs, where financial support for graduate study is limited. In addition, the lack of research funds means that universities are unlikely to develop research programs in forensic science. This lack of funding discourages top scientists from exploring the many scientific issues in the forensic science disciplines. This has become a vicious cycle during which the lack of funding keeps top scientists away and their unavailability discourages funding agencies from investing in forensic science research. Traditional funding agencies have never had a mission to support forensic science research.¹⁵

This passage explains the need for establishing Ph.D. forensic science programs that would generate research in the forensic sciences. It is something that just about every other scientific discipline benefits from. Such programs need to be initiated, developed, and funded. Two areas where Ph.D.-level research is desperately needed by the forensic sciences are error rates and examiner bias, as discussed repeatedly throughout the NAS report.

¹⁵ The Stanford Research Institute formed a forensic science program from 1969 to 1973. Due to lack of funding, the program died. One of the authors (Chisum) was employed in this program. Some of the proposals for research were revived by the NIJ years later.

Error Rates

Too many in the forensic science community have falsely believed and testified that the error rates of their methods and examinations are essentially zero or are too complex for measurement. As such, it is argued, they need not be studied at all. This misconception about error rates and whether they may be reliably gauged, or relevant, often starts at the top. The seed of arrogance and ignorance from senior examiners is planted in the forensic community—in soil of loyalty or fear. It is gathered and spread as junior examiners are trained to parrot responses that they cannot question and do not understand. Once this happens enough times on the record, they become vested and intellectually immovable.

Consider, for example, the continued testimony of Dr. Bruce Budowle, the FBI's top forensic scientist.¹⁶ As provided in *U.S. v. Llera Plaza et al.* (2002, p. 510)¹⁷:

Dr. Budowle's testimony with respect to methodology error was as follows:

Q: Tell us how it [error rate] applies to scientific methods, methodology.

A: Well, this transcends all kinds of forensic, it transcends all disciplines in that, but in the forensic area particularly, this has been an issue discussed repeatedly in lots of disciplines, whether it is DNA chemistry and latent fingerprints.

We have to understand that error rate is a difficult thing to calculate. I mean, people are trying to do this, it shouldn't be done, it can't be done. . . .

An error rate is a wispy thing like smoke, it changes over time because the real issue is, did you make a mistake, did you make a mistake in this case? If you made a mistake in the past, certainly that's valid information that someone can cross-examine or define or describe whatever that was, but to say there's an error rate that's definable would be a misrepresentation.

So we have to be careful not to go down the wrong path without understanding what it is we are trying to quantify.

Now, error rate deals with people, you should have a method that is defined and stays within its limits, so it doesn't have error at all. So the method is one thing, people making mistakes is another issue.

The NAS report makes clear that any testimony suggesting near or complete infallibility regarding a method or an examiner is unscientific and, worse still, false. Furthermore, there was great concern by the NAS committee regarding the number of practitioners in the forensic science community who were unwilling to concede that they had an error rate of "more than zero."¹⁸ As described in the NAS report (2009, pp. 1-9–1-10):

In testimony before the committee, it was clear that some members of the forensic science community will not concede that there could be less than perfect accuracy either in given laboratories or in specific disciplines, and experts testified to the committee that disagreement remains regarding even what constitutes an error. . . . Failure to acknowledge uncertainty in findings is common: Many examiners claim in testimony that others in their field would come to the exact same conclusions about the evidence they have analyzed.

¹⁶ Dr. Bruce Budowle is referenced multiple times in the NAS report and also presented before the NAS committee as part of their inquiry.

¹⁷ *U.S. v. Carlos Ivan Llera Plaza, Wilfredo Martinez Acosta, and Victor Rodriguez*, Case Nos. CR. 98-362-10, CR. 98-362-11, 98-362-12, United States District Court, E.D. Pennsylvania, January 7, 2002.

¹⁸ For an excellent discussion of this issue, see Cole, S.A. (2005). More than zero: Accounting for error in latent fingerprint identification. *Journal of Criminal Law and Criminology*, 95.

The insistence by some forensic practitioners that their disciplines employ methodologies that have perfect accuracy and produce no errors has hampered efforts to evaluate the usefulness of the forensic science disciplines. And, although DNA analysis is considered the most reliable forensic tool available today, laboratories nonetheless can make errors working with either nuclear DNA or mtDNA—errors such as mislabeling samples, losing samples, or misinterpreting the data.

The NAS report puts these issues to rest, clearly identifying a need for humility and future research when it explains that based on its inquiry (2009, p. 1-6):

The fact is that many forensic tests—such as those used to infer the source of toolmarks or bite marks—have never been exposed to stringent scientific scrutiny. Most of these techniques were developed in crime laboratories to aid in the investigation of evidence from a particular crime scene, and researching their limitations and foundations was never a top priority. There is some logic behind the application of these techniques; practitioners worked hard to improve their methods, and results from other evidence have combined with these tests to give forensic scientists a degree of confidence in their probative value. Before the first offering of the use of DNA in forensic science in 1986, no concerted effort had been made to determine the reliability of these tests, and some in the forensic science and law enforcement communities believed that scientists' ability to withstand cross-examination in court when giving testimony related to these tests was sufficient to demonstrate the tests' reliability. However, although the precise error rates of these forensic tests are still unknown, comparison of their results with DNA testing in the same cases has revealed that some of these analyses, as currently performed, produce erroneous results.

The NAS report goes on to define the type of errors that can occur in forensic casework, explains that they can indeed be measured when clearly distinguished, and warns “[t]he assessment of the accuracy of the conclusions from forensic analyses and the estimation of relevant error rates are key components of the mission of forensic science” (p. 4-9).

Examiner Bias

The NAS report discusses the issue of examiner bias and subconscious observer effects at length. It explains (2009, p. 4-9):

Human judgment is subject to many different types of bias, because we unconsciously pick up cues from our environment and factor them in an unstated way into our mental analyses. Those mental analyses might also be affected by unwarranted assumptions and a degree of overconfidence that we do not even recognize in ourselves. Such cognitive biases are not the result of character flaws; instead, they are common features of decision making, and they cannot be willed away.⁹

A familiar example is how the common desire to please others (or avoid conflict) can skew one's judgment if coworkers or supervisors suggest that they are hoping for, or have reached, a particular outcome. Science takes great pains to avoid biases by using strict protocols to minimize their effects.

Fn9: See, e.g., M.J. Saks, D.M. Risinger, R. Rosenthal, and W.C. Thompson. 2003. Context effects in forensic science: A review and application of the science of science to crime laboratory practice in the United States. *Science and Justice* 43(2):77-90.

This is an important discussion to have on record, as many in the forensic community believe and argue one or more of the following regarding examiner bias and observer effects: They don't exist, they can be willed away, they are dealt with by peer review and publication, and/or they have never heard of them. Of course, none of these is true—save the last.

In failing with these arguments, the next line of attack from vested forensic practitioners and their law enforcement employers has been to suggest that if these concerns were real, it wouldn't just be the defense bar discussing them in law review articles, which is why a chapter on this subject was included in Chisum and Turvey's *Crime Reconstruction* (in this edition, see Chapter 4: Observer Effects and Examiner Bias: Psychological Influences on the Forensic Examiner).

Given our previously published findings, and their agreement with the NAS report, we concur with its assessment that (2009, p. 4-11): "Research has been sparse on the important topic of cognitive bias in forensic science—both regarding their effects and methods for minimizing them." Further, we agree with the inference that more study of these subjects is necessary—not less.

Because of the politics involved, error rates and examiner bias are best studied by disinterested students of criminology and forensic science at the graduate level. Within a university environment, scholarship and the mandates of good science can be supported and encouraged. Such researchers are also freer to make objective findings, and to publish them, than those who are politically bound to the interpretive policies of an agency or organization.

CONCLUSION

Despite the remarks of some and the fears of others, we do not view the NAS report as an attack on the forensic science community. On the contrary, we view it as a call to salvage its scientific credibility. Currently the forensic science community lacks both scientific research and real or even impartial leadership—and it needs one to encourage the other. Although it is imperfect in many ways, the NAS report is an excellent set of starter blueprints for the continued scientific development of forensic science, and much needed forensic reform. Consequently, it is cited throughout this book.

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As a director of digital forensics and investigations at Stroz Friedberg, he maintained an active docket of cases and comanaged the firm's technical operations in the areas of computer forensics, cyber-crime response, incident handling, and electronic discovery. He also spearheaded Stroz Friedberg's external and in-house forensic training programs as director of training. Eoghan has performed thousands of forensic acquisitions and examinations, including Windows and UNIX systems, Enterprise servers, smart phones, cell phones, network logs, backup tapes, and database systems. He also has extensive information security experience as a former information security officer at Yale University and in subsequent consulting work. He has performed vulnerability assessments; deployed and maintained intrusion detection systems, firewalls, and public key infrastructures; and developed policies, procedures, and educational programs for a variety of organizations.

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W. Jerry Chisum, B.S.

William "Jerry" Chisum, now retired from teaching and active government service, started criminalistics practice in 1960. He studied under Dr. Paul L. Kirk at U.C. Berkeley where he received a bachelor's degree in chemistry. He worked in San Bernardino and then set up the Kern County Laboratory in Bakersfield. After joining the California Department of Justice, he took a leave of absence (1971–1973) to work at Stanford Research Institute.

Jerry has always been interested in crime scene evidence and has developed numerous methods of crime reconstruction. He is a coauthor of the text *Crime Reconstruction* with Brent Turvey and has published numerous other chapters and monographs on related subjects. His teaching has been international in scope. He taught as a part-time professor at the California State University, Sacramento for 4 years. He instructed with Joe Rynearson for over 25 years

in various locations in California, Idaho, Indiana, Illinois, New Mexico, Washington, DC, and Nevada. He has lectured on crime reconstruction at the FBI Academy in Quantico, Virginia; U.C. Berkeley; the University of New Haven; the Connecticut State Police Academy; the First Conference on Serial Murders, Oklahoma City; the Second and Third Conferences on Serial Murders, Nashville; ACSR Symposium on Crime Scene Reconstruction, Oklahoma City; the American Academy of Forensic Sciences; the First Chinese-American Conference on Police Science in Taiwan; the Australian Forensic Science Society in Brisbane; twice in Dar Es Salaam, Tanzania; and the Tri-State Annual Law Enforcement Conference in Great Spirit Lake, Iowa.

Jerry has been president of the California Association of Criminalists three times. He served as president of the American Society of Crime Lab Directors and as president of the Stanislaus County Peace Officers Association. He has also served as vice-president of the Academy of Behavioral Profiling.

Although now retired from government service, Jerry still is active in case consultation and accepts cases from throughout the United States. He can be reached via email at wjchisum@comcast.net.

Craig M. Cooley, M.S., JD

Craig M. Cooley is a staff attorney with the Innocence Project in New York, New York. Craig received his JD from Northwestern University School of Law (2004). In addition, he completed his M.S. in forensic science at the University of New Haven (2000). He also holds a B.S. in psychology from the University of Pittsburgh (1996).

During graduate school, Craig worked as an investigative intern with the Sacramento County Public Defender's Office and as a graduate research assistant for the California Department of Justice's Bureau of Forensic Services. Subsequently, he worked as an assistant federal defender in Las Vegas, Nevada (2005–2007), where he represented Nevada death row inmates in federal and state postconviction proceedings as part of the Capital Habeas Unit.

Craig's research and writings have been published in the *Journal of Behavioral Profiling*, *George Mason University Civil Rights Law Journal*, *New England Law Review*, *Indiana University Law Journal*, *Stanford Law & Policy Review*, *Oklahoma City University Law Review*, and *Southern Illinois University Law Journal*. He has also been published in textbooks and professional manuals, such as *Criminal Profiling*, *Crime Reconstruction*, and *Forensic Criminology*.

Dr. John D. DeHaan

Dr. John DeHaan has been a criminalist for more than 32 years. He has worked at county, state, and federal forensic labs. He is a native of Chicago, and his bachelor of science degree in physics was from the University of Illinois at Chicago. He has been involved with fire and explosion investigations for over 30 years and has authored dozens of papers on fires, explosions, and their investigation and analysis. He is best known as the author of the textbook *Kirk's Fire Investigation* (now in its sixth edition). His doctorate is from the University of Strathclyde in Glasgow, Scotland, with a dissertation on the "Reconstruction of Fires Involving Flammable Liquids."

John is a member of NFPA and served on its 921 Technical Committee from 1991 to 1999. He is also a member of the IAAI and serves on its forensic science committee. He holds a diploma in

fire investigation from the Forensic Science Society (United Kingdom) and one from the Institution of Fire Engineers (U.K.). He is a Fellow of the American Board of Criminalistics in Fire Debris Analysis and a member of the Institution of Fire Engineers. He retired from the California Department of Justice in December 1998 and is now the president of Fire-Ex Forensics, Inc., based in Vallejo, California. He continues to consult on fire and explosion cases all over the United States, Canada, and overseas. He can be reached at jddehaan@fire-exforensics.com.

Jodi Freeman, M.Crim.

Jodi Freeman holds an honors bachelor degree in health sciences from the University of Western Ontario, Canada, with a double major in health sciences and criminology. She recently graduated from Bond University, Australia, with a master's degree in criminology.

During her master's program, Jodi completed an independent study under Brent Turvey, in the area of behavioral evidence analysis. In 2010, Jodi completed a crime scene analysis internship with forensic solutions. Working in this role, she continues to assist with research, casework and workshop facilitation. Jodi can be contacted at jodi.freeman@rogers.com.

Meagan Gallagher, M.S.

Meagan Gallagher is a criminalist with the California Department of Justice Bureau of Forensic Services. She works in the Central Valley Laboratory of the California Department of Justice system. She graduated with honors with a degree in biology from the University of Massachusetts, Amherst, and, before becoming a forensic scientist, did biomedical research at the Dana Farber Cancer Institute in Boston. She graduated at the top of her class from the forensic science master's program at the University of California at Davis. She continues to pursue research projects in forensic science and has published findings in the *California Association of Criminalists News* and in the *Journal of Forensic Sciences*. She is an active member of the California Association of Criminalists and she has an indelible interest in trace evidence analysis.

Charla M. Jamerson, BSN, RN, MNS, SANE-A, CMI, III

Charla Jamerson received her bachelor's of nursing science from Excelsior College of Nursing in 2002 and her RN diploma from the Baptist School of Nursing Northwest in 1995. In 2003, she completed the graduate certificate program in forensic nursing and forensic internship at the University of Colorado, Colorado Springs. She subsequently completed a master's in nursing science and is a certified family nurse practitioner.

Charla is a registered nurse in the state of Arkansas; is certified as a sexual assault nurse examiner (SANE) by the International Association of Forensic Nurses; and is a medical investigator by the American College of Forensic Examiners. From 2000 to 2003, she was the director of forensic nursing and forensic nurse examiner at the Children's Safety Center in Springdale, Arkansas. From 2003 to 2006, she was the owner, director of Forensic Nursing Services, and head clinician of Jamerson Forensic Nursing & Investigative Services, Inc. in Fayetteville, Arkansas.

She is currently in the nurse practitioner program at Stony Brook University, New York, studying to get her master's, and can be reached at cjame24152@aol.com.

Bruce R. Moran, B.S.

Over his 34-year career, Bruce Moran has authored or coauthored in excess of 27 published works, including his chapter in the first edition of *Crime Reconstruction*. He is a criminalist/firearms examiner in the criminalistics unit of the Sacramento County District Attorney's Laboratory of Forensic Services in Sacramento, California. He is a recognized expert in firearm and tool mark examination and crime scene investigation/reconstruction and presently serves as a team leader on the crime scene response unit.

Bruce holds a bachelor of science degree in forensic science and a minor in chemistry from California State University, Sacramento, received in 1977. He earned ABC diplomate status in 1990. He has a broad background in the forensic sciences but has special interest in firearms examination and crime scene investigation and reconstruction. He is a distinguished member of the Association of Firearm and Toolmark Examiners and is an active member of the International Association for Crime Scene Reconstruction. He is also a member of the California Association of Criminalists, the International Association of Blood Pattern Analysts, and a life member of the International Association for Identification.

Bruce has provided training for forensic scientists, law enforcement professionals, and prosecuting and defense attorneys in the field of general criminalistics, crime scene investigation/reconstruction, and firearm and tool mark identification and has served as an adjunct professor at California State University, Sacramento, California, in 1997 and the University of New Haven, Forensic Science Master's program in 2000. He has also presented papers and workshops on these topics at professional meetings in the United States, Europe, and Asia. He has served since 1993 as an instructor for the Department of Justice-California Criminalistics Institute in Sacramento, California, on the topics of firearm and tool mark examination and identification and has been a forensic subject matter expert/consultant for the Cold Case Homicide Investigation course offered by the California Department of Justice-Advanced Training Center since 2000.

In 2009, he was the recipient of the Calvin H. Goddard Award in forensic technology.

John Thornton, D.Crim.

John Thornton's career in forensic science spans a half-century and includes many publications. He holds a doctorate of criminalistics and was a student of Dr. Paul Kirk. He is an emeritus professor of forensic science at the University of California at Berkeley and, despite ostensible retirement, continues to teach concepts of forensic science and methods of personal identification at the University of California at Davis. He has 25 years of experience in operational crime laboratories and served a 4-year sentence as a lab director.

John has participated in crime scene processing and crime reconstruction from Hawaii to Massachusetts and Alaska to Florida. He has taught physical evidence methods in Colombia, India, Mexico, Israel, Spain, and China. He has served on the board of directors of the American Board of Criminalistics and has served as president of the California Association of Criminalists, chairman of the criminalistics section of the American Academy of Forensic Sciences, and chairman of the ethics committee of the California Association of Criminalists.

Brent E. Turvey, M.S.

Brent E. Turvey spent his first years in college on a pre-med track only to change his course of study once his true interests took hold. He received a B.S. from Portland State University in psychology, with an emphasis on forensic psychology, and an additional B.S. in history. He went on to receive his master's of science in forensic science after studying at the University of New Haven in West Haven, Connecticut (1996).

Since 1996, Brent has consulted with many organizations, attorneys, and law enforcement agencies in the United States, Australia, Scotland, China, Canada, Barbados, Singapore, and Korea on a range of rapes, homicides, and serial/multiple rape death cases as a forensic scientist and criminal profiler. In August of 2002, he was invited by the Chinese People's Police Security University (CPPSU) in Beijing to lecture before groups of detectives at the Beijing, Wuhan, Hanzou, and Shanghai police bureaus. In 2005, he was invited back to China to lecture at the CPPSU and to the police in Beijing and Xian—after the translation of the second edition of his text into Chinese for the university. In 2007, he was invited to lecture at the First Behavioral Sciences Conference at the Home Team (Police) Academy in Singapore, where he also provided training to their behavioral science unit. In 2010, he examined a series of sexual homicides for the solicitor-general of the Crown Office and Procurator Fiscal Service in Edinburgh, Scotland.

Brent has been court qualified as an expert in the areas of criminal profiling, victimology, crime scene investigation, sex crimes investigation, false reports, crime scene analysis, forensic science, and crime reconstruction in many courts and jurisdictions (state and federal) around the United States, in both civil and criminal matters.

Brent has published in numerous peer-reviewed journals and is the author of *Criminal Profiling: An Introduction to Behavioral Evidence Analysis*, first, second, third, and fourth editions (1999, 2002, 2008, 2010), and coauthor of *Rape Investigation Handbook*, first and second editions (2004, 2011), *Crime Reconstruction, Forensic Victimology* (2009), and *Forensic Criminology* (2010)—all with Academic/Elsevier Science.

Brent is currently a full partner, forensic scientist, criminal profiler, and instructor with Forensic Solutions, LLC, and an adjunct professor of Justice Studies at Oklahoma City University. He can be contacted via email at bturvey@forensic-science.com.

Forensic Science

W. Jerry Chisum and Brent E. Turvey¹

Key Terms

Crime reconstruction; Criminalistics; Forensic generalist; Forensic science; Forensic scientist; Forensic services; Forensic specialist; Forensic technician; Role strain; Science; Scientific knowledge; Scientific method; Scientist; Technician

The interconnected criminal and civil justice systems in the United States exist at the municipal, county, state, and federal levels. Each consists of the following major branches: *law enforcement, forensic services, judiciary, and corrections*. Law enforcement agencies at the local, state, and federal levels investigate reported crime, establish the facts, and determine whether a law has been violated. They also seek to identify and arrest criminal suspects. The judiciary is composed of attorneys, judges, magistrates, courts, and other professionals who provide related services (e.g., court reporters, bailiffs, and administrators). It deals with the adjudication and exoneration or punishment of criminal defendants. Corrections is composed of those agencies charged with handling the probation, incarceration, management, rehabilitation, treatment, parole, and execution of convicted criminals. This can include prisons, mental health hospitals, and a wide variety of other state-funded facilities.

Forensic services refers to the branch of the criminal justice system that deals with the examination and interpretation of evidence—physical, behavioral, and testimonial. Government-employed technicians, analysts, forensic scientists, and mental health experts perform a wide variety of forensic services on behalf of the state, most often employed directly by the police or the prosecution. However, the forensic community in the United States is also populated by a large number of privately employed, independent forensic examiners and laboratories. They are regularly engaged to perform examinations for the police, the prosecution, and the courts.

When state or private funds are available, as happens in major cases or those involving financially capable defendants, private forensic professionals may be hired to provide a necessary

¹ Some sections of this chapter have been adapted from [Turvey \(2010\)](#) and [Turvey and Petherick \(2010\)](#).

counterbalance within the adversarial system. However, access to qualified private forensic examiners is by no means equal, varying widely from state to state. It is therefore reasonable to say that not every available forensic service is an adjunct of the government, although it is more often the case than not. And not every defendant has access to qualified forensic experts.

The purpose of this first chapter is to explain the relationship between **forensic science** and **crime reconstruction** as they relate to the justice system. Although this may seem too fundamental for inclusion in an advanced forensic science text, the authors disagree. For reasons that will become clear, is not uncommon to find even senior forensic practitioners who are ignorant of what forensic science and crime reconstruction are, let alone their scope and role in the process. Developing this understanding will provide the philosophical cohesion and integrity necessary for an informed reading of all subsequent chapters within. It will also resonate beyond those pages into research, casework, and testimony.

FORENSIC SCIENCE

Forensic science is the application of scientific knowledge and principles to the resolution of legal disputes, whether criminal or civil. This definition, generally consistent across forensic textbooks and professional organizations, is intentionally broad. There are, in fact, many different kinds of forensic scientists, as shown in this outline of specialties²:

A. Criminalistics

1. Event/incident analysis
 - a. Accident reconstruction/forensic engineering
 - b. Bloodshed pattern analysis
 - c. Criminal activity reconstruction
 - d. Digital evidence reconstruction
 - e. Fire scene reconstruction
 - f. Shooting incident reconstruction
 - g. Transfer evidence reconstruction
 - h. Wound pattern analysis and reconstruction
2. Drug chemistry analysis and identification
3. Forensic biology
 - a. DNA analysis and comparison
 - b. Serological analysis and comparison
4. Fire debris analysis and comparison
5. Pattern comparison
 - a. Firearm and tool mark analysis and comparison
 - b. Footwear pattern analysis and comparison
6. Trace evidence analysis

² This outline does not include all forensic specialties, only those found most commonly in service of the court. Additionally, it is limited to those forensic sciences associated with the examination of physical evidence.

- a. Commercial materials analysis and comparison
 - b. Fiber analysis and comparison
 - c. Glass analysis and comparison
 - d. Gunshot residue analysis
 - e. Hair analysis and comparison
 - f. Natural materials analysis
 - g. Soil analysis and comparison
- B. Digital evidence analysis
- C. Fingerprint development and comparison
- D. Forensic dentistry/odontology
- E. Forensic nursing
- F. Forensic pathology
- G. Forensic toxicology
- H. Questioned documents

The most common type of forensic scientist is the criminalist. As suggested in the aforementioned outline, **criminalistics** is a division of forensic science dedicated to the recognition, examination, and interpretation of physical evidence using the natural sciences, logic, and critical thinking.

[Thornton and Peterson \(2002\)](#) explain that **forensic scientists** are defined by the possibility that they will be called upon to present scientific findings, under penalty of perjury, in a court of law. Subsequently, they will be asked to explain to the court what those findings mean and how they came to them. Those examiners whose work does not bring them into contact with the legal system are not “forensic” in nature. As provided in [Thornton and Peterson \(2002, p. 148\)](#):

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

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

Ultimately, then, the mission of forensic science is to develop and provide scientific knowledge and information for the decision makers of the justice system. These include:

- Police officers
- Attorneys
- Juries
- Judges/magistrates

- Probation/parole officers

The forensic scientist is not a decision maker in the justice system, and, as already discussed in the Prefaces,³ their goals must remain separate to maintain any semblance of impartiality.

GENERALISTS VS. SPECIALISTS

As in the field of medicine, or any other field for that matter, there are **forensic generalists** and there are **forensic specialists**. The distinction between generalist and specialist forensic practitioners is an important one that has been too often deemphasized. Forensic generalists and forensic specialists alike are required in order to effect informed forensic case examination, laboratory testing, and crime reconstruction.

Forensic generalists are a particular kind of forensic scientist, broadly educated and trained in a variety of forensic specialties. They understand the range of forensic testing available for particular kinds of evidence and the meaning of those findings to a reconstruction of events. They are “big picture” people who can help reconstruct a crime from work performed with the assistance of other forensic scientists and then direct investigators to forensic specialists as needed. They are not experts in all areas, but in the specific area of evidence interpretation. According to [DeForest and colleagues \(1983, p. 17\)](#):

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

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

There are fewer and fewer generalists in the forensic science community, and it is not uncommon for forensic scientists to gain employment in government service without a generalist background at all. Rather it is more common for forensic scientists to be narrowly trained as specialists of some sort without the benefit of a general forensic education and then to learn other subspecialties once employed by a public crime lab. In fact, most crime lab employees are cross-trained in multiple areas of evidence to save having to hire additional personnel.

³ The reader is urged to read the Preface to the first edition (online) and the Preface to the second edition in the frontmatter, as they are integral to understanding the professional context and message of science that the authors intend to impart.

FORENSIC CONFUSION: TECHNICIANS AND SCIENTISTS

As explained in [Inman and Rudin \(1999\)](#), there is much confusion over who precisely the “real” forensic scientists are, and who they are not. An assessment of the discontinuity is offered in the NAS report⁴ by [Edwards and Gotsonis \(2009\)](#), p. S-5):

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

Moreover, [Edwards and Gotsonis \(2009\)](#) found the forensic science community poorly focused and badly fragmented, with no clear practice standards, consistent terminology, or standardized means of practitioner certification.⁵

Suffice it to say that forensic science is not always practiced in a crime lab, it is not always practiced by someone working for law enforcement (nor should it be), and, unfortunately, it is not always practiced by actual scientists. However, it must also be remembered that the vast majority of full-time forensic science practitioners in the United States work in police agencies or government-funded crime labs, providing their services almost exclusively to law enforcement and the prosecution. Edwards and Gotsonis explain that (2009, pp. 1–2)

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

These circumstances exist in no small part because forensic science in practice is an applied science ([Inman and Rudin, 1999](#)). This means that practitioners borrow from the research and principles of other established scientific disciplines and apply it to their own forensic casework.

⁴ A full discussion of the NAS report, what it is, and its highly relevant findings is provided in the Preface to the second edition of this textbook: “The NAS Report: A Mandate for Science in Forensic Science.” Readers are encouraged to take the time to read this Preface, as well as the NAS report itself.

⁵ [Edwards and Gotsonis \(2009\)](#): “Not all forensic services are performed in traditional crime laboratories by trained forensic scientists. Some forensic tests might be conducted by a sworn law enforcement officer with no scientific training or credentials, other than experience. In smaller jurisdictions, members of the local police or sheriff’s department might conduct the analyses of evidence, such as latent print examinations and footwear comparisons.”

Because many forensic practitioners are not themselves scientists, especially those in direct police service, the results of their borrowed methods and analyses can range from the exceptionally informed to the patently absurd.

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

there are also sharp distinctions between forensic practitioners who have been trained in chemistry, biochemistry, biology, and medicine (and who bring these disciplines to bear in their work) and technicians who lend support to forensic science enterprises. Many of these differences are discussed in the body of this report.

The greatest distinction identified in the NAS report is that of testing versus interpretation (p. 2-4):

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

As provided in the Preface of the first edition of this text,⁶ a **technician** is one trained in procedures learned by routine or repetition. A forensic technician is trained in the specific procedures related to collecting and even testing evidence found at or in association with crime scenes. This is without any need for employing or even understanding the underlying science involved, the scientific method, or the principles of forensic science. This describes police technicians documenting crime scenes and collecting evidence, and more than a few of the forensic personnel working in government crime labs who are trained to perform analytical testing without an interpretive role.⁷

A **scientist** is someone who possesses an academic and clinical understanding of the scientific method and the analytical dexterity to construct experiments that will generate the empirical reality that science mandates. A **forensic scientist** is one who is educated and trained to examine and determine the meaning of physical evidence in accordance with the established principles of forensic science, with the expectation of presenting his or her findings in court. They also holds a degree in a natural science or in forensic science.

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

The contrast between technician and scientist is both subtle and tremendous. Currently, the trend is to populate government-funded crime labs with forensic technicians who do little more than inject a sample and push a button without knowing the science beneath their methods and

⁶ Preface to the first edition: A Holistic Approach to Crime Reconstruction; see front matter.

⁷ The authors are never surprised to find crime lab employees who have learned their entire profession on the job, without a formal scientific education, holding only undergraduate degrees in unrelated areas such as criminal justice, business administration, public administration, or general studies.

instrumentation. This saves money in terms of having to hire fewer of those with advanced degrees. This also limits the testimony of forensic technicians to results only and prevents them from being able to explain the meaning of those results with competence.

As the authors have experienced on countless cases, it is technicians, investigators, and ultimately attorneys who are providing a majority of crime reconstructions in court, often with little understanding of forensic science or the scientific method, to say nothing of the natural limits of physical evidence. Crime lab personnel are performing the necessary laboratory analysis, but police and prosecutors are taking the final step to explain events and their relationships in court. This has the net effect of elevating the lay testimony of investigators and forensic technicians to that of the forensic scientist, while at the same time reducing the expert findings of the forensic scientist to the level of the technician. It should not need to be said that this is highly inappropriate, if not also misleading, to the trier of fact.

CRIME RECONSTRUCTION

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

Crime reconstruction is best conceived as the work of forensic generalists putting together theories of the crime based on the consideration of aggregated results from a variety of forensic disciplines. As explained in the Preface to the first edition of this text, the generalist–reconstructionist need not know how to perform all of the forensic examinations that were conducted. They need not have the ability to operate a camera to view a photograph; they need not have the ability to extract DNA and amplify it to comprehend a DNA analyst’s report; and they need not have the ability to perform an autopsy to understand the cause and manner of death or to appreciate the trajectory of the projectiles that passed through the body. Rather, they must be able to understand what the results of forensic examinations are, how they were reached, what they mean, and how they may be integrated to render a picture of knowable events.

Integration of findings is key because crime is best reconstructed when forged by a collaboration of the forensic evidence, not by a reliance on one single examination or discipline. Even DNA findings cannot be given meaning in a particular case absent a reconstruction of the conditions of transfer. Relying on one piece of evidence, or one theory, without placing it in context with other physical evidence and thus reconciling it, is not only potentially misleading but also a disservice to the justice system.

CRIME RECONSTRUCTION AS A SCIENTIFIC PRACTICE

Crime reconstruction is a forensic discipline based on the forensic sciences, the scientific method, analytical logic, and critical thinking. But is the discipline of reconstruction a science in its own right? This requires some discussion. The first problem is consistency with terms and usage between forensic professionals, as described in [Moenssens \(1997\)](#):

One of the recurring problems we must face in the law of opinion evidence is that the words “scientific evidence,” as they have come to be used by courts, lawyers, and legal commentators, do not necessarily connote that the evidence is arrived at purely by mathematically verifiable scientific principles. Indeed, courts are not always in agreement on whether a particular forensic practice is to be called “scientific” or not. Much opinion testimony that has been by common usage labeled as “scientific evidence,” involves aspects wherein standard and measurable rules govern certain determinations. It also involves evaluations that are much more a matter of art and interpretation, yielding an opinion that is rarely quantifiable, despite the fact that defined methodologies for conducting examinations exist. Forensic disciplines may prescribe the use of certain protocols and measurements for some phases of the analytical process, but when it comes to interpreting the meaning of the evidence in court it often becomes a matter of judgment based on the expert’s considerable experience.

Education in the sciences and specialized training help define a **scientist**, not just experience, and even this is not enough. Although it often escapes notice, scientists are actually defined by their adherence to the scientific method when solving problems, such as how something works, why something does not work, or how something happened. Anyone who fully comprehends and diligently employs the scientific method is a scientist, lab coat or not. Although these seemingly limited criteria may appear to the uninitiated as a lowering of the bar, they actually raise it. A degree requirement, for example, even in the hard sciences, in no way ensures student exposure to, or comprehension of, the scientific method. The emphasis, again, is on full comprehension and diligent employment of the scientific method; all the college degrees in the world combined with a lifetime of experience do not matter unless it shows in one’s work. This is discussed later in this chapter and is a theme that runs through every page of this text.

A **forensic scientist**, as discussed previously, is one who examines and determines the meaning of physical evidence in accordance with the established theories and principles of forensic science, with the expectation of presenting his or her findings in court. This presumes use of the scientific method, analytical logic, and critical thinking.

The **scientific method** is a way to investigate how or why something works, or how something happened, through the development of hypotheses and subsequent attempts at falsification through testing and other accepted means.⁸ It is a structured process designed to build scientific knowledge by way of answering specific questions about observed events through analysis and critical thinking. Observations are used to form testable hypotheses, and with sufficient testing hypotheses can become scientific theories. Eventually, over much time, with precise testing marked by a failure to falsify, scientific theories can become scientific principles. The scientific method is the particular approach to knowledge building and problem solving employed by scientists.

Scientific knowledge is any knowledge, enlightenment, or awareness that comes from examining events or problems through the lens of the scientific method. The accumulation of scientific knowledge in a particular subject or discipline leads to its development as a **science**. The classic definition of a **science**, as provided by Thornton (1997, p. 12), is “an orderly body of knowledge with principles that are clearly enunciated,” as well as being reality oriented and having conclusions susceptible to testing.

A strong cautionary is needed here. The use of statistics does not make something scientific. The use of a computer does not make something scientific. The use of chemicals does not make

⁸ A more complete discussion of the scientific method is provided in Chapter 5: Practice Standards for the Reconstruction of Crime.

something scientific. The use of technology does not make something scientific. Science is found in the interpretations; in whether the scientific method has been used to synthesize the knowledge at hand and whether that knowledge has been applied correctly to render interpretations, with the necessary humility.

The relationship of scientists, the scientific method, and science is thus: Scientists employing the scientific method can work within a particular discipline to help create and build a body of scientific knowledge to the point where its theories become principles, and the discipline as a whole eventually becomes a science. And the discipline remains a science through the continued building of scientific knowledge.

Crime reconstruction as a discipline is ripe for development as a science; however, its scientific theories have, arguably, yet to achieve the necessary level of empirical maturity. Crime reconstruction is reality based, there is an orderly body of knowledge that exists in the literature, there are generally accepted theories and practice standards, and reconstruction conclusions reached through the scientific method are susceptible to verification through independent peer review and testing. Where the discipline falls short is in the realm of empirically established scientific principles that are clearly enunciated, but this hardly distinguishes it from the majority of the forensic sciences [for discussions, see [Inman and Rudin, 1999](#); [Jonakait, 1991, 1994](#); [Thornton, 1994](#); see also [Edwards and Gotsonis \(2009\)](#), which proclaims the utter absence of science in almost every aspect of forensic science]. The vast majority of forensic sciences do not have principles or even practice standards for interpretation that are clearly enunciated, and those claiming otherwise should be asked precisely what these are while under oath.

In any event, there is much good forensic science theory in crime reconstruction, and as described in this text it is often based on sound scientific methodology. There is simply not enough published research to establish a clear body of scientific principles. This will take more time, more data, and more research. Consequently, courts rightly perceive the discipline of crime reconstruction as an area of specialized knowledge built on scientific knowledge.

ROLE STRAIN: ASSERTING SCIENTIFIC IMPARTIALITY

In mystery novels, television, and films, the homicide detective reconstructs crime and deduces the identity of the criminal—then gets an ironclad confession. In reality, the homicide detective seldom has the scientific background necessary to build a reconstruction on his or her own. For the majority of detectives, the use of physical evidence is secondary to the interview and interrogation of the witnesses and suspects. Theirs is commonly a mind-set of chasing suspects like a dog on a scent, and once focused they are regularly undeterred until a capture has been made. They build cases and box suspects in with deliberation through the lenses of authority and suspicion. It is an approach that, if unchecked by an impartial filter, can result in a wrongful arrest and even a miscarriage of justice.

Forensic science is meant to assist the justice system as an impartial and even skeptical filter for unsupportable case theory and biased agendas. As a result, the objective mandates of good science are frequently in direct conflict with the needs of investigators, the desires of attorneys, and even the rule of law as decided by various courts. This conflict creates often unbearable strain in the role that forensic scientists intend to serve.

Role Strain

The constant shifting of roles and the collision of multiple role expectations can cause what sociologists refer to as **role strain**. As explained in [Kennedy and Kennedy \(1972, p. 16\)](#), role strain is a reference to the “difficulties and contradictions inherent in one’s role.” In private practice, forensic criminologists must abide by the often incompatible principles of both science and law.

This is compounded by the expectations of police agencies, attorneys, and judges. If directly employed by the government, agency policy and politics will ensure further tension for the forensic scientist. As discussed in [Thornton \(1983, pp. 86–88\)](#):

Basic conflicts that influence the practice of forensic science become apparent at the interface of law and science. Law and science on occasion have conflicting goals, each having developed in response to different social attitudes and intellectual needs. The goal of law is the just resolution of human conflict, while the goal of science traditionally has been cast, although perhaps too smugly, as the search for “truth.” Certainly there is nothing intrinsically dichotomous in the pursuit of these goals; the court or jury strive in good faith to determine the truth in a given situation as a way to resolve conflicts. But proof is viewed somewhat differently by law and science, as is the application of logic and the perception of societal values.

Numerous writers have commented on these differences, including Glanville Williams in his *Proof of Guilt* (1958):

The principles of [the legal system] are not the product of scientific observation, but embody a system of values. These values do not necessarily have to be changed with the march of knowledge of the material world. . . . The rule conferring upon an accused the right not to be questioned . . . may be a good or a bad rule, [but it] has certainly not been made better or worse by the invention of printing or the aeroplane.

How, then, do these differences between law and science lead to abuse of forensic science? They do simply because all the players want to win and are likely to use any ethical means at their disposal to do so. The attorneys in a case are aligned with only one side, and it is entirely appropriate under the adversary system for them to advocate a particular point of view, even without full and fair disclosure of all relevant facts. Subject only to the rules of evidence, the rules of procedure, and the Code of Professional Responsibility, attorneys are free to manipulate scientific evidence to maximize the opportunity for their side to prevail. Not only is behavior of this sort countenanced by the law, it is the ethical responsibility of counsel to attempt to do so.

In some government agencies, “the culture of group loyalty and protection is powerful” and attitudes develop where “loyalty to [coworkers]—even corrupt ones—exceeds loyalty to the [agency] and to the law” ([Mollen, 1994, p. 5](#)). As these conflicting rules, values, and circumstances compound, strain draws and weakens even the most honorable practitioners.

When roles and expectations are in direct and irrefutable conflict, forensic scientists must decide which duty is primary and which set of rules they are going to follow. Theoretically, science should win out: objectivity and skepticism are what give them value to the criminal justice system. In reality, however, acting objectively and skeptically comes at a cost. It can end friendships, it can earn one the derision of colleagues or supervisors, it can hamper promotions and pay raises, it can bring unwanted attention to individual errors and failings, and it can even get one fired. Role strain blurs matters further and weakens the resolve to conduct oneself impartially.

Concern for this kind of agenda-oriented bias is echoed by retired Army CID Investigator [Ross M. Gardner \(2005\)](#), who admits that impartiality within this community remains a problem:

We (police supervisors of which I used to count myself as) have done a poor job of teaching impartiality across the board. There are still many police officers and criminal investigators who think they work for the DA or who think their job is to put people in jail. Our job has been and always will be investigating and reporting crime and then bringing the people we think are involved to justice. Juries and judges (our communities) decide if they really are “bad guys” and what to do with them, a.k.a. justice.

District attorneys (DAs), Mr. Gardner reminds us, have their own agenda. They want to convince the jury of the guilt of the defendant, a belief that may be based on evidence, emotion, politics, or any combination thereof. However, the interpretation of the evidence does not always favor the prosecution. District attorneys, in preparation for prosecuting a case, put together a theory of the crime. The less reconstruction done by forensic scientists, the more this role falls to the DA. Without the proper tools, this can have disastrous results, especially when the defense lacks the ability and/or resources to independently investigate and understand the evidence.

Zealous Advocates

Attorneys are zealous advocates—that is their nature and function. The prosecutor zealously seeks to convict the defendant by making the crime more heinous in nature. The defense zealously seeks to exonerate the defendant by minimizing the prosecution’s arguments and evidence. Both will theorize about how the crime occurred with different objectives. Both cannot be correct and, lacking a scientific reconstruction, both will probably be wrong. The case theories of attorneys are alternatives and should be examined against the evidence.

No court or attorney should direct or dictate the forensic scientists’ methods. They may have particular questions about the evidence, or particular issues that they believe require attention, and that is typically the nature of their need for assistance. However, the application of scientific methodology and the interpretation of any conclusions must remain the strict domain of the forensic scientist.

Misunderstandings and miscommunications often occur when attorneys seek the services of forensic scientists because attorneys work in a professional domain that is essentially binary in nature. Evidence either supports or fails to support a legal finding of guilt or innocence, and through their efforts attorneys either win or lose the case. The findings of the forensic scientist are not binary—they are multivalued and independent of legal determinations. Very seldom is anything in science black or white. Rather, it is often some shade of gray along an almost infinite continuum. Those practicing in the legal professions need to recognize that forensic scientists are professionals in their own fields, as attorneys are in theirs. Respect must be had for the differences in their desired ends.

There is another component adding tension to the strained relationship between forensic science and the law. In any criminal legal proceeding, the prosecution often has its own stable of police officers and police scientists working directly or indirectly under its administration. This circumstance can create the false impression that only forensic scientists working for the prosecution are on the right or just side of the conflict, protecting society and speaking for the victim. This is an impression that many prosecutors are happy to encourage and that many forensic scientists are infrequently quick to correct. The defense expert is often regarded

as the one “wearing the black hat” or on “the Dark Side” in the words of prosecutors, police officers, and public-employed forensic scientists. This can help create the false impression that the forensic scientists working for the defense are on the wrong or unjust side of a conflict, out to protect the defendant. This is also a false impression that many prosecutors are pleased to encourage.

As already explained, for the forensic scientist there are no sides to a case. There is only what the evidence supports or fails to support. The problem is that the nature of the adversarial process can pressure even well-intentioned forensic scientists to forget this, enabling them to become advocates bent on getting the bad guy. The phrase that has been used to describe this occurrence is “cops in lab coats”—those in police laboratories who try to make their results match their agency’s case against the accused. According to Dr. Elizabeth Johnson, a private forensic DNA analyst, formerly DNA section chief for the Harris County, Texas, medical examiner’s office (“DNA Testing,” 2003),

[It is] a problem that’s found in many cities when crime labs are located in police departments and analysts can feel pressured to be “cops in lab coats”—trying to make the science match the police department’s case.

“Too much of the time the police or the detectives come in and they submit evidence and they stand around and visit for a while and start telling chemists their version of what happened in the crime,” says Johnson. “That’s a dangerous situation.”

David McBride, the former chief of police in Oklahoma City, Oklahoma, who oversaw the recently embattled police crime lab there before scandal broke out, has admitted publicly that this kind of bias is far too common, and (“Under the Microscope,” 2002)

could happen anywhere that a forensics lab is attached to a police agency, and that is the case in most large American cities.

He says it creates scientists who consider themselves cops in lab coats. “I think there’s an inherent potential conflict there,” he says. “And I don’t know that that’s always healthy for the criminal justice system.”

This problem is also described in James and Nordby (2003, p. 4):

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 police or prosecutor.

This particular form of bias creates a confirmatory environment in which forensic scientists are rewarded, often directly, through promotions, bonuses, or letters of appreciation, for their certainty and for their assistance with successful prosecutions (Saks, 1998):

No other fields are as closely affiliated with a single side of litigation as forensic science is to criminal prosecution. . . . The institutional setting of forensic science promotes habits of thought that more closely resemble the thinking of litigators than of scientists. While science pursues knowledge through disconfirmation, prosecutions are won by confirmatory proofs. This confirmatory bias dominates the thinking of most forensic scientists. Where science advances by open discussion and debate, forensic science has been infected by the litigator’s preference for secrecy. Tests of the proficiency of crime laboratories are conducted anonymously, kept secret, and are

not routinely published. It is ironic that while studies of the effectiveness and accuracy of so many professional enterprises are available in published literature, the same is not true of a field whose sole purpose is to do some of the public's most public business.

Some regard confirmatory, pro-prosecution bias a problem that begins with inexperience and continues for lack of exposure to actual science, as in [Moenssens \(1993\)](#):

This special issue [pro-prosecution bias] demonstrates that even where crime laboratories do employ qualified scientists, these individuals may be so imbued with a pro-police bias that they are willing to circumvent true scientific investigation methods for the sake of "making their point."

Unfortunately, this attitude is even more prevalent among some "technicians" (nonscientists) in the crime laboratories, for whom the presumption of innocence disappears as soon as police investigative methods focus on a likely suspect. These individuals, who are frequently trained to do forensic work on the job after obtaining an undergraduate degree in chemistry or biology, are bestowed with the job title of "forensic scientist" after only a short time in their crime laboratory function. Their pro-police bias is inconsistent with being a scientist. In fact, the less of a scientific background a lab person has, the less critical that person is likely to be in terms of investigating the validity of claims made by other laboratory personnel. These are the "experts" who typically jump on the bandwagon of anything new that comes down the pike, and will staunchly advocate its reliability, even in the absence of any objective investigation and validated experimentation.

Again, many of these individuals do good work in the field in which they have been trained, but their bias is often so strongly pro-prosecution that they may lack the kind of objectivity and dispassionate judgment that one expects of a true scientist, be it forensic or otherwise.

Such attitudes, and a bias, are perpetuated by a slew of popular television shows and documentaries in which forensic scientists are portrayed as part of the law enforcement team, and sometimes the whole affair, wielding science like a badge to push suspects into confessions and even make arrests. This powerful imagery, given an air of authenticity by consulting law enforcement officers and police scientists whose names roll in the credits, contradicts everything that good forensic science is about.

Even when the forensic scientist does maintain an aura of impartiality, the system may cause them to contribute a biased result. Unless the forensic scientist has gone to the crime scene and knows what evidence has been collected, or may have been present but uncollected, he or she will be limited to receive and analyze only that which is given to him or her. The evidence they are provided is selected by the investigator in support of a particular theory or by the prosecutor in support of a conviction. The forensic scientist is given the evidence with a specific request for analysis.

They should ask, "What is the purpose of this analysis?" or "What is the question you are trying to answer with this test?" Only then can they, and not the nonscientist, ascribe meaning to the evidence. As long as the forensic scientist receives only selected evidence and selected information about a case, the analyses and conclusions of that scientist are biased to that extent.

On the other side of the spectrum, there are private forensic experts who will testify to any position for the right amount of money or prestige, rightly labeled by some as "hired guns" or "whores of the court." Such individuals will offer whatever conclusion or interpretation helps their employer, regardless of whether it contradicts something they have testified to before. This practice also contradicts good science because a true forensic scientist will prefer to give his or her client "bad" news before anyone else does—to realistically educate the client regarding the nature and the strengths of the opposition's evidence.

Taking the Side of the Evidence

The paradigm of sides within the forensic science community has and continues to strain and rend its members because of their need to secure or maintain employment, relationships, friendships, and fidelities with those outside, but in control of, the forensic realm. In other words, bias toward one side of the courtroom or the other is often about politics—the politics of a too often subordinated group, forensic scientists, in relation to their vested interest colleagues and employers to whom they are commonly beholden.

While the justice system necessarily sets two legal sides against each other, objective scientists do not take up the banner of either. In fact, their only value to the legal process is with respect to their objectivity. These scientists are there to advocate for evidence and its dispassionate interpretation—nothing more.

Forensic scientists can have no emotional, professional, or financial stake in the outcome. In other words, they cannot be paid to guarantee findings or testimony favorable to their employer, nor can their advancement be connected to the success of one party over another. This is, of course, separate from being compensated for time spent performing analysis and giving testimony.

The division of investigative, legal, and scientific spheres exists to allow forensic practitioners to act as an objective foil to those who hire them—whether they are attorneys or law enforcement investigators. As discussed previously, investigators and lawyers have different goals and ethical considerations than do scientists. Each is admonished to (1) act within the scope afforded his or her role and (2) not intrude upon that of the others.

When scientists step outside their objective role to withhold or distort relevant findings and, in essence, take sides, justice is perverted. Science exercised on behalf of the law is forensic science; science exercised on behalf of politics, personal or professional, is not science at all—it is a form of propaganda. Rising above this through soundness of reason and methodology is a tremendous challenge and an awesome responsibility.

SUMMARY

Forensic science is the application of scientific knowledge and principles to the resolution of legal disputes, whether criminal or civil. A **forensic scientist** is one who examines and determines the meaning of physical evidence in accordance with the established theories and principles of forensic science, with the expectation of presenting his or her findings in court. The unique role of the forensic scientist is ultimately that of an educator to attorneys, judges, and juries.

A **scientist** is someone who possesses an academic and clinical understanding of the scientific method. The **scientific method** is a way to investigate how or why something works, or how something happened, through the development of hypotheses and subsequent attempts at falsification through testing and other accepted means. Crime reconstruction is a forensic discipline based on the forensic sciences, the scientific method, analytical logic, and critical thinking. But this chapter discusses whether reconstruction is a science in its own right.

Crime reconstruction is the determination of the actions and events surrounding the commission of a crime. Crime reconstruction is reality based, there is an orderly body of knowledge that exists in the literature, there are generally accepted theories and practice standards, and

reconstruction conclusions reached through the scientific method are susceptible to verification through independent peer review and testing. Where the discipline falls short is in the realm of empirically established scientific principles that are clearly enunciated, but this hardly distinguishes it from the majority of the forensic sciences.

There is much good forensic science theory in crime reconstruction and, as described in this text, it is often based on sound scientific methodology. There is simply not enough published research to establish a clear body of scientific principles. This will take more time, more data, and more research. Consequently, courts rightly perceive the discipline of crime reconstruction as an area of specialized knowledge built on scientific knowledge.

QUESTIONS

1. List the four major branches of the criminal and civil justice systems in the United States.
2. List three different kinds of forensic scientists.
3. Explain the difference between a *forensic generalist* and a *forensic specialist*.
4. The vast majority of forensic sciences have principles and practice standards for interpretation that are clearly enunciated. True or false?
5. Explain the difference between a *forensic scientist* and a *forensic technician*.

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A History of Crime Reconstruction

W. Jerry Chisum and Brent E. Turvey

The palest ink is better than the best memory. —*Chinese Proverb*

The present reaps what the past has sown, and the future is the product of the present. —*Buddha*

Key Terms

Bertillonage; Crime reconstruction; Locard's exchange principle

There are few disciplines whose labors are as culturally resonant as those of the historian. Without the historian, we would lose track of everything we have been, errors and achievements alike, and become entrenched hopelessly in an immediate, immature culture that lacks sufficient foundation to learn or grow. That is to say, without the historian we risk losing our history and we compromise the value of our future. We are forever condemned to making the same errors we have made in the past. The historian allows us to learn from our experience and build upon it.

History, the chronicling and study of past events, is a quiet but feared discipline. History reminds us where our knowledge and wisdom came from when we lose sight of those who cut the path. History teaches us what has been lost to fire and fancy, despite conquering or dominant ideologies that would leave us ignorant of all that came before. History collects, history records, and history remembers. And it patiently waits for unsatisfied minds to discover it.

From this it may be rightly inferred that the purpose of studying history is not to learn dry facts for later academic recitation in order to appear intellectual. The study of history is about going back to see what has come before in order to honestly gauge where we are right now and, it is hoped, why. The study of history is about digging beneath and beyond cultural and institutional indoctrination because what you know and what you've been told are not always so.

The study of history is for critical thinkers—those who will not blindly and politely accept what they have been handed by someone claiming to be an authority. It is for those who would rather come to understand things and their relationships for themselves. It is for those who understand the value of hunting down information and sourcing it out, and who would prefer

not to be led by the hand into intellectual servitude. It is a bold and dangerous journey that can educate, inspire, and inflame a lifetime of study.

Crime reconstruction is the determination of the actions and events surrounding the commission of a crime. A reconstruction may be accomplished by using the statements of witnesses, the confession of a suspect, or the statement of a living victim or by examining and interpreting the physical evidence. Some refer to this process as crime scene reconstruction; however, the scene is not actually being put back together as it was; only some of the actions and sequences of events are being established. When working at the evidentiary level, this is in no small part because of the natural limits to what forensic science is capable of. Consequently, the term *crime scene reconstruction* is at best an inaccurate description of what forensic science is actually able to contribute to the cause of justice.

Some go further and confuse crime reconstruction with the specific task of crime scene processing and the overall field of crime scene investigation. As we have discussed, and will explain further in other chapters, these are not the same thing. Suffice it to say that reconstruction is performed by forensic scientists and is based on the evidence processing that is done at the scene, the results of the scene investigation, and the subsequent analysis of physical evidence.

Ardent scholars will attest that there can be no one definitive history of any subject, and crime reconstruction is not an exception. Crime reconstruction has many components, many practitioners, and many students. Every reconstruction specialty has a history of practitioners; every practitioner has a history of students; every student has a history to discover and study.

The purpose of this chapter is to examine a history of crime reconstruction from the point of view of the forensic generalist, as described in the Preface. The generalist understands that crime reconstruction is the result of objectively examining a whole related system of evidence rather than a narrow, specialized portion. Not just the evidence as it was found in the scene but also the results of all subsequent forensic examinations. Not just the technical process of collecting of bits and pieces with tape and spray but also the methodical, scientific examination of evidentiary relationships, their origins, and their ultimate meaning within the case. The generalist considers the totality of the known evidence and only then frames theories regarding the actions and circumstances of a crime, steered by good science and the scientific method and with no investment in the outcome. The generalist then tests those theories and the theories of others against the evidence, using a framework of analytical logic and critical thinking in order to determine the facts.

From this perspective, there are certain individuals whose work, theories, and publications are of considerable and particular value to understanding the history of crime reconstruction, not to mention their enormous contribution to the other professions inhabiting the various forensic disciplines. Deliberate students are strongly encouraged to make use of the references at the end of this chapter and explore more of the details of this limited history for themselves.

DR. JOSEPH E. BELL (1837–1911)

From close observation and deduction, gentlemen, you can make a correct diagnosis of any and every case. However, never neglect to ratify your deductions, to substantiate your diagnosis with the stethoscope, and by other recognized and every-day methods of diagnosis. –*Dr. Joseph Bell (as quoted in Freeman, 2004)*



FIGURE 2.1 Dr. Joseph E. Bell.

Dr. Joseph Emory Bell (Figure 2.1) was a surgeon at the Royal Infirmary and a professor at the University of Edinburgh Medical School during the 19th century. He reportedly had a great facility for both observation and inference with regard to assessing patients in his keep. As the previous quote indicates, he also believed in testing theories and what can only be described as the scientific method where final conclusions were concerned. The discipline of careful observation and inference is one that he religiously impressed upon his students.

The following account of Dr. Bell is set forth in an essay by Dr. Harold Emery Jones (1904):

All Edinburgh medical students remember Joseph Bell—Joe Bell—as they called him. Always alert, always up and doing, nothing ever escaped that keen eye of his. He read both patients and students like so many open books. His diagnosis was almost never at fault.

“This, gentlemen” announced [Professor Bell], “contains a very potent drug. To the taste it is intensely bitter. It is most offensive to the sense of smell. But I want you to test it by smell and taste; and, as I don’t ask anything of my students which I wouldn’t be willing to do myself, I will taste it before passing it round.”

Here he dipped his finger in the liquid, and placed it in his mouth. The tumbler was passed round. With wry and sour faces the students followed the Professor’s lead. One after another tasted the liquid; varied and amusing were the grimaces made. The tumbler, having gone the round, was returned to the Professor.

“Gentlemen,” said he, with a laugh, “I am deeply grieved to find that not one of you has developed this power of perception, which I so often speak about; for if you watched me closely, you would have found that, while I placed my forefinger in the medicine, it was the middle finger which found its way into my mouth.”

Dr. Bell was an accomplished lecturer, served as the personal surgeon to the queen when she visited Scotland, and published several medical textbooks in his lifetime. However, he is perhaps best remembered for the association he enjoyed with one of his students, Sir Arthur Conan Doyle, author and creator of the fictional character Sherlock Holmes. Dr. Bell, who wrote the foreword for at least one of the Sherlock Holmes adventures, is widely regarded as the primary inspiration for that fictional character and his uncanny deductive abilities.

Arthur Conan Doyle first met then 39-year-old Dr. Joseph Bell in his capacity as a lecturer in 1877. It was Doyle’s first year of medical school. By the end of Doyle’s second year, Dr. Bell

selected him to serve as a clerk on his ward at the Royal Infirmary in Edinburgh. Reflecting later on the inspiration for Holmes, his scientifically inclined protagonist, [Doyle \(1989\)](#) wrote:

I thought of my teacher Joe Bell, of his eagle face, of his curious ways, of his eerie trick of spotting details. If he were a detective he would surely reduce the fascinating unorganized business [of detective work] to something nearer an exact science. I would try [to see] if I could get this effect. It was surely possible in real life, so why should I not make it plausible in fiction? It is all very well to say that a man is clever, but the reader wants to see examples of this—such examples as Bell gave us every day in the wards. The idea amused me.

Of the Sherlock Holmes stories, and of Arthur Conan Doyle in specific, Dr. Bell wrote with some pride:

Dr. Conan Doyle has made a well-deserved success for his detective stories, and made the name of his hero beloved by the boys of this country by the marvelous cleverness of his method. He shows how easy it is, if only you can observe, to find out a great deal as to the works and ways of your innocent and unconscious friends, and, by an extension of the same method, to baffle the criminal and lay bare the manner of his crime. There is nothing new under the sun.

Dr. Bell's method of medical diagnosis was in essence a reconstruction of ailment by careful observation of behavior and symptoms, an encyclopedic knowledge of disease, and a tireless study of the habits of men. The chief lesson to his students was attention to all details at all times, and scrupulous ratification of theories through a firsthand investigation of fact. This, among other things, inspired Conan Doyle to develop what may be referred to as the Holmesian method of crime reconstruction.

At this point it is perhaps necessary to concede that some may regard the inclusion of a fiction writer and his mentor in any history of crime reconstruction as an error in judgment, but this is not the case. The situation is not comparable to modern-day authors, where pulp novels and nonfiction true crime are spun out to horrify readers and glorify crimes and criminality. These were professionals, educated in all that medicine and science had to offer in their day. Each Sherlock Holmes story was a carefully crafted lesson in the application of science and deductive reasoning, with cases solved by investigative ability and attention to detail. The error would be failing to admit their direct and inspirational roles in forensic history, as we will explore further.

SIR ARTHUR CONAN DOYLE (1859–1930)

Crime is common. Logic is rare. —*Sherlock Holmes* in *The Adventure of the Copper Beeches*

Arthur Conan Doyle ([Figure 2.2](#)) was born in Edinburgh on May 22, 1859. He received a Jesuit education and then went on to study medicine at the University of Edinburgh Medical School under Dr. Joseph Bell in 1877. Throughout his education, he enjoyed good stories and reading, and he was inspired by authors such as Edgar Allan Poe and Bret Harte. During his second year at medical school, while working as an assistant for Dr. Bell, he was able to pen no fewer than two short stories of his own for publication—*The Mystery of Sasassa Valley* and *The American Tale*.

While in his third year at medical school, Doyle was offered the post of ship's surgeon on the *Hope*, a whaling boat on its way to the Arctic Circle. He took the position and followed the crew to Greenland, where they hunted for seals. A young man in his early twenties, he was disgusted



FIGURE 2.2 Dr. Arthur Conan Doyle as a young man.

by the brutality of it. However, he was fascinated and thrilled by the whale hunt that followed, to the point of later writing a story integrating his experiences called the *Captain of the Pole-Star*.

In 1880, he returned to medical school and completed his studies a year later, receiving a bachelor of medicine and master of surgery degree. After a difficult beginning marked by near bankruptcy, Dr. Arthur Conan Doyle's hard work eventually paid off and his private practice began to earn him a comfortable living.

In 1886, Conan Doyle split his time between his medical practice and his writing of the first story that was to launch the fictional career of Sherlock Holmes, *A Study in Scarlet*, published in 1887 (Figure 2.3). It has been widely theorized that the name "Sherlock Holmes" was chosen based on the American jurist and fellow doctor of medicine, Oliver Wendell Holmes, and Alfred Sherlock, a prominent violinist.

In *A Study in Scarlet*, through the character of Dr. John Watson, Conan Doyle outlined the evidence-based method of inference and deduction that would become the defining element of Sherlock Holmes' fictional reconstruction casework (Doyle, 1887):

Like all other arts, the Science of Deduction and Analysis is one which can only be acquired by long and patient study, nor is life long enough to allow any mortal to attain the highest possible perfection in it. Before turning to those moral and mental aspects of the matter which present the greatest difficulties, let the inquirer begin by mastering more elementary problems. Let him, on meeting a fellow-mortal, learn at a glance to distinguish the history of the man, and the trade or profession to which he belongs. Puerile as such an exercise may seem, it sharpens the faculties of observation, and teaches one where to look and what to look for. By a man's finger-nails, by his coat-sleeve, by his boots, by his trouser-knees, by the callosities of his forefinger and thumb, by his expression, by his shirt-cuffs—by each of these things a man's calling is plainly revealed. That all united should fail to enlighten the competent inquirer in any case is almost inconceivable.

Of this first effort by Conan Doyle, the British author David Stuart Davies (2004) wrote regarding the nature of the evidence-based inferences within:

Doyle establishes Holmes' mystifying detective brilliance in the early pages. . . . Sherlock Holmes is more than just an armchair observer. He actively pursues clues in a dynamic manner which characterizes all his subsequent

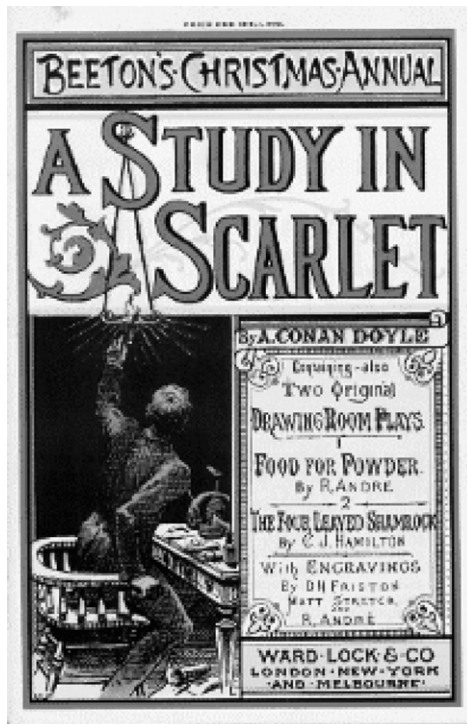


FIGURE 2.3 *A Study in Scarlet*, published in November 1887 as the main part of *Beeton's Christmas Annual*.

investigations. In addition to engaging in analytical reasoning, he studies the wheel marks of a hansom cab, examines elaborate patterns of footprints, identifies cigar ash, flings himself to the ground in search of clues, and in the end engages in a step by step summary of his methods—a staged finale that became an indispensable element of the mystery story format. In this novel, amongst his other habits and traits, we learn of Holmes' violin playing—"Low melancholy wailings"—his chemical experiments and his love of strong tobacco.

Conan Doyle's protagonist also held fast to the principle of eliminating unnecessary bias and reducing preconceived theories in reconstructions. Through Holmes, he chastised those impatient for results in the absence of evidence (Doyle, 1887):

My companion was in the best of spirits, and prattled away about Cremona fiddles and the difference between a Stradivarius and an Amati. As for myself, I was silent, for the dull weather and the melancholy business upon which we were engaged depressed my spirits.

"You don't seem to give much thought to the matter in hand," I said at last, interrupting Holmes's musical disquisition.

"No data yet," he answered. "It is a capital mistake to theorize before you have all the evidence. It biases the judgment."

The second Sherlock Holmes story, *The Sign of the Four*, was written for *Lippincott's Magazine*, and other subsequent stories were written for *The Strand Magazine*. In carefully woven plots, Conan Doyle continually referenced observation, logic, and dispassion as invaluable to the

detection of scientific facts, the reconstruction of crime, and the establishment of legal truth. In *The Sign of the Four*, Sherlock Holmes gave further voice to Conan Doyle's understanding and appreciation of scientific objectivity (Doyle, 1890):

Detection is, or ought to be, an exact science and should be treated in the same cold and unemotional manner. You have attempted to tinge it with romanticism, which produces much the same effect as if you worked a love-story or an elopement into the fifth proposition of Euclid.

Conan Doyle specifically referred to the concept of “reconstructing the events,” or the crime, in more than a few of his stories. In these stories, there was a heavy emphasis on establishing or refuting suspect statements with physical evidence. For example, in *The Crooked Man*, a conversation takes place between Holmes and Watson that describes a Socratic style of theory elimination through observation, scientific examination, and discussion (Doyle, 1893):

Holmes pulled a large sheet of tissue-paper out of his pocket and carefully unfolded it upon his knee.

“What do you make of that?” he asked.

The paper was covered with the tracings of the footmarks of some small animal. It had five well-marked footpads, an indication of long nails, and the whole print might be nearly as large as a dessert-spoon.

“It's a dog,” said I.

“Did you ever hear of a dog running up a curtain? I found distinct traces that this creature had done so.”

“A monkey, then?”

“But it is not the print of a monkey.”

“What can it be, then?”

“Neither dog nor cat nor monkey nor any creature that we are familiar with. I have tried to reconstruct it from the measurements. Here are four prints where the beast has been standing motionless. You see that it is no less than fifteen inches from fore-foot to hind. Add to that the length of neck and head, and you get a creature not much less than two feet long—probably more if there is any tail. But now observe this other measurement. The animal has been moving, and we have the length of its stride. In each case it is only about three inches. You have an indication, you see, of a long body with very short legs attached to it. It has not been considerate enough to leave any of its hair behind it. But its general shape must be what I have indicated, and it can run up a curtain, and it is carnivorous.”

Later, in *The Abbey Grange*, Holmes reconstructs a crime for Watson based on the careful observation of tool marks and bloodstain patterns (Doyle, 1904):

“Man, Watson, man. Only one, but a very formidable person. Strong as a lion—witness the blow that bent that poker! Six foot three in height, active as a squirrel, dexterous with his fingers, finally, remarkably quick-witted, for this whole ingenious story is of his concoction. Yes, Watson, we have come upon the handiwork of a very remarkable individual. And yet, in that bell-rope, he has given us a clue which should not have left us a doubt.”

“Where was the clue?”

“Well, if you were to pull down a bell-rope, Watson, where would you expect it to break? Surely at the spot where it is attached to the wire. Why should it break three inches from the top, as this one has done?”

“Because it is frayed there?”

“Exactly. This end, which we can examine, is frayed. He was cunning enough to do that with his knife. But the other end is not frayed. You could not observe that from here, but if you were on the mantelpiece you would see that it is cut clean off without any mark of fraying whatever. You can reconstruct what occurred. The man needed the rope. He would not tear it down for fear of giving the alarm by ringing the bell. What did he do? He sprang up on the mantelpiece, could not quite reach it, put his knee on the bracket—you will see the impression in the dust—and so got his knife to bear upon the cord. I could not reach the place by at least three inches—from which I infer that he is at least three inches a bigger man than I. Look at that mark upon the seat of the oaken chair! What is it?”

“Blood.”

“Undoubtedly it is blood. This alone puts the lady’s story out of court. If she were seated on the chair when the crime was done, how comes that mark? No, no, she was placed in the chair after the death of her husband. I’ll wager that the black dress shows a corresponding mark to this. We have not yet met our Waterloo, Watson, but this is our Marengo, for it begins in defeat and ends in victory. I should like now to have a few words with the nurse, Theresa. We must be wary for a while, if we are to get the information which we want.”

Dr. Joseph Bell would go on to write of the Sherlock Holmes character, and of the importance of acumen facilitated by science:

Mere acuteness of the senses is not enough. Your Indian tracker will tell you that the footprint on the leaves was not a redskin’s, but a paleface’s, because it marked a shoe-print, but it needs an expert in shoe-leather to tell where that shoe was made. A sharp-eyed detective may notice the thumb-mark of a grimy or bloody hand on the velvet or the mirror, but it needs all the scientific knowledge of a Galton to tender the ridges and furrows of the stain visible and permanent, and then to identify by their sign-manual the suspected thief or murderer. Sherlock Holmes has acute senses, and the special education and information that make these valuable; and he can afford to let us into the secrets of his method.

Seventy years after the creation of the Holmes character, Jurgen Thorwald would reflect on Conan Doyle’s hero as the prototypical generalist (Thorwald, 1966, p. 234):

Sherlock Holmes was the harbinger of a kind of criminological investigation which did not fit into any of these special [forensic] disciplines, and which ultimately far surpassed them in range. What Holmes did was to avail himself of all the chemical, biological, physical, and technological methods which were springing up at the turn of the century.

Not unlike the intense proliferation of popular forensic science-oriented television programs today, the public became enamored with the stories and the character and could not get enough of either. The intense international success of the Sherlock Holmes series eventually became a great burden for Conan Doyle. Ironically, he felt the stories were too commercial, and he wished to be remembered for more serious works. With great hope for closing this chapter of his life and moving on to other challenges, Conan Doyle killed off the Sherlock Holmes character in *The Final Problem*, which was published in late 1893. As a consequence, it has been reported that approximately 20,000 readers cancelled their subscriptions to *The Strand*.

Several years later, during the Boer War, Conan Doyle volunteered and served as a doctor at a field hospital in Bloemfontein, South Africa. There he learned of death from war and disease firsthand. Subsequently, he wrote *The Great Boer War*, a 500-page chronicle published in October 1900. It was a report of the state of the war and also a commentary on the organizational shortcomings of the British forces.

After the war, Conan Doyle took stock and wrote a new Sherlock Holmes story, a prequel called *The Hound of the Baskervilles*. It was published in August 1901 and was an instant international success. In 1902, King Edward VII knighted Conan Doyle ostensibly for services rendered to the Crown during the Boer War. However, it has long been rumored that the king, an avid fan of Sherlock Holmes, bestowed the honor on Conan Doyle as a reward for stories told and with the hope of more stories to come.

Sir Arthur Conan Doyle (Figure 2.4) did not disappoint his fans. In 1903, he brought Sherlock Holmes back to life in a new series of stories beginning with *The Return of Sherlock Holmes*.



FIGURE 2.4 Sir Arthur Conan Doyle.

Sir Arthur Conan Doyle's work with fictional crime fighting did not just entertain and inspire others, although that would have been enough to heavily influence the forensic sciences, specifically crime reconstruction, forever; it also had practical applications in his own work outside of writing and medicine. Conan Doyle, it is often forgotten, was a chief architect of the concept of postconviction case review in the early 20th century and a firm believer in overturning miscarriages of justice.

This included the case of George Edalji, an Indian who had been wrongly convicted of mutilating and killing sheep, cows, and horses. In 1903, someone was inflicting long, shallow cuts to these animals in the Great Wyrley area of the United Kingdom, under cover of night, causing them to bleed to death. Anonymous letters were written to the police, taunting them and identifying the offender as George Edalji, a local Indian solicitor. Edalji was arrested and a trial was held. He was found guilty and was sentenced to 7 years in prison. However, there was a public outcry that an injustice had been done and that Edalji had been framed for reasons of race. Ten thousand people signed a petition protesting the conviction, demanding his release from prison. As a result, he served only 3 years, but the conviction stood.

In 1906, Sir Arthur Conan Doyle learned of the Edalji case, became deeply concerned about the circumstances of the conviction, and set about to examine the facts for himself. The forensic evidence and the context of the crimes all pointed away from Edalji's involvement, and Sir Arthur Conan Doyle became determined to educate the public. The British government took notice in more ways than one ("[The George Edalji Case](#)," 2005):

As he reviewed the facts it seemed to Conan Doyle that the evidence was overwhelming. Edalji was innocent. The bloody razors found in the Edalji home were later discovered to be merely rusty razors. The handwriting expert who testified that Edalji's handwriting matched the writing on the taunting letters was discovered to have made a serious mistake on another case causing an innocent man to be convicted. The mud on George's boots was of a different soil type than that of the field where the last mutilation took place. The killings and letters continued after Edalji was prosecuted.

And then there was the final piece of evidence that Conan Doyle gathered. The evidence that he saw in an instant the first time he set eyes on George Edalji. Conan Doyle stated, "He had come to my hotel by appointment, but I had

been delayed, and he was passing the time by reading the paper. I recognized my man by his dark face, so I stood and observed him. He held the paper close to his eyes and rather sideways, proving not only a high degree of myopia, but marked astigmatism. The idea of such a man scouring fields at night and assaulting cattle while avoiding the watching police was ludicrous. . . . There, in a single physical defect, lay the moral certainty of his innocence.”

Conan Doyle wrote a series of articles for the *Daily Telegraph* about the Edalji case. He outlined everything in great detail. These articles caught the public’s attention and that caught the attention of the British government. At that time there was no procedure for a retrial so a there was a private committee meeting to consider the matter. In the spring of 1907 the committee decided that Edalji was innocent of the mutilations, but still found him guilty of writing the anonymous letters.

Conan Doyle found anything less than a finding of innocent on all charges a miscarriage of justice, however the decision made a huge difference for Edalji. The Law Society readmitted him. Edalji was once again able to practice as a solicitor.

It is important to note that partially as a result of this case the Court of Criminal Appeal was established in 1907. So not only did Conan Doyle help George Edalji, his work helped to establish a way to correct other miscarriages of justice.

It should be remembered that when he discovered the likely culprit in the crimes (a school student and butcher’s apprentice) and made it known, Conan Doyle began to receive anonymous threatening letters.

Also, the panel that was eventually appointed to investigate Conan Doyle’s new evidence in the Edalji case was made up of three commissioners, one of whom was a cousin to the original lead investigator. Conan Doyle was disgusted by their slander of Edalji and their collusion to protect each other’s reputations even while being forced to pardon him for crimes he clearly had not committed. Conan Doyle’s involvement with the Edalji case left him more than a little jaded, to say the least.

In 1909, a German named Oscar Slater was tried and convicted in Edinburgh for murdering an elderly woman named Marion Gilchrist with a hammer the year before. Miss Gilchrist had been bludgeoned to death, her personal papers had been rifled through, and a diamond brooch had been stolen. That case came to Conan Doyle’s attention as well, and once again he was compelled to investigate. What he learned did not require much deduction, only observation and the force of indefatigable publicity (“[The Oscar Slater Case](#),” 2005):

While it was true that Slater did possess a small hammer it wasn’t large enough to inflict the type of wounds that Miss Gilchrist had sustained. Conan Doyle stated that a medical examiner at the crime scene declared that a large chair, dripping with blood, seemed to be the murder weapon.

Conan Doyle also concluded that Miss Gilchrist had opened the door to her murderer herself. He surmised that she knew the murderer. Despite the fact that Miss Gilchrist and Oscar Slater lived near one another, they had never met.

The Case of Oscar Slater caused some demand for a new trial. However the authorities said the evidence didn’t justify that the case be reopened. In 1914 there were more calls for a retrial. New evidence had come to light. Another witness was found that could verify Slater’s whereabouts during the time of the crime. Also, it was learned that before Helen Lambie [Gilchrist’s only servant] named Slater as the man she’d seen in the hallway the day of the murder she had given the police another name. Unbelievably, the officials decided to let the matter rest.

Conan Doyle was outraged. “How the verdict could be that there was no fresh cause for reversing the conviction is incomprehensible. The whole case will, in my opinion, remain immortal in the classics of crime as the supreme example of official incompetence and obstinacy.”

The matter probably would have ended there in 1914, but in 1925 a message from Oscar Slater was smuggled out of Peterhead Prison, addressed directly to Conan Doyle. In it, he begged

Conan Doyle not to forget his case and also to make one last effort to free him. Reinvigorated, Conan Doyle began lobbying once more, writing everyone he knew in the media and government.

As a result of renewed interest, an investigative journalist in Glasgow named William Park published a book about the case that brought public interest in the Slater case to a fever pitch. The story was in every newspaper. Helen Lambie was subsequently sought out and found living in the United States; she then confessed during an interview that she had actually known the real murderer, just as Conan Doyle had suggested years before. She further confessed that the police had talked her out of this initial identification and persuaded her she was mistaken. In short, she confessed to falsely accusing Oscar Slater of a crime she knew he did not commit to protect someone of her acquaintance who she refused to name.

Mary Barrowman, a 14-year-old girl at the time of the murder who claimed she bumped into a man under a lamppost running from Gilchrist's apartment on the day of the murder, also came forward. She confessed that she had, under some pressure by police, tailored her eyewitness identification to match the accused.

In 1927, having been contacted by Conan Doyle, the secretary of state for Scotland ordered the release of Oscar Slater. Eventually, an appeal was granted. However, officials still refused to admit to any wrongdoing and would not suggest corruption or blame other officials for any breakdowns or wrongdoing. Slater's conviction was ultimately overturned on a technicality, allowing the authorities to save face. According to [Gildart and Howell \(2004, p. 3\)](#),

Arthur Conan Doyle had always been convinced of Slater's innocence. An inquiry into the verdict in 1914 had upheld the original decision, but in 1927 Conan Doyle sent to [Prime Minister J. Ramsay] MacDonald a copy of a newly published book by William Park, *The Truth about Oscar Slater*. This suggested both the weakness of the prosecution's case and that the police had suppressed inconvenient evidence. Discussions between MacDonald and the secretary of state for Scotland, Sir John Gilmour, preceded Slater's release on 15 November 1927. The Court of Criminal Appeal for Scotland had only been inaugurated the preceding year and had no power to deal with cases that predated its foundation. However a single-clause bill was passed that permitted Slater to appeal [championed by Arthur Conan Doyle]. [Lord Craig Mason] Aitchison appeared for Slater before the High Court of Justiciary in July 1928. He spoke for 13 hours, claiming that "the Crown's conduct of the case was calculated to prevent and did prevent a fair trial" [*The Times*, 10 July 1928]. The verdict was given on 20 July. The court ruled against the defense claim that on the basis of the evidence offered at the original trial the jury had acted unreasonably. Similarly new evidence did not justify the overturning of the original verdict. However the appeal was allowed on the ground that the judge in 1909, Lord Guthrie, had misdirected the jury; he had underlined the prosecution's emphasis on Slater's unattractive character. The defendant had allegedly lived off prostitution. This was held to have weakened the presumption of innocence [*The Times*, pp. 10–13, 21 July 1928; Marquand (1977, pp. 412–413) for a location of the trial in the context of anti-Jewish prejudice, see Barber (2003)].

Although it was not the absolute exoneration Conan Doyle's efforts sought, an innocent man was set free, the level of public debate on the justice system was raised, and the creation of the Court of Criminal Appeal was successfully leveraged.

Sir Arthur Conan Doyle was far more than the creator of a popular fictional character. He was a medical doctor and a scientist. He was a forensic practitioner and a forensic reformer. He believed in logic, he believed in the scientific examination of evidence, and he taught these philosophies through his stories, which remain inspirational to forensic scientists of modern day. When he died in 1930 of heart disease, it was not without having helped to create much of the philosophical forensic landscape that we currently find ourselves navigating.

The late Stuart Kind, former director of the Metropolitan Police Lab (Scotland Yard Laboratory), wrote the following (Kind, 1977, p. 12): “Even the forensic scientist himself owes his existence and attitudes a good deal more to Conan Doyle, and a good deal less to Newton and Darwin, than he is usually prepared to admit.”

DR. JOHANN (HANS) BAPTIST GUSTAV GROSS (1847–1925)

A thousand mistakes of every description would be avoided if people did not base their conclusions upon premises furnished by others, take as established fact what is only possibility, or as a constantly recurring incident what has only been observed once. –*Dr. Hans Gross (1906)*

Johann (Hans) Gross (Figure 2.5) was born on December 26, 1847, in Graz, Austria. He studied criminology and the law, and he eventually came to serve as an Examining Magistrate of the Criminal Court at Czernovitz. It was during this time that Gross observed firsthand the failings of apathetic and incompetent criminal investigators, as well as criminal identifications made by flawed and biased eyewitness accounts. He also became painfully familiar with the continuous stream of false suspect, eyewitness, and alleged victim accounts that poured into his office as a regular matter of course. These experiences led him to the conclusion that because people were essentially unreliable, and investigators were often their own worst enemy, a methodical, systematic way of determining the facts of a case was needed.

It is not known whether the works of Conan Doyle directly inspired Gross, but both men were moving in precisely the same direction at precisely the same time. In 1893, the same year that Conan Doyle killed off the Sherlock Holmes character, Gross finished his seminal work, *Handbuch für Untersuchungsrichter, als System der Kriminalistik* [*Criminal Investigation, a Practical Textbook for Magistrates, Police Officers, and Lawyers* (Gross, 1906)]. It was a watershed event in which Gross proclaimed the virtues of science against intuition, and a systematic approach to holistic crime

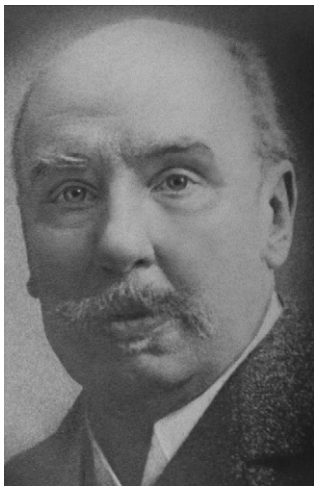


FIGURE 2.5 Dr. Hans Gross.

reconstruction against uninformed experience and overspecialization. Specifically, Gross wrote on the importance of objectivity and theory falsification when seeking to reconstruct events. A good example includes the following passage (Gross, 1924, p. 21):

Carried away by zeal and the desire to bring the case to some conclusion, the Investigating Officer has proceeded too fast and without the calm and prudence requisite to such inquiries, and so all his work has been in vain. There is but one way to avoid this, to proceed “steadily,” be it at a walk, at a trot, or at the charge; but in such inquiries a halt must from time to time be made and instead of going forward he must look back. He will then examine one by one the different points of the inquiry, taking them up in order from the beginning. He will analyze each acquired result even to the smallest factor of those apparently of the least importance, and when this analysis is carried to its furthest limits, he will carefully verify each of these factors, from the point of view of its source, genuineness, and corroboration. If the accuracy of these elements be established, they may then be carefully placed one with another and the result obtained examined as if viewed for the first time. The case will then generally assume quite another complexion, for at the outset the sequence was not so well known; and if it has a different aspect from at the first each time the matter is so revised, the question must be asked whether it is in proper adjustment with the whole argument which has been formulated and whether there is any mistake to rectify. If the whole result is defective, the Investigating Officer must confess, “My calculation is false, I must begin all over again.”

The success of this groundbreaking textbook was, without exaggeration, unparalleled in the history of forensic science and crime reconstruction. The forensic community as it existed, perhaps made fertile and hungry by the works of Conan Doyle, enthusiastically devoured *System der Kriminalistik*. It achieved a fifth edition and was translated into eight languages by 1907. This included versions in French, Spanish, Danish, Russian, Hungarian, Serbian, English, and Japanese, each with an overwhelmingly supportive foreword written by a forensic contemporary impatient to see it printed and adopted in his respective country.

To illustrate the appeal and impact of this text, the words of M. Gardeil, professor of criminal law at Nancy, describing Gross in the introduction to the French translation, may be of some use:

An indefatigable observer; a far-seeing psychologist; a magistrate full of ardour to unearth the truth, whether in favor of the accused or against him; a clever craftsman; in turn, draughtsman, photographer, modeler, armourer; having acquired by long experience a profound knowledge of the practices of criminals . . . he opens us the researches and experiences of many years. His work was no dry or purely technical treatise; it is a living book, because it has been lived.

Although Conan Doyle’s vision had been ultimately idealistic and fictional, *System der Kriminalistik* was quite practical and quite real. The blueprint for scientific investigation, and the generalist, was cast by Gross and then embraced by those working cases. As written by Thorwald (1966, pp. 234–235):

You had only to open Gross’s book to see the dawning of a new age. . . . Each of his chapters was an appeal to examining magistrates (his word for criminologists) to avail themselves of the potentialities of science and technology far more than they had done so far.

Gross became a professor of criminal law at the University of Czernovitz, a professor of criminology at the University of Prague, and later a professor of criminal law at the University of Graz. With the success of *System der Kriminalistik* as a platform, he launched other professional ventures that continue to contribute significantly to the development of forensic science. In 1898, Gross began serving as the editor for the *Archiv fur Kriminalanthropologie und Kriminalistik*,

a journal to which he was a frequent contributor. He also introduced the forensic journal *Kriminologie*, which still serves as a respected medium for reporting improved methods of scientific crime detection. In 1912, he established the Museum of Criminology, the Kriminalmuseum, at the University of Graz. According to the [Graz Tourism Bureau \(2005\)](#),

In 1912 a dream came true for Hans Gross: The "Imperial Criminological Institute" was opened at the University of Graz. It was the first of its kind in the world. For Gross, it was the culmination of an 18-year struggle to have criminology recognized as a serious academic discipline. But it was worth it. He earned a place in history for himself as the "founder of scientific criminology" and one for his "Graz school of criminology" as a model for similar institutes around the world. Hans Gross said the real center of the Institute was the museum.

Some authors have credited the formulation of modern criminalistics as a discipline to Hans Gross, in no small part because he coined the term *Kriminalistik* and placed a heavy emphasis on examination of the various forms of physical evidence by respectively qualified expert scientists as an indispensable part of the forensic process ([DeForest and colleagues, 1983, p. 12](#)). However, a criminalist (actually a criminologist by international definition), by his usage, would have been one who studies crime, criminals, and the scientific methods of their identification, apprehension, and prosecution. The modern term *criminalist* is used in the United States to describe a particular type of analytical forensic scientist and is therefore far narrower in scope.

Regardless, there is a curious legacy to Dr. Hans Gross and his collective publications. In the first half of the 20th century, he was highly regarded by U.S. authors and widely cited in works of criminal investigation, forensic science, and crime reconstruction. In the last quarter of the 20th century, actual references in such texts waned, and his work was barely mentioned at all. However, this did not stop many authors from republishing his ideas relating to reconstruction as though they were novel. As a consequence, many of the forensic students and reconstruction professionals minted since the early 1990s have no idea who Hans Gross is, let alone that he helped forge and professionalize the field they have chosen.

The significance of *System der Kriminalistik* cannot be understated. It was the first comprehensive textbook to systematically cover the integrated philosophy and practice of scientific criminal investigation, forensic analysis, and crime reconstruction. Its philosophies have not been diminished by the passage of time and should be required study for any student of these subjects.

DR. ALEXANDRE LACASSAGNE (1843–1924)

Dr. Alexandre Lacassagne was a professor of forensic medicine with the faculty of medicine at the University of Lyons, France. In 1880, he became the director of the Lyons Institute of Forensic Medicine. He was a medical doctor, an anthropologist, and a fervent advocate of combining science with criminology. According to [Thorwald \(1966, p. 281\)](#), Lacassagne also planted very specific ideas in the minds of his students about the potential importance of what we now refer to as trace and transfer evidence in the investigation and reconstruction of crime:

He had encouraged some of his students to make studies on clues that few or no criminologists had hitherto considered. Thus, he proposed the idea that the dust on clothing, or on people's ears, noses, and fingernails, could provide information on the occupations and whereabouts of suspects.

DR. EDMOND LOCARD (1872–1966)

I must confess that if, in the Police Laboratory in Lyon, we are interested in any unusual way with this problem of dust, it is because of having absorbed the ideas found in Gross and Conan Doyle, and also because certain investigations in which we have been involved have happened, so to speak, to force the issue. —*Dr. Edmond Locard (1929)*

Edmond Locard was born in 1872 in Saint-Chamond, France (Figure 2.6). He was a student of Dr. Lacassagne. In time, he became a doctor of medicine and a master of law, and he would eventually replace Lacassagne as the director of the Lyons Institute of Forensic Medicine.

In 1908, having been educated by Lacassagne and inspired by the works of Gross and Conan Doyle, Locard traveled the world to better study how police agencies in major cities were incorporating the scientific method and trace evidence analysis into their investigation and reconstruction of crime. During the next two years, he would visit agencies and colleagues in Paris, Lausanne, Rome, Berlin, Brussels, New York, and Chicago. To his dismay, he found no true police crime labs or even scientific detectives, and the majority of police agencies remained steeped in **Bertillonage** (a form of personal identification based on a system of body measurements and photography of features). The only real question that existed, Locard found, was whether fingerprinting should become the new standard for personal identification, over Bertillonage, as had been declared necessary in 1893 by Gross in *System der Kriminalistik* (1906).



FIGURE 2.6 Dr. Edmond Locard.

In 1909, the Institut de Police Scientifique et de Criminologie was formally created at the University of Lausanne, Switzerland, under the direction of Professor Rudolph A. Reiss (1875–1929). It was the first university to deliver a degree in forensic science (criminalistics) covering all major subjects. Professor Reiss had originally offered courses in forensic photography, scene of crime investigation, and identification, and he had been involved in forensic casework since at least 1903. The institute developed from the success of those courses and his tireless efforts.

In the summer of 1910, after having visited with Professor Reiss, Locard returned to Lyon and persuaded the prefects of the Rhone Department to provide him with two rooms in an attic of the Law Courts and two Surete officials as assistants. (The French Surete Nationale was a plain-clothes undercover unit developed to keep strict surveillance over all ex-convicts and known criminals living in and migrating into the city; to pursue all lawbreakers and make arrests; and to prevent criminal activity before it occurred. In Locard's day, the Surete Nationale, which was separate from the local police, was assuming a lot of police functions, and this alliance protected his lab politically.) The arrangement was what Locard wanted, but the actual accommodations were not the best, as described in [Thorwald \(1966, p. 283\)](#):

The laboratory was reached through a gloomy entrance hall from which one corridor led to the prison and a dirt-stained door into the dusty caves and archives. Every day Locard climbed the steep winding staircase leading to his laboratory four floors up.

This marked the creation of what has become regarded as the world's first police crime laboratory, as it was housed under the auspices of law enforcement and staffed by law enforcement agents. However, contrary to some publications, this was not the world's first forensic science laboratory. The first forensic science labs were private, often specialized, and tended to be housed in universities, as Locard had experienced in Switzerland with Reiss. For example, one of the earlier forensic science labs of record was established in 1868, the French Institut de médecine légale de Paris (Paris Institute for Forensic Science).

In any event, once in place at his lab in Lyon, Locard took to the task of implementing everything he had learned from the publications of Hans Gross, from the stories of Conan Doyle, from his study and travels, and from his devotion to forensic science and crime reconstruction. These efforts included foundational research, publications, and the development of practice standards in dust analysis, detailed in [Locard \(1929\)](#), and fingerprint examination, as described by [Clark \(2005\)](#):

Dr. Edmond Locard ... established the first rules of the minimum number of minutiae necessary for identification.

He is also known as the father of Poreoscopy, which is the study of pores that appear in the fingerprint ridge, and their use in the individualization process. Dr. Locard also realized the value of the shape of the ridge as being permanent, and he should also be known as the father of Edgeoscopy.

Locard went beyond the variations of the individual friction ridge path which Sir Francis Galton noted as he defined those friction ridge events. The variations of the individual friction ridge features which he noted, has evolved into "Ridgeology," which is a coined phrase describing the use of those features in the fingerprint identification process. Dr. Locard should also then be known as the father of "Ridgeology."

Locard also helped establish one of the first forensic science professional organizations. In 1929, after the death of Professor Reiss, Locard returned to Lausanne and gathered with his European forensic scientist colleagues to form the International Academy of Criminalistics.

His contributions to the forensic sciences were nothing short of massive, as summarized in [Söderman \(1957, p. 25\)](#):

He put the analysis of handwriting on a firmer footing, systematized the analysis of the dust in the clothes of suspects, invented a modified method of analyzing blood stains, and invented poroscopy, whereby the pores in the papillary ridges of fingerprints are used as a means of identification.

However, Locard is most famous for the forensic axiom that bears his name: **Locard's exchange principle**. It has been misstated, misrepresented, and misattributed over the years by those lecturing and writing authoritatively on the subject. Confusion in the forensic science community and among students has resulted.

A reference from Locard found in *La Police et Les Méthodes Scientifiques*, in the original French, may be of use to understand what he actually meant ([Locard, 1934, pp. 7–8](#)):

a recherche des traces n'est pas, autant qu'on pourrait le croire, une innovation des criminalistes modernes. C'est une occupation probablement aussi vieille que l'humanité.

Le principe est celui-ci. Toute action de l'homme, et a fortiori, l'action violente qu'est un crime, ne peut pas se dérouler sans laisser quelque marque. L'admirable est la variété de ces marques. Tantôt ce seront des empreintes, tantôt de simples traces, tantôt des taches.

Translation:

Searching for traces is not, as much as one could believe it, an innovation of modern criminal jurists. It is an occupation probably as old as humanity.

The principle is this one. Any action of an individual, and obviously, the violent action constituting a crime, cannot occur without leaving a mark. What is admirable is the variety of these marks. Sometimes they will be prints, sometimes simple traces, and sometimes stains.

In 1935, a Spanish translation of this same general principle was provided in [Locard \(1935, p. 107\)](#):

Al malhechor le es imposible actuar, y sobre todo actuar con la intensidad que supone la acción criminal, sin dejar indicios de su paso.

Translation:

To the criminal, it is impossible for him to act, and mainly to act with the intensity that supposes criminal action, without leaving indications of his step.

The principle has been adapted and adopted in its English translation by the forensic science community in the United States. As stated by Dr. John Thornton, a practicing criminalist and a former professor of forensic science at the University of California (UC) at Berkeley ([Thornton, 1997, p. 29](#)),

Forensic scientists have almost universally accepted the Locard Exchange Principle. This doctrine was enunciated early in the 20th century by Edmund Locard, the director of the first crime laboratory, in Lyon, France. Locard's Exchange Principle states that with contact between two items, there will be an exchange of microscopic material. This certainly includes fibers, but extends to other microscopic materials such as hair, pollen, paint, and soil.

By recognizing, documenting, and examining the nature and extent of evidentiary traces and exchanges in a crime scene, Locard postulated that criminals could be tracked down and then later associated with particular locations, items of evidence, and persons (i.e., victims). He regarded this postulation as both obvious and ancient, and he likened the recognition and examination of trace evidence to hunting behavior as old as mankind (Locard, 1934, p. 7). The prey, for example, in the normal course of drinking at a watering hole, leaves tracks and spoor and other signs that betray their presence and direction; the hunter deliberately seeks out this evidence, picks up the trail, and follows. Every contact leaves a trace that may be discovered and understood. The detection and identification of exchanged materials are interpreted to mean that two objects have been in contact. This is the cause-and-effect principle reversed; the effect is observed and the cause is concluded. Understanding and accepting this principle of evidentiary exchange make possible the reconstruction of contacts between objects and persons. Consequently, the incorporation of this principle into evidentiary interpretations is perhaps one of the most important considerations in the reconstruction of crime.

It is true that Locard concerned himself chiefly with organizing and systematizing methods of analyzing prints, traces, and stains. He wrote extensively on how to identify and individuate dust, how to identify and individuate fingerprints, how to analyze and interpret handwriting, how to analyze and interpret blood stains, etc. However, a careful read of his publications reveals that his goals were ultimately those of reconstructing crime through the skills brought to bear by a forensic generalist. As Locard (1934, p. 6) explained, “Criminalistics [forensic science] seeks tools everywhere, in biology, physics, and more particularly chemistry, and proposes solutions to every problem brought up by the criminal investigation.” Consequently, he organized and systematized methods of physical evidence analysis in order that reasonable and well-founded reconstruction interpretations might be possible. After all, what is the point of seeking out dust, prints, or other traces if one does not wish to examine them or interpret the meaning of their presence?

EDWARD OSCAR HEINRICH (1881–1953)

*The camera never lies, but a camera in the hands of a liar is a dangerous instrument. –Edward O. Heinrich
(as quoted in Block, 1958, p. 37)*

Edward Oscar Heinrich (Figure 2.7) was born in 1881 in Clintonville, Wisconsin. At age 18, he became a licensed pharmacist in Tacoma, Washington; he worked hard and saved his money, aspiring to a college education and becoming a chemist. In 1908, he realized that goal and graduated from U.C. Berkeley with a bachelor’s degree in chemistry. Soon thereafter, he moved back to Tacoma, where he worked for the city as a chemist and sanitary engineer for the next nine years. This position gave Heinrich his first exposure to forensic casework—it involved frequent requests for investigative assistance from both the police and the coroner’s office.

Applying chemistry to casework taught Heinrich the limits of specializing. He learned that to be of use—to fully reconstruct events—a forensic scientist must have at least a general working knowledge of as many forensic specialties as possible. As a result, he continually made a study of ballistics, geology, physics, photography, hairs, handwriting, paper, and inks; he read every reference text and article he could get his hands on. In essence, he made a forensic generalist



FIGURE 2.7 Edward Oscar Heinrich, “The Wizard of Berkeley.”

of himself, and his reputation grew with the successful employment of his methods to both criminal and civil cases.

In 1916, Heinrich became the chief of police in Alameda, California, and reorganized the department from top to bottom in terms of criminal files, fingerprints, and the employment of more modern investigative techniques. During that time, after the onset of World War I, he also lent his services to U.S. Army intelligence, providing training and performing forensic analysis.

Only a few years later, Heinrich would open his own private lab in Berkeley. To augment his practice, he became a member of the U.C. Berkeley faculty where he lectured on the subject of criminal investigation and served as a research associate in police science. When Heinrich began his private forensic casework, his methods were the exception and not the rule (Block, 1958, pp. 41–42):

Scientific work was little known and often ridiculed. Plodding, without definite direction, took its place—chasing here and there for information, trying to find someone who might know something about the crime.

In every way Heinrich’s approach was quite opposite.

That approach—his methodology—was one of the unique features of his whole career.

“Understand this first,” he usually said. “Crime analysis is an orderly procedure. It’s precise and it follows always the same questions. . . .

“Precisely what happened? Precisely when did it happen? Precisely where did it happen? Why did it happen? Who did it?”

...

“It’s all like a mosaic, and every fact must be evaluated before it can be fitted into the pattern. In that way, every fact as it is developed and equated becomes a clue.”

Heinrich would dedicate his life to advancing the cause of scientific investigation and reconstruction through the employment of his methods, despite any opposition. As recalled in Walton (2004, p. 5):

In Berkeley, the work of Edward Oscar Heinrich laid the foundation for the future of professional forensic sciences. From his laboratory, Heinrich repeatedly demonstrated the value of scientific examination of trace

evidence as his meticulous inspections provided the necessary links between the crime and suspects. As a result, his work was in demand by prosecutors and defense attorneys alike throughout the West.

According to Heinrich, the crime scene always contained a variety of clues, and it was up to a scientific investigator to find and interpret them accurately (Walton, 2004). Those interpretations could be combined to form a reconstruction of events that established both contacts and actions. Evidence, to Heinrich, was the only reliable witness to a crime (Block, 1958, pp. 43–44):

In the test tube and crucible or through the lens of the microscope and camera I have found in my own practice the evidence of poison, the traces of the deadly bullet, the identity of a clot, the source of a fiber, the telltale fingerprint, the differing ink, the flaw in the typewriter, the slip of the pen upon which I have turned in dramatic scenes of our courts the rightful title to an estate, of the liberty, even the life, of an individual.

Clues thus found and verified as physical facts definitely related to an action become of enormous importance to clarifying erroneous observations of eyewitnesses.

Heinrich did not regard the interpretation of evidence and its reconstruction as something within the ken of the average person or investigator. He regarded reconstruction as an ordered, disciplined, and scientific practice borne out of tireless dedication to one's personal education, experience, and research (Block, 1958, p. 44):

It is a matter of understanding the scientific aspects of ordinary phenomena. Rarely are other than ordinary phenomena involved in the commission of a crime. One is confronted with scrambled effects, all parts of which separately are attributed to causes. The tracing of the relationship between isolated points of fact, the completion of the chain of circumstances between cause and effect, are the highest functions of reason—to which must be added the creative imagination of the scientist.

Heinrich died in 1953 at the age of 72, with many of the techniques and philosophies that he had practiced adopted in police crime labs throughout the United States. His sheer force of dedication to the forensic sciences inspired many and accomplished much by way of instruction and example.

DR. PAUL L. KIRK (1902–1970)

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. —*Dr. Paul Kirk (1953, p. 4)*

Paul Leland Kirk (Figure 2.8) was born in Colorado Springs, Colorado, in 1902. He was first and foremost a scientist, but he was also a man of practical application as opposed to pure theory. He was educated at Ohio State University, where he received an A.B. in chemistry; the University of Pittsburgh, where he received an M.S. in chemistry; and the University of California, where he received a Ph.D. in biochemistry.

From 1929 to 1945, Kirk served as a professor of biochemistry at U.C. Berkeley. Later in his career, he would tell students that he was initially drawn to forensic science in his early teaching days when a biochemistry student approached him with a question about a deceased dog and whether or not it could be determined if the dog had been poisoned. Investigating this issue

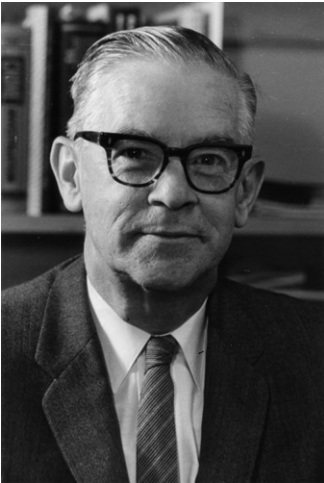


FIGURE 2.8 Dr. Paul Kirk. Source: John E. Murdock (ATF Forensic Lab, Walnut Creek, CA).

piqued Kirk's forensic curiosities. Soon after, he was contacted by authorities to examine the clothing of a victim of rape—they wanted to know whether or not anything on the clothing could be found, at the microscopic level, to associate the victim with her attacker. Kirk's discovery of fibers from the attacker's shirt, and the subsequent conviction of the rapist, sealed his interest and secured his reputation for solid results based on careful examinations. Subsequently, in 1937, Kirk assumed leadership of the criminology program at U.C. Berkeley. The program gained momentum and grew in its reputation under his charge.

In 1939, during World War II, it was believed that Nazi scientists were developing an atomic bomb. In response, the United States initiated its own top-secret atomic weapon program overseen by the Army Corps of Engineers in June 1942 (a year and a half before formally entering the war). This was done in order to develop the atomic bomb first and gain the upper hand in a war that had already consumed Europe and Asia and would most certainly involve the United States directly at some point. This covert effort would become known as the Manhattan Project.

Theoretical physicist Robert J. Oppenheimer was asked to direct research on the Manhattan Project at a remote site in Los Alamos, New Mexico, which would later become the Los Alamos National Laboratory. He set to the task of identifying top scientists and engineers from universities nationwide—to fill a room with the smartest people available and get them working. Because of his extensive knowledge and ability with work done at the microscopic level, Dr. Paul Kirk was among them. From 1942 to 1945, Kirk was on leave from his university teaching duties to the Manhattan Project, where he helped develop the process for isolating fissionable plutonium.

In 1945, Kirk returned to U.C. Berkeley and reconnected to his interest in forensic science. He formalized a major in technical criminology that year. In 1950, Chief Vollmer established the school of criminology, and Kirk was appointed to chair the criminalistics department. According to [DeForest and colleagues \(1983, p. 15\)](#), "The program grew to be well-known, and Kirk developed a substantial reputation in forensic science, devoting his time to instruction, research, and casework." In 1953, Kirk published the first edition of *Crime Investigation*, a treatise on criminal

investigation, crime reconstruction, and forensic examination that endures to this day as a foundational industry standard with few equals (Kirk, 1953). In the preface, he describes arriving at the same precipice as all who studied forensic science before him, and he calls once again for the education of forensic generalists (p. v):

LeMoyne Snyder, in his excellent book, *Homicide Investigation* [Snyder, 1944, pp. 269–271], includes a short chapter, “Why I Wrote This Book,” which should be required reading for all law enforcement agents. The situation described there, involving a lack of coordination, communication, and understanding, was one in which conscientious but untrained and incompetent officials did everything possible to make the crime impossible of solution, and little if anything to aid in its solution. The possible implication that this situation is characteristic only of homicides is, unfortunately, not true. Far too many crimes of all types are “investigated” as he describes. His reasons for writing the book apply equally to the writing of this one, which aims only to attack the same fundamental problem but on a broader basis.

This volume is not intended as a guide for specialists. Rather, it is written with the needs of police investigators, general criminalists in smaller police laboratories, and students of criminalistics and police science in mind.

Kirk also supported the validity of Locard’s exchange principle for use in reconstruction work, and he refined it to a point so keen that his words are frequently confused for those of Locard (Kirk, 1953, p. 4):

Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothing, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects. All of these and more bear mute witness against him. This is evidence that does not forget.

However, Kirk also argued for caution in the interpretation of evidentiary exchanges. Unlike Gross or Locard before him, Kirk was not so enamored with forensic science that he misunderstood its limitations and potential abuses. On establishing the identification of an object’s source, he makes it clear that it is an endeavor with inherent hazards, to include the examiner, under even the best conditions (Kirk, 1953, p. 16; revised in Kirk and Thornton, 1970, p. 10):

In the examination and interpretation of physical evidence, the distinction between identification and individuation must always be clearly made, to facilitate the real purpose of the criminalist: to determine the identity of source. That is, two items of evidence, one known and the other unknown, must be identified as having a common origin. On the witness stand, the criminalist must be willing to admit that absolute identity is impossible to establish. Identity of source, on the other hand, often may be established unequivocally, and no witness who has established it need ever back down in the face of cross-examination.

It is precisely here that the greatest caution must be exercised. The inept or biased witness may readily testify to an identity, or to a type of identity, that does not actually exist. This can come about because of his confusion as to the nature of identity, his inability to evaluate the results of his observations, or because his general technical deficiencies preclude meaningful results.

Kirk also shared the views of Gross and Locard regarding issues of witness reliability, physical evidence, and crime reconstruction, explaining (Kirk and Thornton, 1970, p. 33),

The utilization of physical evidence is critical to the solution of most crime. No longer may the police depend upon the confession, as they have done to a large extent in the past. The eyewitness has never been dependable, as any experienced investigator or attorney knows quite well. Only physical evidence is infallible, and then only when it is properly recognized, studied, and interpreted.

Paul Kirk is perhaps best remembered for his involvement in the infamous Sam Sheppard case. On July 4, 1954, 31-year-old Marilyn Reese Sheppard, approximately 4 months pregnant, was found murdered on a twin bed in the bedroom of her home in Bay Village, a suburb of Cleveland, Ohio. After a hasty and flawed investigation, fraught with preconceived theories, her husband, Sam Sheppard, was arrested for the crime. On December 21, 1954, a jury convicted him of second-degree murder (intentional but without premeditation).

On January 22, 1955, Kirk visited the Sheppard home to examine the scene and collect evidence in preparation for an appeal on behalf of the Sheppard defense. Subsequently, he wrote a reconstruction report detailing his findings related to bloodstain pattern analysis and the presence of a third person at the scene. Although Sheppard's motion for a new trial and appeal were denied in 1955, a U.S. district judge overturned his conviction in 1964, agreeing that intense media coverage had led to an unfair conviction. In 1966, the U.S. Supreme Court eventually reviewed the case and upheld that decision.

Later that same year, Sam Sheppard was put on trial again, and this time Paul Kirk was allowed to testify. According to [Chisum \(2000\)](#):

The first person to really study the bloodstain patterns in the Sam Sheppard case was Professor Paul L. Kirk from UC Berkeley.

...

The identification of a person through their blood was of primary interest to Paul and was the focus of much of his research after the Sheppard case. However, he died prior to the discoveries that led to his dream of individualization of blood.

He rediscovered blood spatter interpretation. He conducted many experiments in a closed room with a bucket of blood and various tools. He tried to establish the cause of different patterns. He was not the first person to experiment with blood in this manner, however, there was about a 30-year gap in the field. Kirk's affidavit in this case is still looked upon as one of the milestones of blood spatter interpretation.

Paul Kirk did testify in the second trial, which resulted in an acquittal for Dr. Sheppard.

Kirk's involvement in the Sheppard case as an expert for the defense publicly and professionally embarrassed Dr. Samuel Gerber, a senior member of the American Academy of Forensic Sciences (AAFS) who worked the Sheppard case for law enforcement and believed Sam Sheppard to be guilty. As explained in [Chisum \(2000\)](#):

Dr. Sam Gerber, M.D., was the coroner in Cuyahoga County at the time of the [Marilyn Sheppard] murder and for several more years. He was a very powerful person in the county and in the forensic field. He knew how to work the system to his advantage. He was also vindictive as shown by his personal attacks on Prof. Paul Kirk. Many believe he was behind the movement that kept Dr. Kirk out of the American Academy of Forensic Sciences.

Subsequently, Kirk was not allowed to join the AAFS because of his findings in the Sheppard defense, their impact on Sheppard's acquittal, and Gerber's influence.

In 1969, Kirk broke more forensic ground with the publication of *Fire Investigation*. This work was intended to bring the basic principles and methods of fire scene investigation and reconstruction down from the language of highly technical journal publications to ordinary criminal investigators and forensic generalists. Today, in the able hands of Dr. John DeHaan, it survives as a worthy industry standard ([DeHaan, 2002](#)).

After his death in 1970, Kirk's student and colleague Dr. John I. Thornton finished the manuscript for the second edition of *Crime Investigation* ([Kirk and Thornton, 1970](#)) and gave sole

credit for the ideas expressed within as those of Kirk, stating (p. v), "Those of us involved in editing and rewriting served only to tidy up the work a bit, performing a type of literary janitorial service; the essential character of the text is decidedly that of Dr. Kirk."

Paul Kirk left behind a valuable body of work and a legacy of skilled students from all over the world. Since his passing, a fair number of those students have helped shape the forensic science universe in the best possible sense, each in their own right, with several contributing to the development of this text. Also, ironically, the highest honor that one can now earn in the criminalistics section of the AAFS is the Paul L. Kirk Award.

THE BROADER THEME

It is evident that the history of crime reconstruction is built on a succession of inspiration, expectation, and disappointment. Each of the fathers of forensic science entered the profession, in one fashion or another, both inspired by something and to repair something. They came in search of science and, finding it lacking, set about to make things right. The broader theme of their collective work is that physical evidence is of the greatest value when establishing the facts of a case, but it must be cautiously and dispassionately interpreted. In that endeavor, education in the sciences and the scientific method are not to be discarded as impractical but, rather, embraced as essential to defining the quality of subsequent examinations and interpretations.

Moreover, and not less important, is the lesson that the forensic sciences will advance only in the hands of able students and practitioners. Crime reconstruction is a complex process; the less someone knows about it, the simpler it seems. Consequently, the fathers of forensic science made it clear that crime reconstruction should not be the responsibility of anyone unable to reach with the full extension of all that science, analytical logic, and critical thinking has to offer.

These are lessons that current and future reconstructionists would do well to remember and keep close in their casework, testimony, and teaching.

SUMMARY

Crime reconstruction is the determination of the actions and events surrounding the commission of a crime. A reconstruction may be accomplished by using the statements of witnesses, the confession of a suspect, or the statement of a living victim or by examining and interpreting the physical evidence. At the same time, any statements of witnesses, victims, or suspects can be checked against a reconstruction of the physical evidence. All such statements are theories until they are proven facts or are recognized by the court as a legal fact.

Some refer to this process as crime scene reconstruction. However, the scene is not actually being put back together as it was. Only some of the actions and sequences of events are being established, even when this term refers to the use of computer CAD programs and models. When working at the evidentiary level, this is in no small part because of the natural limits of forensic science. Consequently, the term *crime scene reconstruction* is at best an inaccurate description of what forensic science is actually able to contribute to the cause of justice.

QUESTIONS

1. Define crime reconstruction.
2. Crime reconstruction is synonymous with crime scene processing. True or false? How so or why not? Explain.
3. Explain Locard's exchange principle. Give an example.
4. Only some of the actions and sequences of events are established in a crime reconstruction. True or false? Give an example of an action that can't be established.
5. Who coined the term *Kriminalistik* and placed a heavy emphasis on the examination of the various forms of physical evidence by respectively qualified expert scientists as an indispensable part of the investigative and forensic process? When?

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Crime Reconstruction: Ethos and Ethics

John I. Thornton

Integrity without knowledge is weak and useless, but knowledge without integrity is dangerous and dreadful. —*Samuel Johnson*

Relativity applies to physics, not ethics. —*Albert Einstein*

Key Terms

Authority bias; Blind spot bias; Conclusions; Confirmational bias; Contextual bias; Deductive argument; Ethic; Ethos; Fallacies of logic; Howler; Inductive argument; Information bias; In-group bias; Logic; Negativity bias; Omission bias; Outcome bias; Premises; Selection bias; Self-serving bias

It is inevitable that in the process of writing a chapter on ethics, the author will wonder who the audience is and who will bother to read it. Those who have a natural proclivity toward ethical behavior are likely to be disinterested, thinking the subject unnecessary and vaguely insulting. Those whose ethics are susceptible to some degree of negotiation or whose notions of ethics are more sinuous or inclined to rationalization are likely to be even less interested, thinking the subject will promote guilt, self-remorse, and shame. Nevertheless, the subject is sufficiently grave and perilous enough to compel its treatment here.

EVIDENCE, CRIME RECONSTRUCTION, AND ETHOS

We are interested in physical evidence because it may tell a story. Physical evidence—documented properly, collected properly, analyzed properly, and interpreted properly—may establish the factual circumstances at the time a crime occurred. In short, the crime may be reconstructed. Our principal interest is ultimately in the reconstruction, not the evidence per se.

We are interested in DNA, in gunshot residues, in blood spatter, in firearms evidence, and in friction ridge evidence only insofar as these materials enable us to reconstruct the crime incident. It is the story, rather than the evidence, that will be applied to the ultimate determination of

justice. (Some clarification of terminology may be appropriate here. In this discussion, an event is a single occurrence, action, or happening. An incident is a series of related events, contemporaneous in time and for which responsibility may generally be assigned.)

Ethos pertains to the valid essence of something, with as much emphasis placed on the “valid” as the “essence.” The Greek word *ethos* (ἦθος, character) means just that—character—and it is not just coincidence that it is the root of the word “ethics” as well. The dictionary definition of **ethos** is the moral, ideal, or universal element in something, as opposed to that which is subjective or emotional in its appeal.

The crime scene has a certain character, a certain essence. It has been given form and has been shaped by the laws of nature and by the vagaries of human conduct. The crime scene is an entity of sorts. It has its own ethos, as do the processes by means of which the scene is reconstructed.

A premise here is that there is a thing called a *crime scene*, but there is also a thing termed *crime reconstruction*. As with the crime scene, the crime reconstruction has a character, an essence, an ethos. This premise is central to the entire discussion. Also, along with ethos is an ethic—a moral obligation to maintain the integrity of the processes by means of which the reconstruction is accomplished. In short, the ethics of crime reconstruction represent an imperative to “get it right.”

RESPONSIBILITIES OF THE RECONSTRUCTIONIST

An ethical obligation exists to ensure that the professional responsibilities attendant in forensic practice in general, and crime reconstruction in particular, are honored. “Getting it right” involves more than guessing correctly. It necessitates a systematic process. It involves the proper recognition of the evidence, the winnowing of the relevant wheat from the irrelevant chaff, and the precise application of logic, both inductive and deductive.

The process is not trivial. With respect to a given situation, the crime reconstructionist may ask, “What should I do?” But it may not be possible to answer this question until other, subordinate questions are first dealt with, such as “What *can* I do?” and “What is expected of me?” and, in some instances, “What *must* I do?”

The responsibilities of the reconstructionist do not end entirely with “getting it right,” either. There is also the responsibility of ensuring that the reconstruction is not misconstrued by to whomever it is delivered. If the reconstruction is tentative or demands qualification in order to be placed on sustainable scientific grounds, then all appropriate qualifications should be stated emphatically.

The crime reconstructionist is unlikely to find a level of comfort with respect to his or her ethical stance unless an appreciation is developed and achieved regarding the extent and limits of his or her responsibilities. Are there responsibilities? Decidedly yes. And they can be neither denied nor ignored.

A Requisite Truce

The acknowledgment of these responsibilities may require a truce between the reconstructionist and the interests and concerns of the law enforcement community, the scientific community, and the adversary system of justice. The reconstructionist is entitled to adopt an ethical stance of his or her choosing, without regard to the interests or demands of other interested

parties. However, this is done with the understanding that there must be some ultimate accountability for his or her position.

Typically, the most severe test to this position will be the extent to which the reconstructionist must assert his or her scientific values and standards in dealing with law enforcement and legal adversaries within the criminal justice system. Here the reconstructionist has a professional and ethical obligation to dig in his or her heels, and not subordinate, subjugate, or rationalize his or her standards and values in order to please others. Any short-term benefit in doing so will ultimately lead to misfortune and possibly to a career-ending disaster.

Law and Science

The majority, but not all, of crime reconstructions are conducted by persons aligned with law enforcement in some capacity, which has historically resulted in pressure brought upon the reconstructionist. Law and science represent two different cultures. Crime reconstructions presumably (and hopefully) are the products of science, but they are used in the employ of law. A certain tension may result from this, as law and science are not always good bedfellows.

Unless the reconstruction honors the truth, it will be a perversion of reason and unsuited for any use we may have of it. And here we must speak of fundamental truth, not just the perception of it by the observer. Recklessness or malfeasance in the process of crime reconstruction will fall in the domain of ethics, but simple misfeasance may be at play as well. Sincere but misguided beliefs do violence to the ethos of crime reconstruction. We must pursue the ethos of the reconstruction, and the ethics.

ON BEING MISTAKEN

Is it unethical to be mistaken in a crime reconstruction? It is if the mistake was avoidable. It is if the mistake has arisen from haste, bias, recklessness, succumbing to outside pressure, or an ignorance of bias and logical pitfalls.

A goodly bit of what passes for crime reconstruction falls within the domain of commonsense deductions. For example, blood in one part of a room but in no other would indicate that a victim had not visited other areas after being stabbed. A bloody shoeprint with a sole design different from that of the victim might be that of the assailant. (However, it may have arisen after the incident when medical intervention was attempted.) Commonsense deductions of this sort—derived from everyday experience—do not require formal training in logic, but it is nevertheless logic that is the engine for conclusions such as these.

We must be diligent and exhaustive in our striving for technical correctness and the minimization of error. In a very general sense, errors are of three sorts, any one of which may lead to a faulty conclusion in a crime reconstruction. First, an error can simply be a mistake, a misperception of the sort that is typically avoided and for which the reconstructionist may have a history of avoiding in connection with previous cases. A second category is the **howler**, which is an error in which the correct answer or conclusion is reached, but for the wrong reasons. A howler is still an error, and unless it is caught, it may influence other reconstructions at a later time. The third type

involves fallacies, biases, or a combination of both, in which misguided reasoning disrupts the application of valid logic. More will be said about both bias and fallacy.

LOGIC IN CRIME RECONSTRUCTION

Is there a *professional obligation* to employ proper logic? Yes there is. And does it follow that there is an *ethical obligation* to recognize this professional obligation? Again, yes there is.

We use commonsense logic so often and so casually that we generally gloss over many complexities. As a consequence, commonsense logic can be treacherous. Premises may be misapplied, incomplete, or uncertain, and fallacies of logic may be compounded.

But logic has its underpinnings, which are, well, logical. Formal logic, as opposed to casual logic masquerading as common sense, is an exceedingly powerful tool and one not to be ignored or given short shrift. The crime reconstructionist would be well advised to gain some conversancy with the subject, both to solve problems correctly and to avoid a misapplication of logic—that is, to avoid engaging in fallacies of reason. A good place to start would be [Hurley \(2002\)](#).

The point here is that the employment of weak or fallacious logic will almost invariably result in weak or fallacious reconstruction of the crime. Apart from popular fiction—the Sherlock Holmes stories leading the list—logic has not been stressed in written accounts of crime reconstruction. For reasons that are not altogether recoverable, the professional literature on crime scene processing and criminal investigation has not devoted much attention to the subject. But it is not too late to raise the topic.

Logic

Logic is the science that evaluates arguments. (Note that it is considered a “science” in that it makes use of the scientific method. The scientific method, in its simplest form, involves the formation of hypotheses and the testing of those hypotheses through attempts at falsification.) An argument as used here does not mean a verbal fight but, rather, a group of premises that claims to support a conclusion. **Premises** are statements that set forth the reasons or evidence for an idea. **Conclusions** are the statements that the evidence is claimed to support or imply.

For logic to work properly, the parent premises must be valid and the conclusion must follow from valid premises. This places a great premium on the ability of the crime reconstructionist to develop true, rational premises; if this is not accomplished, the arguments will be invalid. Certainly arguments exist in which the premises do, in fact, support the conclusion, but there are arguments that do not support the conclusion, even though they are believed, and therefore claimed, to do so. It is the process of distinguishing between true arguments and false arguments that we call logic.

Induction and Deduction

Frequently, it is supposed that crime reconstruction involves only deductive reasoning. In practice, however, both deductive and inductive arguments are employed. A **deductive argument** is one in which it is impossible for the premises to be true and the conclusion false. A deductive argument is therefore something to be striven for. An **inductive argument** is one in

which it is merely unlikely that the premises are true and the conclusion false. Inductive arguments are those that necessitate some measure of probabilistic reasoning. Often, crime reconstruction is framed in terms of deductive reasoning, but, in fact, most reconstructions involve a mix of both deductive and inductive arguments. Many conclusions must certainly be couched in probabilistic (i.e., “likelihood”) terms, and inductive reasoning is much more common than many crime reconstructionists would care to admit. Simply put, we are forced into it.

A failure to recognize those instances in which we are forced into it may lead to an incorrect reconstruction, which of course is a mistake and which may lead to a disastrous consequence. Is an “honest mistake” an ethical transgression? Yes, it is, if it could have been avoided by a provident amount of thought and effort.

Valid logic is generally synonymous with the casual and sometimes elusive commodity that we call common sense. In its application, it cannot be haphazard. The scene reconstructionist has the professional and ethical obligation to interpret the scene correctly. The imperative to read the scene correctly burdens the reconstructionist to avoid engaging in lapses of proper logic. Valid conclusions based on valid logic are essential. The avoidance of fallacy is also essential. Avoidance of fallacy has historically been given short shrift in discussions of crime reconstruction.

FALLACIES OF LOGIC

Fallacies of logic are a conspicuous peril to the crime reconstructionist. Many fallacies are subtle and reach out to ensnare the reconstructionist who is oblivious to them, operating out of ignorance, or under a bias that obscures them or is so hurried as to cut corners. Fallacies of logic are typically not considered in any discussion of the crime reconstruction; they should be, since they must be avoided at all costs. Failure to avoid them will inevitably result in a corrupt reconstruction. Failure to avoid them may lead to a lapse in professionalism—a lapse in ethics.¹

Fallacies of logic are generally categorized as fallacies of relevance; fallacies of weak induction; and fallacies of presumption, ambiguity, and grammatical analogy. Some examples are useful.²

I. Fallacies of relevance

Fallacies of relevance are those where the arguments are based on premises that are *logically* irrelevant, although they may have considerable *psychological* relevance. Conclusions may *appear* to follow from the premises but do not follow logically.

A. Appeal to force (argumentum ad baculum)

An argument is supplied to one person by another, along with a statement—implicit or explicit—that something adverse will happen to the second person if the offered

¹ We should concede that in some instances, we are actually encouraged to accept fallacies. Lawyers consider it their professional obligation to advance fallacies if it will advance their case. Advertisers, in their marketing strategy, willingly advance fallacies of logic in order to promote their product. In our everyday lives, we can scarcely avoid exposure to instances of corrupt logic. This must not extend to the work product of the crime reconstructionist.

² See also Chapter 19.

conclusion is not accepted. In the most raw form, this may be a clear threat: “Clearly the suspect displayed premeditation. If you don’t agree, forget about my support for a raise.” Here, it is abundantly clear that the person making the threat is engaging in unethical behavior, and the person receiving the threat would in turn incur unethical behavior if he or she succumbed to it. But this fallacy could be much more subtle, along the lines of “Bill, forget about documenting all of those bloodstains. If we don’t finish up in the next 10 minutes all of the restaurants will be closed.”

B. Appeal to pity (argumentum ad misericordium)

The appeal to pity may be directed by the person making the argument, but the appeal may be directed toward some third party as well. “Bill, if you conclude that the scene was processed improperly, you will jeopardize Jim’s reputation and possibly his job. You know that he only has six months before retiring.”

C. Appeal to the people (argumentum ad populum)

This appeal commonly takes some form of the “Don’t you want to get on the bandwagon?” “What do you mean, you aren’t convinced that the fingerprint in evidence isn’t that of the suspect? Several other examiners have already verified the identification.” This becomes a fallacy when the appeal is to the emotions and enthusiasm of the reconstructionist rather than a legitimate appeal to scrutinize the basis of the claimed identification more carefully.

A converse fallacy—an argument *against* the people—exists when the emotions of the reconstructionist are fanned to stigmatize a particular group of people. “What can you expect from that group of gang-bangers?”

D. Argument against the person (argumentum ad hominem)

This may occur when a conclusion is advanced, with another person responding by directing attention not to the first person’s argument but to the *character* of the first person. This may be abusive: “The defense consultant has a detailed crime reconstruction, but consider how much he is being paid to say what he is saying!” It may be more subtle: “Bill is entitled to his opinion, but in the past 20 years he has made no attempt to keep up with recent developments!”

E. Accident

The fallacy of accident applies to situations in which a principle is applied to a particular instance but in which the principle cannot be reasonably expected to apply. This fallacy is termed an “accident” because some “accident” prevents the otherwise valid rule from applying. “It is well established in law that a person is innocent until proven guilty. The suspect hasn’t been found guilty yet, so let’s ignore the fact that he has blood on his clothing.”

F. Straw man

The straw man fallacy is a type of misrepresentation where one person distorts another argument for the purpose of attacking it more easily, then attacks the reformulated argument, and then asserts that the original argument has been discredited effectively.

G. Missing the point (ignoratio elenchi)

Missing the point occurs when the premises support one conclusion, but another conclusion is drawn. “No expended cartridge cases were found at the scene. The shooter must have picked them up” (dismissing the possibility that a revolver was used).

II. Fallacies of weak induction

Fallacies of weak induction are arguments that appear to be inductive, while the premises do not provide sufficient support for the conclusion offered. In such arguments, even when the premises are true, the conclusions are not made more likely.

A. Appeal to unqualified authority (argumentum ad verecundiam)

"The witness, who has never touched a gun and is terrified of them, states that she thinks the firearm used in the crime was a revolver. But I guess we have to go with that."

B. Appeal to ignorance (argumentum ad ignorantiam)

"No one has ever come forward to say that the subject ever lost his temper or even raised his voice in anger. Therefore he just isn't capable of killing his children."

C. Hasty generalization (converse accident)

"Half the scumbags living within a six-block radius have a drug habit. The other half must be dealing drugs."

D. False cause

"The crime rate is steadily rising. Clearly the police are falling down on the job."

E. Weak analogy

"A landlord can enter an apartment to check on its condition. So the police don't need a search warrant to enter if they are only interested in the condition of the premises and aren't really searching for anything."

III. Fallacies of presumption, ambiguity, and grammatical analogy

A. Begging the question (petitio principii)

"There was a full moon the night the crime occurred, and the weather was clear."

(Ignoring the fact that the crime occurred at 11 pm and the moon didn't rise until 3 am.)

B. False dichotomy

The fallacy of false dichotomy occurs when a statement offers two alternatives, but two alternatives only. The classical fallacy is the question: "Have you stopped beating your wife?" The fallacy results from the alternatives not being exhaustive. A similar fallacy occurs with complex questions: "Where did you stash the murder weapon?"

C. Suppressed evidence

The fallacy of suppressed evidence occurs when a premise ignores a vital piece of evidence that outweighs the evidence actually presented and results in an entirely different conclusion. For example, "The scene shows no sign of forcible entry. Therefore the crime must have been committed by a member of the family." (This ignores the fact that entry may have been accomplished without force.)

D. Equivocation

The fallacy of equivocation occurs when a conclusion hinges on a concept that is used in two different senses in the same argument. For example, depending on how it is used, the word "bad" may have two connotations. "The victim had a bad experience. Therefore she must have been a bad person."

E. Amphiboly

The fallacy of amphiboly occurs when an ambiguous statement is misinterpreted, and the conclusion is then based on the faulty interpretation. For example, "Witness A told Informant B that he had made a very bad mistake. If he was able to admit that, then he is probably being truthful in his account of other details."

F. Composition

The fallacy of composition occurs when a narrow attribute, truthful in isolation, is applied to a broader proposition. For example, "The witness was known to have liked ice cream cones, and liked liver and onions as well. Therefore he would have liked a liver and onion flavored ice cream cone."

G. Division

A fallacy of division is the opposite of a fallacy of composition. It occurs when a conclusion involves an application of an attribute, truthful in its own right, from a broad proposition to a specific instance. For example, "Members of the gang wear red to show their affiliation. The victim was wearing red. Therefore he must have been a gang member."

Note, however, that although the progression of logic is defective in this instance, there are other instances in which this application of an attribute is legitimate. There is no lapse in logic to the reformulation of the previous statement as "The victim was a gang member. That explains why he was wearing red."

BEYOND FALLACY: SKEWED AND ERRONEOUS RECONSTRUCTIONS

Apart from lapses in logic, where else may the process of crime reconstruction go awry? Several possibilities present themselves: (1) bias, (2) deliberate but legally ordained deception on the part of police investigators, (3) the outright fraud, (4) the hurried, (5) the inexperienced, and (6) the honest reconstructionist subjected to pressure.

Bias in Crime Reconstruction

In the pursuit of professional responsibilities, fallacies are not the only shoal waters. Bias is another treacherous area; both may result in erroneous reconstruction. Fallacies arise from a glitch in logic, whereas biases arise from guile. It may be unintended guile, and generally is unintended, but it is guile nevertheless. Biases result from held beliefs whose applications are inappropriate to the issue at hand, beliefs whose application is not relevant to the technical issues of the crime reconstruction. Bias is discussed in detail in subsequent chapters³ and is given only a light dusting here.

It is beyond cavil that bias may cause a person to color their perceptions of things. The avoidance of both fallacy and bias requires that it be (1) recognized and (2) controlled. In any given situation, one may have dominion over the other. Bias enters into virtually every aspect of human endeavor, and crime reconstruction is not immunized against it.

There are many types of bias and, depending on the issue under consideration, each type may beget progeny. Some biases are obvious, others less so. A responsibility exists to quell them or, if possible, to altogether vanquish those that may be applicable to a given situation. That is only possible, however, if they are first recognized. Biases are legion. Common types are mentioned here, but it is much more important to recognize them than to know the names of them. Of these,

³ See Chapter 4: Observer Effects and Examiner Bias: Psychological Influences on the Forensic Examiner, and Chapter 5: Practice Standards for the Reconstruction of Crime.

contextual bias and confirmation bias are generally considered to be the two most treacherous, and for these, examples are given.

Contextual bias—being influenced by factors that do not form a legitimate part of one’s technical work. “The suspect has confessed that he was standing over here when he began to shoot. He says he shot twice from over here, and then moved to the other room.” The suspect may be correct, or may be incorrect, but it should be the evidence that speaks, not the suspect or another interested party.

Confirmational bias—the interpretation of evidence partial to existing beliefs. “After hearing the suspect’s explanation, I knew in my heart-of-hearts that he was lying.”

Outcome bias—the tendency to gauge a decision by a conception of its eventual outcome instead of on the quality of the decision at the time it was made.

In-group bias—the tendency to give more credence to the position of others perceived to be members of their own group.

Blind spot bias—the tendency not to compensate for one’s own cognitive biases, even when evidence to the contrary is present or perhaps even abundant.

Negativity bias—the tendency to choose and evaluate things based on an inclination to avoid negative experience rather than the desire to advance a positive view. This is also termed “avoidance” bias.

Selection bias—a distortion of evidence arising from the manner in which the evidence is collected.

Authority bias—the tendency to accept the opinion of someone presumed to be an authority on the subject.

Self-serving bias—the tendency to perceive oneself responsible for favorable outcomes but not responsible for unfavorable ones.

Information bias—the tendency to seek and develop information and factor it into a conclusion, even when that information does not exist or when it is irrelevant.

Omission bias—the tendency to judge harmful actions as worse, or less moral, than equally harmful omissions or inaction.

Some biases are exceedingly seductive. Authority bias, mentioned earlier, is a tendency to gauge evidence, perhaps ambiguous in its own right, according to the opinion of someone in a position of authority on the subject. Deference to authority is often the truly correct position to take, but the issue here is that the evidence is ambiguous, and the experience of the person in authority may be incomplete or irrelevant.

Some biases are more or less universal, particularly those that tend to maintain one’s self-esteem. But many others tend to be idiosyncratic and are not shared with others. The significance of this is that a reconstructionist may confer with a colleague to discuss a case, and in the ensuing discussion, the specter of a bias may raise its fearsome head. In this fashion, bias may be dealt with effectively.

Deliberate Deception

Something must be said about the police practice of misrepresenting evidence in order to induce a confession from a suspect. In the interrogation of a suspect, police investigators may claim to have reconstructed a crime in such a fashion as to implicate a suspect, when in fact they

are bluffing. This is duplicitous but has been condoned consistently by our courts and tolerated by our society.

It should be understood, however, that crime reconstruction rendered for this purpose is fiction. Some elements may be reported truthfully, but the component linking the suspect to the crime is not credible, and the police investigator knows well that it is not. This is not actually crime reconstruction any more than the mystery writer conjuring up a story engages in crime reconstruction. There is no ethical obligation on the part of the investigator to represent the reconstruction correctly and truthfully since deception has set the tone in the first place. But this practice is outside the penumbra of crime reconstruction as understood by ethical crime reconstructionists. This traditional police procedure, although not considered unethical in terms of our developed culture, stands off to the side of ethical crime reconstruction.

There is no reason to criticize police for enthusiasm, but deliberately duplicitous reconstructions may pose a potential threat to the tone of the work, attitudes, assumptions, and philosophies of the reconstructionist. A judge, hearing of a deliberately misrepresented reconstruction concocted for the purpose of enticing a confession, will be much less inclined to accept any subsequent reconstructions from that reconstructionist.

The Fraud

In every profession and in every aspect of human endeavor there are a few individuals who misplace their ethical compass. Often, this is the reason that a crime has occurred in the first place. It would compound the tragedy if this occurred in crime reconstruction as well. Within the ranks of those responsible for crime reconstruction, there have been a very small number of outright dishonest people, but alas the number has not been zero. Occasionally, someone is caught falsifying evidence, testifying untruthfully, or engaging in some activity that is not only unethical but also downright illegal. These people do not belong in the cadre of crime reconstructionists; they belong in jail. The community of crime reconstructionists should be perpetually alert to the possibility of malfeasance and should be merciless in the condemnation of corrupt professional practices. But certainly there is nothing that could be said here that would totally prevent these occasional lapses any more than the Ten Commandments have vanquished all crime and social evils.

Haste

In crime reconstruction, an “honest mistake” may have terribly severe consequences. Innocent people may be implicated, and guilty ones exonerated. As developed elsewhere in this discussion, a mistake resulting from carelessness may be elevated to an ethical concern. In discussing ethics in connection with document examination, [Hilton \(1976, p. 780\)](#) states that most ethical dilemmas arise from carelessness or lack of thoroughness resulting from haste.

The Inexperienced

More deserving of our tolerance, but a threat nevertheless, is the tyro—the inexperienced or the beginner who is unfamiliar with the unique role that the crime reconstructionist plays in the legal system. Many of these will be honest, capable people who are suddenly called upon, with

little experience and perhaps less training, to make judgment calls that may affect the conduct of an investigation. Some of these people may have an inescapable responsibility to conduct crime reconstruction (e.g., police investigators) but simply are inexperienced. Others may be brought to the table because of their particular expertise who are coincidentally called upon to perform some activity necessary for a particular investigation (e.g., engineers, physicians, dentists, chemists, physicists, geologists, and perhaps even rare coin dealers and diesel mechanics). These people may have an incomplete grasp of the proper ethical stance to assume. From where would they learn of it? Whatever ethics they bring to the reconstruction will consist of their preconceived notions of how the world is put together, how it operates, and how it ought to act. A great premium must be placed on the ability of any person acting as a crime reconstructionist to “get it right,” whether they act in this capacity on a routine basis or only once in a lifetime. To these concerns may be added a sincere but misplaced desire to please the agent or agency that has requested an examination—that is, to fulfill the confirmatory function expected of the examiner, even in the absence of external pressure.

The Honest Crime Reconstructionist Subjected to Pressure

It is essential that the crime reconstructionist deliver an opinion that will not plant a false impression in the mind of, well, anyone. Not in the mind of the recipient of an oral report or the reader of a written one. Not in the minds of the jury, the trial judge, or a journalist. The implication of this is that on some occasions the reconstructionist must be prepared to thwart the will of the entity on whose behalf the reconstructionist has been called and to resist any pressure exerted by that agency.

The crime reconstructionist employs the scientific method. But practicing the scientific method within the confines of the legal system instantly precipitates certain potential problems. Certain of these problems arise from the crime reconstructionist operating within a police agency. Some investigators view an undifferentiated community of convicted criminals, suspects, defendants, and potential suspects as the enemy, to be vanquished as quickly as possible and with the use of whatever tool is at hand. If they can use proper science to apprehend and convict a miscreant, fine. If they cannot do it with proper science and must resort to improper or indifferent science, that is okay too. If the crime reconstructionist must work within this milieu, it is likely that sooner or later there will be an attempt on the part of even an erstwhile investigator to pressure the reconstructionist into an opinion that favors the investigator's perception of the case.

Pressure from attorneys, on both the prosecution and the defense side, may be even more relentless, as their canon of ethics allows them, within bounds, to be insincere. Attorneys are legitimately propagandists of a particular point of view. They are advocates, and they want their views to prevail. Until they are told differently, they may wish to enlist the reconstructionist in their efforts. Apparently no one ever bothers to tell them in law school that the crime reconstructionist is not their trained seal.

This is an aspect of a basic dilemma between law and science. Crime reconstruction is, or certainly it should be, an application of the scientific method. Science takes the establishment of truth as its fundamental goal. Crime reconstruction, as the handmaiden of the legal process, takes the pursuit of justice as its goal. Truth and justice are not enemies, but they are not the same thing, which has caused and will continue to cause a certain tension between the two disciplines.

Perhaps the best way to avoid having anyone apply pressure for a particular finding is not to give anyone a reason to believe that they would be successful in doing so. If a police investigator believes that he and the reconstructionist are kindred spirits in helping stamp out the dark forces of evil, this notion will be acted upon and even exploited. If, however, the investigator has reason to believe that the reconstructionist will refuse to succumb to suggestion, fewer attempts will be made and those that are made are likely to be feeble and perhaps even jocular. Police investigators should be made to understand that crime reconstruction is more than a casually offered surmise and that the crime reconstructionist must honor a high standard of objectivity.

The way to avoid being pressured by attorneys, investigators, or anyone else to “put the best face” on the evidence—that is, the best face as they perceive that face to be—is not to yield the first time. If the crime reconstructionist demonstrates a manner of professional chastity and does not yield the first time, it will establish the tenor of the relationship between the attorney and the reconstructionist on terms that the attorney will have to accept. Attorneys do not invite others to shape and form their canon of ethics. It is only fair that they should not dictate how crime reconstructionists should approach their own ethical stance.

Reconstruction Based on Unevaluated Surmise

A crime reconstruction is an opinion. It must be based on the evidence, but there is a component of the reconstructionist’s experience as well—experience born of common sense and experience born of education and training. However, the issuance of an opinion where experience is substituted for defensible fact is treacherous. An opinion that is not subjected to testing is nothing but a surmise. There is an obligation to test an opinion. This may be as abbreviated a process as projecting the evidence against a gestalt of past experience and against a standard of plausibility or may require something considerably more. Reasonable tests may simply not be available in the armamentarium of techniques available to the reconstructionist. However, if tests are available, the most rigorous among them should be selected and applied. The evidence should be evaluated in light of that testing before an opinion is advanced to whatever agent or agency has requested the reconstruction.

How may one guard against this potential pitfall? The following three measures present themselves.

1. By setting appropriate thresholds by means of which a rational mind may be convinced of a fact. These thresholds must be set fairly high and approached with healthy skepticism. This skepticism must be applied to experience as well.
2. If a theory or hypothesis of how the crime occurred cannot be tested or evaluated fully, then that theory or hypothesis should be clearly labeled as tentative; any opinions delivered should be accompanied by appropriate qualifications.
3. Recognizing that the physical evidence may not tell the whole story of what happened, but only isolated bits of the entire drama.

A CANON OF ETHICAL CONDUCT FOR THE CRIME RECONSTRUCTIONIST

The establishment of a canon of ethics, and the enforcement of that canon, is more or less universally construed as contributing to the maturity of a profession.

Types of Ethical Canons

Canons of ethics tend to be one or the other of two kinds—a very abbreviated code, which in essence says, “Thou shalt do no wrong,” and detailed codes, which set forth the specific types of activities that a profession would wish to encourage and those it would wish to proscribe. Ethical codes have been developed for police professionals, such as the *Law Enforcement Code of Ethics* (International Association of Chiefs of Police, n.d.), and for forensic scientists (American Academy of Forensic Sciences, n.d.; California Association of Criminalists, n.d.). The fledgling (September 2009) Society for Wildlife Forensic Science has promulgated an excellent code, which may be found on their Web site (www.wildlifeforensicscience.com). The Subcommittee on Forensic Science of the National Science and Technology Council, Office of the President of the United States, has an Interagency Working Group to consider the issue of ethics within a forensic setting (http://www.forensicscience.gov/iwg_ethics.html). The *Journal of Forensic Sciences* has published a symposium on ethical conflicts in the forensic sciences (*Journal of Forensic Sciences*, Vol. 34, No. 3, May 1989). Portions of published codes are applicable to crime reconstruction, but an ethical code that focuses particularly on crime reconstruction has not been put forward. The following discussion is an attempt to do so.

Building a Reputation: It’s Not about You

In practice, those involved in crime reconstruction soon develop a local reputation among investigators, prosecutors, defense attorneys, and judges. Some are seen as honest and unbiased, whereas others are seen as tilting toward one or the other of the contestants. It is far easier to maintain the former reputation, once achieved, than it is to rebut the latter.

As discussed previously, the very nature of the legal system invites a certain amount of pressure being placed on the crime reconstructionist. It is exceedingly rare for this pressure to be applied crassly, as in “If you don’t write a report stating that the suspect was deliberately lying in wait for the victim and then shot him in cold blood, we will take it as a sign that you are unhappy with your job here.” More often, it is much more insidious, as in “What do you mean that you can’t say that the suspect was lying in wait? He almost said as much in his statement.” The way to deal with this sort of pressure, from whomever, is to communicate fully—to talk about what you will be able to prove and to talk about what you would be able to justify in your reconstruction and what you would not. It is generally helpful to deflect the conversation away from you, the reconstructionist, and back to the specifics of the evidence present at the scene. It is not about you, it is about the evidence—what it is capable of showing.

The Professional Canon of Ethics for the Reconstructionist

One simple device that may assist the crime reconstructionist in maintenance of a proper professional stance against external pressure is a printed statement of ethical behavior posted conspicuously in his or her office. A consulting reconstructionist could have it posted on his or her Web site. This may read something along the lines of the following.

1. As a practicing crime reconstructionist, I pledge to apply the principles of science and logic and to follow the truth courageously wherever it may lead.

2. As a practicing crime reconstructionist, I acknowledge that the scientific spirit must be inquiring, progressive, logical, and unbiased.
3. I will never knowingly allow a false impression to be planted in the mind of anyone availing themselves of my services.
4. As a practicing crime reconstructionist, it is not my purpose to present only that evidence which supports the view of one side. I have a moral and professional responsibility to ensure that everyone concerned understands the evidence as it exists and to present it in an impartial manner.
5. The practice of crime reconstruction has a single professional demand—correctness. It has a single ethical demand—truthfulness. To these I commit myself, totally and irrevocably.
6. The exigencies of a particular case will not cause me to depart from the professionalism that I am required to exercise.

It is hoped that the crime reconstructionist would have embraced these covenants in any event and that they are not just for show. Nevertheless, a published display will serve notice to everyone that the reconstructionist is unlikely to be receptive toward efforts to encroach upon these principles. In short, this posted statement may prevent someone from attempting to manipulate the reconstructionist. Additionally, when faced with any ethical dilemma, the crime reconstructionist should seek the counsel of other professional colleagues or should seek the aid of a professional organization that has established ethical guidelines.

SUMMARY

Ethos refers to the moral, ideal, or universal element in something, as opposed to that which is subjective or emotional in its appeal. The crime scene has a certain character, a certain essence. It has been given form and has been shaped by the laws of nature and by the vagaries of human conduct. The crime scene is an entity of sorts. It has its own ethos, as do the processes by means of which the scene is reconstructed.

Along with ethos is an ethic—a moral obligation to maintain the integrity of the processes by means of which the reconstruction is accomplished. An ethical obligation exists to ensure that the professional responsibilities attendant in forensic practice in general, and crime reconstruction in particular, are honored. “Getting it right” involves more than guessing correctly. It necessitates a systematic process. It involves the proper recognition of the evidence, the winnowing of the relevant wheat from the irrelevant chaff, and the precise application of logic, both inductive and deductive.

Logic refers to the science that evaluates arguments. There is a professional obligation to employ proper logic and an ethical obligation to recognize this professional obligation. Valid conclusions based on valid logic are essential, as is the avoidance of *fallacies of logic*. Fallacies of logic are generally categorized as fallacies of relevance; fallacies of weak induction; and fallacies of presumption, ambiguity, and grammatical analogy.

Apart from lapses in logic, the process of crime reconstruction may go awry for different reasons. These reasons include (1) bias, (2) deliberate but legally ordained deception on the part of police investigators, (3) the outright fraud, (4) the hurried, (5) the inexperienced, and (6) the honest reconstructionist subjected to pressure.

QUESTIONS

1. Define *ethos* and *ethic*.
2. List the three types of errors.
3. Explain the difference between an *inductive argument* and a *deductive argument*.
4. List and define three types of bias.
5. List three *fallacies of logic*.

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Observer Effects and Examiner Bias: Psychological Influences on the Forensic Examiner

Craig Cooley and Brent E. Turvey

Men generally believe quite freely that which they want to be true. –*Julius Caesar, from “(H)omines fere credunt libentur id quod volunt.” G.J. Caesar, Caesar’s commentaries on the Gallic War 155 (51 bce)*

Key Terms

Bias; Cherry-picking; Cognitive psychology; Forensic identification scientists; Institutional bias; Observer effects

Our assumptions define and limit what we see, i.e., we tend to see things in such a way that they will fit in with our assumptions even if this involves distortion or omission. We therefore may invert our title and say “Believing Is Seeing.” –*Johnson (1953, p. 79)*

[T]he history of science generally, and the history of psychology more specifically, suggests that more of us are wrong longer than we need to be because we hold our theories not quite lightly enough. –*Robert Rosenthal as quoted in Zuckerman (1992)*

Dr. *Paul L. Kirk (1974, p. 4)*, pioneering criminalist, wrote “Physical evidence cannot be wrong; it cannot be perjured; it cannot be wholly absent. *Only in its interpretation can there be error*” (italics added). This passage is of significance to forensic scientists because they are defined by their interpretive role with regard to physical evidence. The challenge is that much of what they are confronted with is ambiguous—evidence that might be interpreted in more than one way depending on a variety of subjective influences.

THE PROBLEM OF OBJECTIVITY

When asked about bias, the majority of forensic scientists claim that they are entirely objective when performing their analyses, or that they try very hard to be. They also hold firm that their employer, their emotions, and their personal beliefs gain no influence on their final conclusions. To admit otherwise would be professional suicide, as objectivity and emotional detachment are prized above all other traits in the course of a forensic examination. One could even argue that these are the defining traits.¹

Given the professed objectivity of forensic scientists, and their scientific training, it could be asked how bias might persist in their results. This is a perfectly reasonable question. Some claim that it does not, and that an objective attitude combined with scientific training is sufficient to cure most, if not all, ills that may infect forensic examinations and subsequent results. However, this is untrue because it ignores a fundamental principle of cognitive psychology—the pervasive existence of observer effects.

As cognitive psychologists have documented, tested, and proven repeatedly, “[T]he scientific observer [is] an imperfectly calibrated instrument” (Rosenthal, 1966, p. 3). Imperfections stem from the fact that subtle forms of bias, whether conscious or unconscious, can easily contaminate what appears outwardly to be an objective undertaking. These distortions are caused by, among other things, **observer effects**. This particular form of bias is present when results of a forensic examination are distorted by the context and mental state of the forensic scientist, to include subconscious expectations and desires.

Identifying and curtailing observer effects are considerable tasks when one takes into account the forensic community’s affiliation with both law enforcement and the prosecution. Specifically, this association has fashioned an atmosphere in which an unsettling number of forensic professionals have all but abandoned objectivity and have become completely partial to the prosecution’s objectives, goals, and philosophies.² They may even go so far as to regard this association as virtuous and heroic, and believe any alternative philosophy to be morally bankrupt. So strong is the influence of this association between forensic science and law enforcement that some forensic scientists have deliberately fabricated evidence, or testified falsely, so that the prosecution might prove its case; however, this is the extreme end of the spectrum.³

¹ For instance, according to Dr. Henry Lee (1993), “The adversarial relationship between the state and a defendant tends to place the forensic experts engaged by one side or the other into an adversarial relationship. . . . Nevertheless, most forensic scientists, regardless of who employs them or engages their services, think of their results as entirely objective and try not to allow themselves to be forced into adversarial roles.”

² Giannelli (1997) discusses how the forensic community’s structural configuration has created many prosecution forensic scientists; the NAS report, reviewed in the Preface, explains that law enforcement and forensic science cultures must be separated because of the very different missions that each undertakes; that because so many forensic scientists work as subordinates within a law enforcement agency or culture, they may forget that they are scientists and instead continually seek to join or at least gain the approval of the prosecution team (Edwards and Gotsonis, 2009).

³ Bales (2000) discusses many instances concerning FBI examiners; Turvey (2003) reviews the nature and motivations of 42 overt forensic fraudsters (not merely the inept or ignorant), finding that “in 34 (81%) of 42 total cases, forensic fraud was committed on behalf of the prosecution, and most often by law enforcement crime lab personnel.”

It is fair to say that the majority of forensic science practitioners acknowledge the existence of overt forms of conscious bias. That is, they generally recognize and condemn forensic ignorance, forensic fraud, and evidence fabricators when they are dragged into the light and exposed for all to see. When asked, most can recount specific instances they've seen or learned of, some involving severe consequences for the forensic scientist involved and others involving no consequences.⁴

The forensic science community is attenuated to the potential for extreme forms of outright fraud and overt bias, especially given widespread coverage of the increased and repeated major crime lab scandals since the mid-1960s. However, it tends to be wholly unaware when it comes to understanding and accepting that well-documented forms of covert bias can taint even the most impartial scientific examinations. This remains true even with the publication of the NAS report (Edwards and Gotsonis, 2009; discussed in the Preface), as too many forensic scientists have failed to read it or be questioned about its findings under oath. This is disheartening for the simple reason that covert and subconscious biases represent a far greater threat to the forensic community than the small percentage of overtly biased, dishonest, or fraudulent forensic examiners.

COGNITIVE PSYCHOLOGY: A PRIMER

To grasp the elusive yet powerful nature of subconscious bias requires a brief lesson in cognitive psychology. **Cognitive psychology** is the psychological science that studies cognition, the mental processes that are believed to underlie behavior. This includes examining questions about the workings of memory, attention, perception, knowledge representation, reasoning, creativity, and problem solving.

The following is a well-established principle of cognitive psychology: individuals' desires and expectations can influence their perceptions, observations, and interpretations of events. In other words, the results of one's observations are dependent on at least two things: (1) the object or circumstance being observed and (2) the person's state of mind. Cognitive psychologists have coined several terms to describe this phenomenon, including *observer effects*, *context effects*, and *expectancy effects* (Neisser, 1976; Risinger et al., 2002; Rosenthal, 1966; Saks et al., 2003). This chapter uses all three to describe different manifestations of subconscious examiner bias, but readers may consider them essentially interchangeable.

PURPOSE

The purpose of this chapter is to remedy the omission of observer effects as a subject of study in the practitioner-oriented forensic science literature for the benefit of all forensic examiners. Furthermore, it is hoped that this will foster discussion of the subject by those practicing

⁴ Forensic science agencies and professional organizations have a history of protecting the inept and unethical within their ranks, or simply turning a blind eye, to preserve their organizational reputations.

now and in the years to come. We begin by covering the predominant observer effects that may influence forensic examiners: prescreened evidence, single sample testing, attorney–investigator communication, contradictory findings, and selective reexamination. Mechanisms for dealing with observer effects are then outlined, including awareness, evidence lineups, blind testing, and filtering domain-irrelevant information.

The ultimate goal of this chapter is not to convince forensic examiners that they are inherently biased and should therefore change careers. Rather, it is to help them recognize and identify the potential influences of observer effects within their own work. Ultimately this will help blunt them to the extent that this is possible.

OBSERVER EFFECTS

As Professor D. Michael Risinger and colleagues (2002) explained in their groundbreaking law review article on observer effects in forensic science, many different forms of observer effects exist (p. 9): “At the most general level, observer effects are errors of apprehension, recording, recall, computation, or interpretation that result from some trait or state of the observer.” These covert biases are more concerning than deliberate fraud and misconduct because they are often misperceived, or even thought of as beneficial, and therefore tend to go undetected.

In order to blunt the impact of observer effects, scientists must be aware that they exist and can significantly influence their analyses and results. Once recognized, they can also be studied and understood; once understood, they can be addressed and even mitigated. All scientific disciplines accept the need to blunt examiner bias and observer effects as a given and it is reflected in their published research. Put simply, “[s]ensitivity to the problems of observer effects has become integral to the modern scientific method” (Risinger et al., 2002, p. 6).

A History of Neglect

The observer effect phenomenon should be of particular concern to forensic scientists, especially reconstructionists, because so much of their role involves the selective recognition, documentation, and interpretation of physical evidence, the meaning of which hinges on objectivity in their observations. In this regard, forensic scientists have tremendous authority and an immense responsibility. If their examinations are distorted in any fashion, the results can be catastrophic for everyone concerned. It naturally follows that developing and imparting an understanding of observer effects would rate high in the consideration of forensic scientists when interpreting evidence, writing reports, conducting research, and teaching students. Sadly, as already mentioned, this has not been the case.

Historically, subconscious observer effects have not been discussed, or even mentioned, in most forensic science texts (Ashbaugh, 1999; De Forest et al., 1983; Fisher, 1999; Heard, 1997; Houck and Siegel, 2006; James and Nordby, 2003; Lee et al., 2001; Saferstein, 2001) or reference works (Saferstein, 2002, 2004; Siegel et al., 2000), although Inman and Rudin (2000) provide what is arguably a serious discussion of related issues in several sections of their exploratory treatise, *Principles and Practice of Criminalistics*.

The only forensic science texts to focus on these subjects are the first edition of this text (and this second), the NAS report (Edwards and Gotsonis, 2009),⁵ and Turvey and colleagues (2010).

Likewise, no forensic science programs, undergraduate or graduate, regularly teach students about (1) observer effects in general and (2) how these effects may thrive in a government crime lab that is annexed with a law enforcement or prosecutorial agency. Future forensic scientists are not made aware of how to recognize them, or to guard themselves and their results from their influence. They are not even told that they exist and that they are anathema to good science.

Despite the lack of specific mention in major forensic texts and forensic science curricula, one could perhaps argue that forensic scientists have conducted comprehensive experiments designed to better learn the circumstances under which observer effects arise in their work and how examiners may take pains to tame them. In other words, one could argue that just because observer effects are not mentioned in books and classrooms does not mean that forensic scientists are necessarily ignorant of the subject.

Regrettably, this argument cannot be made because little such experimentation has been reported.⁶ The limited research of Itiel Dror and colleagues on fingerprint comparison errors (e.g., Dror et al., 2006; Dror and Charlton, 2006) deserves attention here. As explained in Saks and Koehler (2008, pp. 201–202):

A study by Itiel Dror et al. found that four of five fingerprint experts who previously had identified two prints as a match reached different conclusions on a later examination, after they learned that the prints were from different persons. In a follow-up study, six other fingerprint experts were provided with eight pairs of prints that they previously had judged. The study found that introduction of contextual information induced four of the six experts to change at least one of their previous match judgments. Some pairs that were judged to be exclusions subsequently were judged to be matches, and vice-versa. Surprisingly, some experts made inconsistent decisions in the control condition where contextual information was not introduced (thus reflecting random, and not systematic, error). These results suggest that criminalists should employ the same kind of blind examination procedures that are used widely in other fields. Such procedures would protect first-stage judgments from the contextual influences that contribute to errors.

Dror and colleagues aside, forensic sciences are among the very few “scientific” disciplines that have failed to concede the existence and impact of observer effects, let alone study them. This is no small omission, as will be discussed later.

Unaware and Overconfident

Because the forensic community has generally neglected this basic principle of cognitive psychology and good research methodology by failing to account for subconscious examiner influences on research and casework, the following tends to be true:

⁵ The impact of the NAS report on the forensic science community is still unknown, although the authors have found that very few forensic practitioners have read it for lack of any belief that it is relevant. However, it is true that a number of forensic science organizations (national and regional alike) have released position statements regarding the NAS report, voicing both agreement and disagreement—as none of them would prefer to be called biased or ineffective. The extent to which this will translate into substantive reform is unknown.

⁶ The authors concede that this kind of experimentation may be going on within agencies that do not report their findings or seek to have them published.

- Forensic scientists are unaware that observer effects exist and can impact their examinations and results,
- Forensic scientists naively profess to be aware of subconscious observer effects yet refuse to admit that anything could possibly impact their conclusions; they claim that they have been trained to be objective and can, by exercising a unique willpower, purge their minds of any impurities (conscious and subconscious alike) that may taint their analyses.

With respect to the latter situation (i.e., “these effects cannot distort my analysis”), what some forensic scientists are in fact claiming is that their training montage consists of learning a special ability that is denied all other scientific disciplines, which makes them invulnerable to subconscious influences. This position is not defensible, although many upper-tier forensic scientists continue to profess otherwise.

For instance, it appears that some forensic pathologists may adhere to the latter position (i.e., “I can disregard any biasing evidence so my conclusions will not be distorted”). Consider the following passage from a commonly referenced forensic pathology textbook (Di Maio and Di Maio, 1993, p. 14):

[The police] prefer the charlatan who tells them what they want to hear to the expert who tells them unpalatable truths or that conclusions cannot be made. One of the characteristics of the unqualified expert in forensic pathology is an ability to interpret a case in exquisite detail. This “expert” sets the time of death, plus or minus a few minutes, accurately positions the deceased, and gives detailed analysis of the events surrounding the death and precise deductions about the assault. If the police have expressed prior opinions, it is not uncommon for the opinions of the “expert” to agree almost in complete detail with the police hypotheses. The experienced forensic pathologist tends to hedge, knows there may be more than one interpretation of a set of facts, and is more “wishy-washy” than the charlatan.

While explaining that law enforcement suggestion and pressure represent major conscious obstacles for the “unqualified” forensic pathologist, this passage suggests that the “qualified” forensic pathologist will have the necessary skill and resilience to remove any bias from the information he or she received prior to rendering a final autopsy report. The authors do not explain how this is actually accomplished, only that it is.

This is not an isolated view. Similarity can be seen in the following statements.

- “Although the laboratories are intended primarily to assist the police, the work is carried out under the sole control of the director who makes his reports as an entirely independent investigator, that is to say irrespective of whether they favor the prosecution or the defense; they may therefore, be used subsequently in Court by either side” (Grant, 1941, p. 16).
- “For forensic science practitioners to perform their function properly within the legal system, they must exercise independence and integrity. Stated simply, forensic scientists cannot be biased for or against an investigation in which they are involved. The job of each practitioner is to champion his or her expert opinion based on accepted, properly performed scientific inquiry. Forensic scientists who understand their roles in a democratic criminal justice arena help to protect individual rights and freedoms while ensuring that justice is delivered” (Fisher, 1993, p. xxiv).

Although Grant and Fisher both state the obvious—forensic scientists must be neutral and objective—they seem to suggest, particularly Fisher, that only overt biases, such as purposeful fraud or misconduct, can destroy an examiner’s neutrality and objectivity. As this chapter highlights, such a suggestion is misinformed. An examiner’s objectivity and neutrality can be

compromised unknowingly and easily in a variety of ways in today's publicly funded crime labs. Consequently, forensic scientists will better "help protect individual rights and freedoms" once they acknowledge that they, like their counterparts in every other scientific discipline, can fall prey to observer effects.

EXAMPLE

Leaders in the forensic science community are not immune from ignorance on the subject of observer effects. One of the authors of this chapter (Cooley) served as a scientific evidence panel member at a death penalty symposium at the Indiana University School of Law. The author's presentation registered concern with the panel regarding the forensic community's misunderstanding of, and even indifference toward, the need to acknowledge and deal with subconscious influences on evidence interpretation (a.k.a. observer effects).

Immediately following the panel discussion, a copanelist (Dr. Carl Selavka) approached the author and said, "I have never heard of observer effects or examiners' biases. However, even if these effects do exist they cannot and do not affect my interpretations because I am an objectively trained scientist" (C.M. Selavka, personal communication, September 10, 2004).⁷ Dr. Selavka is a Ph.D.-educated chemist who served as director for a large state police laboratory system. The copanelist's second claim (i.e., "observer effects cannot taint my analysis"), like the "qualified" forensic pathology argument, demonstrates a general ignorance pertaining to the subconscious nature and potential influence of observer effects. Dr. Selavka, while certainly well intended, demonstrates how leaders in the forensic science community may be unaware of, and unprepared for, observer effects. However, this also begs the question of whether those he has educated, trained, and supervised over the years may suffer a similar condition.⁸

As [Risinger and colleagues \(2002\)](#) explain, the notion that observer effects can be willed away is unfounded (p. 51):

Every field that has considered the problem has concluded that it cannot be solved merely by trying to will it away. When everyone from Nobel prize winners to average citizens, who informally subject themselves to home-made "blind taste tests," take steps to make sure their judgments are not distorted by extraneous context information, then it is hard to conceive of what it is that makes forensic scientists think they are immune from the same effects.

Neglect and misunderstanding toward observer effects have prevented and continue to prevent the forensic community from developing procedures that could minimize their impact. With no preventative measures in operation, these imperceptible effects thrive in an environment that provides two powerful ingredients for the distillation of subconscious examiner influence—ambiguity and expectation. As a result of this collective ignorance and inaction,

⁷ Dr. Selavka made these comments to Cooley immediately after their panel discussion for the "Toward a Model Death Penalty Code: The Massachusetts Governor's Council Report" symposium at Indiana University School of Law. See "[Symposium: Toward a Model Death Penalty Code](#)" (2005).

⁸ In 2007, after serving as lab director since 1998, Dr. Selavka was forced to resign under tremendous pressure in the wake of a major DNA scandal uncovered by a federal inspection ([Saltzman, 2007](#)).

even the most neutral forensic scientists may offer conclusions that are imprecise, erroneous, or misleading, even when achieved through validated forensic techniques (Saks, 2003).

THE THIRD RAIL

At this point, it is natural for students of forensic science to ask why the forensic community they seek to join has neglected to openly discuss or study observer effects and their impact. Especially since every other legitimate science has done so.

Conversations with colleagues across the legal and scientific spectrum spanning two decades of forensic practice led the authors to an inescapable conclusion. Mention of the existence of overt bias is enough of a sore point among some law enforcement and prosecution-employed laboratory personnel without having to concede the existence of subconscious and ultimately unknown observer effects. Furthermore, many forensic scientists and reconstructionists are employed directly by police agencies or by crime labs affiliated with, or under the direction of, law enforcement (to include the prosecution). Consequently, open discussion and study of examiner bias has long been considered a “third rail” in the forensic community. Only in this text, and in the NAS report that followed the first edition (Edwards and Gotsonis, 2009), has this subject been up for serious discussion.

A brief explanation is warranted: The third rail is the method of providing electrical power to a railroad, such as a mass transit system, by means of an exposed conductor. Anyone who makes the mistake of touching the third rail is killed instantly by a surge of electricity. So it is with the issue of observer effects and their influence on subconscious examiner bias because such a discussion necessarily involves critical review of the actions and motives of both law enforcement and prosecutorial agencies. These are not professional communities that are generally perceived as receptive of criticism or review, and they are frequently hostile to external or independent efforts involving either.

The hostility of law enforcement toward open discussions of bias would not ordinarily be a problem for a scientific community, except, again, law enforcement actually employs a majority of the forensic scientists and reconstructionists whose subconsciously influenced results are at issue. Therefore, this is not an ordinary scientific community—the community that employs the forensic examiner is also the community that puts him or her at risk for observer effects. Any forensic scientist who raises this issue risks touching the third rail—being the object of hostility and derision within the law enforcement and government lab community, and losing not only employment but also friends and, in some cases, professional identity. This is what is at stake, and it must not be trivialized. These are the very things we aspire to. To risk their surrender is unimaginable for most.

To be perfectly blunt, this situation cannot be allowed to continue. The inability to have an open discussion about the impact of observer effects among forensic examiners, independent of agency or employer, severely hampers the professional growth of all forensic sciences. Good science works to account for bias—it does not ignore it or profess that it does not exist. To that end, this work and the NAS report (Edwards and Gotsonis, 2009) have been important steps in the right direction.

SUBJECTIVITY AND EXPECTATION IN FORENSIC SCIENCE

As mentioned previously, observer effects are governed by the fundamental principle of cognitive psychology asserting that the subconscious needs and expectations shape both perception and interpretation. In a forensic science context, this includes what is recognized as evidence, what is collected, what is examined, and how it is interpreted. The ingredients necessary for the examiner to fall prey to this kind of bias are as follows:

1. The forensic scientist must be confronted by an ambiguous stimulus (e.g., a crime scene or an item of evidence) that is open to varying interpretations.
2. The forensic scientist must be made aware of an expected or desired outcome (Neisser, 1976).

This form of bias is characterized by the “tendency to resolve ambiguous stimuli in a manner consistent with expectations” (Thompson, 1996).

Confronting Ambiguity and Subjectivity

In a forensic science context, *ambiguity* becomes a factor when evidence or circumstances are incomplete, murky, and equivocal (Phillips et al., 2001). *Subjectivity* becomes a factor when identifications and interpretations rest on the examiner’s experiences or beliefs (Thornton and Peterson, 2002). These factors are problematic when a forensic interpretation is premised on an examiner’s belief that his or her experience is all that is required to render an identification.

Consider also that the majority of forensic examinations involve at least three layers of subjectivity: evidence collection, evidence quantity and quality, and a lack of articulated standards for qualifying the results of comparative analysis and identifications.⁹

Collected and Provided

The first subjective layer is the collection of evidence. What is collected and provided to the forensic scientist for analysis is perhaps one of the most subjective processes that inhabit the realm of forensic science.

Presented with a crime scene, police investigators and technicians collect and submit evidence to the forensic scientist for examination and interpretation. At best, it represents an incomplete picture of the evidence that was left behind in the wake of a crime: Investigators cannot recognize everything and cannot collect everything. At worst, it represents evidence collected in accordance with a specific preconceived theory that police investigators are seeking to bolster.

Too often, evidence collection is conducted with the intention of ignoring or simply omitting facts and evidence that might point the forensic scientist away from an undesirable conclusion. The forensic scientist is given what attorneys and investigators deem of importance to their case and often nothing further. Quantity and quality of the evidence aside, what is collected and subsequently considered evidence (and what is not) can and does have an impact on the subsequent examination.

⁹ *Identification sciences* are those that answer the question “What is it?” *Comparative analyses* are those that answer the question “Who or what does this belong to?” For example, the first identifies a visible pattern on a surface as a fingerprint with particular individuating characteristics, whereas the second involves its comparison to potential sources.

Quantity and Quality

The second layer of subjectivity involves the quantity and quality of the evidence provided. As already explained, unlike the vast majority of practicing scientists, most forensic scientists have no control over the quality or quantity of their evidence. Depending on the abilities of local crime scene personnel, the quantity of evidence collected will vary dramatically. In some instances, the examiner will have an abundance of evidence to examine; in others, the examiner may find the sample sizes less than sufficient—sometimes to the point where no significant examination or testing can be performed.

With respect to the quality of evidence, forensic examiners must frequently perform forensic assessments on physical evidence that is of substandard quality. The quality of evidence can be compromised by a variety of agents and/or circumstances, which have been described as *evidence dynamics* (see Chapter 7: Evidence Dynamics). The very nature of the evidence may prohibit meaningful interpretation. Determining whether and when the physical evidence is of sufficient quantity and quality to allow for meaningful examination and interpretation can add further subjectivity to the process when minimum thresholds are not established.

Subjective Comparison Standards

A third layer of subjectivity occurs when forensic examiners are determining whether two pieces of physical evidence are “consistent with” or “match” each other. This is often accomplished by identifying an unspecified number of corresponding points of similarity during a comparative analysis. The majority of forensic disciplines do not require their examiners to isolate a specific number of matching points before they claim an absolute identification between two items. Likewise, forensic scientists regularly utilize varied criteria that are typically not published or even articulated (Phillips et al., 2001).

Interwoven with this process is the probabilistic determination that a match or event is not coincidental.¹⁰ DNA aside, the results of comparative analysis and identifications are too often manifestations of an examiner’s experience rather than logical inference, empirical study, and published research.¹¹ Without established evidentiary thresholds and practice standards for evidentiary interpretation, forensic examiners are able to make apparent scientific interpretations of evidence that are actually based on what they feel and believe rather than on what has been proven or disproven by their methods.

The occurrence of ambiguous physical evidence, as well as evidence that is susceptible to subjective interpretation, opens the door for subconscious observer effects to influence examiner results. However, it is the lack of examiner confidence, coupled with expectation, that invites them inside.

¹⁰ Determining whether the match is a coincidental match—examiners are essentially asking how probable is it to find a match by pure chance.

¹¹ Phillips et al. (2001, p. 299) state that “[W]ith the exception of such areas as biological fluids . . . the forensic sciences possess little empirical data to assist examiners in interpreting the meaning of their test results and affixing a probability or confidence to their findings” and “ordinarily, the examiner does not have access to a database that assists in quantifying the rarity of the marks, or which even records them, but must rely on memory of other samples viewed in the past.” Edwards and Gotsonis (2009) explain that (p. 187) “the forensic science disciplines suffer from an inadequate research base: Few forensic scientists have the opportunity to conduct research, few academics are positioned to undertake such research, and, importantly, the funding for forensic research is insufficient.”

The Lure of Expectation

Forensic scientists are regularly put into situations in which they are privy to information that can easily cultivate conscious or unconscious expectations. The most common expectation developed is that a suspect or defendant must be guilty of something, if not the crime they are accused of. The occurrence of this expectation is not surprising when one considers, again, the structural alignment of publicly funded crime labs. As discussed in the NAS report (2009, p. 122):

Human judgment is subject to many different types of bias, because we unconsciously pick up cues from our environment and factor them in an unstated way into our mental analyses. Those mental analyses might also be affected by unwarranted assumptions and a degree of overconfidence that we do not even recognize in ourselves. Such cognitive biases are not the result of character flaws; instead, they are common features of decision-making, and they cannot be willed away. A familiar example is how the common desire to please others (or avoid conflict) can skew one's judgment if co-workers or supervisors suggest that they are hoping for, or have reached, a particular outcome. Science takes great pains to avoid biases by using strict protocols to minimize their effects.

The overwhelming majority of, if not all, public crime labs are annexed with the very police and prosecutorial agencies to which they provide assistance.¹² The primary objectives of these parent agencies are to identify, prosecute, and convict the guilty. Often this involves the explicit mind-set of building cases against suspects. Working in a pro-prosecution environment, where a suspect's guilt is both suspected and even anticipated, it is easy to see how and why some forensic scientists can subconsciously develop certain pre-examination expectations that may influence their results.¹³ This section discusses specific forensic science and law enforcement practices capable of inducing these potentially biasing expectations.

Single Sample Testing

For the most part, when investigators turn over evidence to forensic examiners, it typically falls into three groups:

1. Samples taken from the crime scene
2. Samples taken from the victim
3. Samples provided by the suspect

Single sample testing in the forensic sciences has been shown to directly affect whether an examiner's report will associate the suspect with the crime scene or the victim. For instance,

¹² Thornton and Peterson (2002, p. 2) state: "Most forensic examinations are conducted in government-funded laboratories, usually located within law enforcement agencies, and typically for the purpose of building a case for the prosecution."

¹³ Miller (1987, pp. 157–158) states: "In criminal investigations, the police generally have little or no doubt regarding the suspect's guilt. Their preoccupation lies with obtaining sufficient proof for a conviction. That attitude may be communicated to the forensic examiner through personal interaction or through the written synopsis accompanying the evidence to be examined. It is conceivable that the forensic examiner may unconsciously believe that the suspect must be guilty or the police would not have made the arrest. Such unconscious beliefs may potentially create prejudice, bias, and stereotypes on the examiner's part regarding conclusions about the evidence. The occurrence of belief transfers from one to another person has been well documented in the social-psychological literature."

in one published study, researchers found that fewer than 10% of forensic reports failed to associate a suspect to the crime scene or the victim (Peterson et al., 1984). Stated conversely, 90% of forensic reports inculpated the suspect in some fashion. As Professor D. Michael Risinger of Seton Hall Law School and colleagues (2002, p. 47) explain:

This high rate of inculpation comes from the fact that each piece of evidence connected with any suspect has a heightened likelihood of being inculpatory, since investigators do not select suspects or evidence at random, but only those they have some reason to think were connected to the crime. Thus, forensic scientists have a continuing expectation that the evidence before them is inculpatory.

The emphasis here is on the existence of a continuing expectation of inculpation because of past results and an examiner's propensity for generalizing: 9 times out of 10 the hairs match, the fingerprints match, or the DNA matches—so odds are it's probably going to match this time.

Single sample testing is eerily similar to an eyewitness "show-up," which is an identification procedure in which an eyewitness is presented with a single suspect for comparison and identification (Technical Working Group for Eyewitness Evidence, 1999). Eyewitness research has continually recognized an assortment of shortcomings associated with this form of identification (Wells et al., 1998). Considering that forensic examiners and eyewitnesses perform comparable identification and comparison tasks, the same weaknesses that surface during eyewitness show-ups can undoubtedly emerge during single sample forensic evaluations (Risinger et al., 2002). The most obvious is the expectation that the samples submitted to the forensic examiner will, in some way, inculpate the defendant because this is usually the case.

Note that the possibility of examiner error is diminished in such circumstances by the use of analytical logic, the scientific method, and empirical research. However, single sample testing becomes problematic in the context of ambiguous and subjectively interpreted evidence.¹⁴ This is necessarily exacerbated when results are predicated entirely on examiner experience, as is the case with some reconstruction interpretations.

Prescreened Evidence

Even the most scrupulous reconstructionist can be undone by resting solid conclusions on incomplete information. As already discussed, forensic examiners, especially those working for state agencies, are often fed a narrow amount of physical evidence from attorneys and investigators that may or may not be sufficient to render fully informed reconstruction interpretations. Commonly, they will not have visited the crime scene and viewed its context and will not have collected the evidence themselves. In such instances, they are forced to rely on the efforts of law enforcement-employed crime scene technicians who, working directly under the influence of detectives, have decided what is important and what is not based on an initial and perhaps incorrect theory of the crime.

One retired crime scene investigator wrote the following to express concerns regarding this practice in a discussion on the need for increased forensic science education on the

¹⁴ This is meant to exclude cases where samples are brought in either at one time or over a period of time, from various subjects, as part of a broad search for suspects that fit a general category under suspicion (e.g., a "dragnet"). The "match" may inculpate the defendant, who may not have been under any specific suspicion.

part of crime scene personnel (Wally Lind, retired crime scene analyst, personal e-mail communication with Turvey):

Detectives have theories, and detectives usually decide what gets lab tested. Detective theories can be wrong and unfair to the victim and defendant. Detective[s] don't send in evidence to learn what happened, they send it in to support their theories. And, unfortunately, the defense has no say in what gets lab tested by the state.¹⁵

This circumstance creates a situation in which, from the start, forensic scientists or reconstructionists are disadvantaged. Unless they are given unfettered access to the crime scene when possible, and full crime scene documentation, they cannot be certain that enough forensic data have been collected to answer the questions presented by the available evidence in a meaningful or faithful manner. What they are generally provided is a narrow picture of evidence that has been preselected by investigators because of its value to furthering the cause of a particular theory. Subsequently, any expectation on the part of forensic examiners that they are getting everything relevant to their analysis is more than likely unwarranted.

Far from being an argument that forensic scientists are too disadvantaged to perform reconstructions because they lack firsthand knowledge of the scene as it was found, quite the opposite is true. Forensic scientists evaluate not just the scene, but also the nature and quality of the evidence processing and documentation efforts. The jury, it must be remembered, will also be asked to make determinations about events using the same evidence, without having gone to the scene. If the nature and quality of the scene processing and documentation efforts are insufficient for the forensic scientist to reconstruct certain events, the same must be true for the lay juror. When crime scene technicians and investigators have not sufficiently processed or documented the scene to enable a reconstruction, for whatever reason, the jury needs to have this brought to their attention.

Prescreening of evidence may also occur in an environment in which an expectation exists on the part of investigators that forensic scientists and reconstructionists have a strong desire to help their cause. That is, investigators may expect that forensic personnel will do whatever they can with whatever they are given to find (or create) a connection between the victim, the suspect, or the crime and prove their theory. Unless forensic scientists establish unequivocal and unwavering evidentiary thresholds for their examinations, they may find themselves unable to resist the temptation to perform analyses and render conclusions under these circumstances, even when the evidence is insufficient.

Irrelevant Data: Communication between Investigators and Examiners

When forensic scientists are presented with a new case, they typically receive evidence and contextual information in one of two ways. Either they meet directly with the lead investigator and have a conversation or the pertinent case information is forwarded to them via mail, e-mail, courier, or facsimile. Both circumstances are equally capable of inducing improper examiner expectation.

¹⁵ Chisum and Turvey have both worked numerous cases in which detectives have collected evidence but not sought testing for fear of the outcome. The crime lab may agree or go along with this, as testing takes time, effort, and other resources.

Unlike investigators, forensic examiners have a duty to act with restraint in regard to the information they consider when performing analyses and forming conclusions. As [Risinger and colleagues \(2002, p. 28\)](#) explain:

A forensic scientist is not a detective. We repeat, popular television shows to the contrary notwithstanding, a forensic scientist is not a detective. The conclusions of the forensic scientists are put before the jury. The reason the products of the forensic scientist's efforts are admissible is not because forensic scientists are better at drawing conclusions about the meaning of normal relevant evidentiary information than detectives or jurors; it is because the law has accepted that, as to a defined area of specialized knowledge or skill, the products of their practice are better than the jury could do alone. When the forensic scientist is exposed to, relies on, or is influenced by any information outside of her own domain, she is abusing her warrant, even though she may honestly believe that such information makes her conclusion more reliable, and even, or especially, if she is right about this. Her role is not to give a conclusion based even partly on information outside her domain, which the jury can presumptively evaluate at least as well as she, but only to give the jury the reliable product of her discipline that is beyond what they could deduce on their own.

This brings us to the question of how forensic examiners come into contact with domain-irrelevant information. For the most part, they do not receive only the physical evidence when assigned a new case. Rather, the lead investigators frequently supplement their forensic examination requests with detailed crime scene and investigative reports. For instance, [Miller \(1987, pp. 157–158\)](#) wrote:

In the examination and identification of human hair . . . investigators usually submit the questioned and known suspect hair samples along *with a synopsis of facts surrounding the investigation* [italics added]. The main purpose of the synopsis is to provide information to the examiner that may assist in the analysis. The synopsis usually contains the facts and circumstances leading to the arrest of a suspect. In some cases, the synopsis may even include eyewitness accounts, other forms of physical evidence collected in the case, and admissions or confessions made by the suspect.¹⁶

As the scenario suggests, investigative reports and correspondences regularly convey superfluous information about the crime, the victim, and the defendant—often intended to evoke an emotional response of some kind (e.g., sympathy, urgency, seriousness). For instance, examiners may be told that other physical evidence inculcates the defendant, or they may be told what investigators anticipate based on case theories and witness statements. In short, forensic scientists are frequently made privy to “potentially or irrefutably inculpatory evidence in a case” ([Saks, 2000](#)).

Although perhaps investigatively relevant, much of this information is unnecessary when performing many forensic examinations, particularly comparative analysis and identifications. These superfluous facts make murky forensic evaluations even murkier because they convey and implant the hopes, beliefs, and expectations of the investigator. The reconstructionist, however, must gather all of these theories and work to disprove them. It is their job to prove detectives wrong, to diminish bias, and to filter weak theories from the case.

¹⁶ In his book, *Bones: A Forensic Detective's Casebook* ([Ubelaker and Scammell, 1992](#)), Douglas Ubelaker, a forensic anthropologist for the Smithsonian Institute, details how, on numerous occasions, he received extensive case information from the FBI when the FBI requested his services. Realizing that “being influenced by someone's expectations” is a major threat to forensic examiners, Ubelaker developed a system in which he would only read the information necessary to log in the evidence sent to him.

CASE EXAMPLES

Boots and Procter

Consider the case of Christopher Boots and Eric Procter. Boots and Procter were charged in 1986 and convicted in 1987 for the 1983 execution-style slaying of a convenience store clerk in Springfield, Oregon [see *State v. Boots*, 767 P.2d 450 (Or. App. 1989), *rev'd*, 780 P.2d 725 (Or. 1989); *State v. Procter*, 767 P.2d 453 (Or. App. 1989)]. Aside from some dubious and ultimately discredited bloodstain pattern analysis results that failed to convince a grand jury in 1984 (the criminalist admitted during a deposition that he had used the same ruler to scrape blood from the victim's and then the suspect's clothing for blood on the same day), the only physical evidence linking Boots and Procter to the crime was described by forensic scientists as two flakes of double-base smokeless gunpowder located on Procter's pants.

A criminalist with the Springfield crime lab analyzed the first flake of possible gunpowder in 1983. The test, which consumed the particle, was positive for oxidizers. Oxidizers are certainly found in gunpowder, but they are also found in fireworks, matches, fertilizer, car paint, and many other substances. A photo of the flake could not be located. The criminalist discovered a second alleged gunpowder flake in 1986, this time sending half of it to the FBI crime lab in Washington, DC, to verify his conclusion that it matched particles found on the victim (Teichroeb, 2004).

In addition to forwarding the evidence, he enclosed the following letter to the FBI laboratory (Risinger et al., 2002, pp. 35–36):

As per our phone conversation of March 6, 1986, I am submitting the partially burned flakes of double base powder out of our Oliver homicide.

This is a murder case that took place in June 1983. The killer or killers entered a local 7–11 store in the late evening hours and forced the young male clerk into the back room (cooler) and broke a full 10 ounce bottle of Orange Crush over his head and then shot him in the head three times with a .22 caliber weapon (probably a Hi-Standard revolver). Due to some interagency problems the case to date has not been prosecuted, but will be soon.

Going through the trace evidence, some of which had been analyzed by SEMEDAX, I found a partially burned double base powder flake on one of the planchets. The flake was originally found on the trousers of one of our suspects.

We want, if possible, for you or Ed to compare this flake (B) to some partially burned flakes (A) found on the body of our victim. The only difference between the treatment of the flakes is that flake B has been carbon coated to prepare it for SEM work.

Exhibits:

Both A and B are sandwiched between the glass slides and clearly circled and labeled. (I have tried to get them to move by tapping the slide but they appear to be stationary.)

(Sample A) Several partially burned flakes of double base powder from the victim.

(Sample B) One piece of partially burned flake of double base powder from the trousers of a suspect.

Request:

If possible, please compare A to B.

Time is of the essence now because of a lawsuit one of the suspects is bringing against the police department for false arrest.

I would appreciate any help you can give. Thank you very much.

/S/

The FBI lab produced a confirmatory result. An FBI supervisor testified at both criminal trials that the particle was double-base gunpowder (Teichroeb, 2004).

Also linking Boots and Proctor to the crime was the bloodstain pattern analysis performed by the Oregon criminalist. According to the record [*State of Oregon v. Eric A. Proctor*, 94 Or. App. 720, 767 P.2d 453, Or. App., Jan 11, 1989]:

[The criminalist] collect[ed] and identif[ied] . . . high velocity blood spatter from defendant's [Proctor's] shirt. Not expecting to find blood spatter in his forensic examination, [the criminalist] scraped and vacuumed the surface of the shirt and examined the resulting debris microscopically, looking for hairs and fibers that might serve as evidence linking defendant to the crime. He discovered that the debris contained blood particles of a size and shape consistent with high velocity blood spatter caused by the impact of a bullet into a nearby bloody target. The technique [the criminalist] employed to collect the sample was not one that would ordinarily be used to determine the presence of blood spatter.

According to further reports (Teichroeb, 2004, p. A1):

At the criminal trials, [the criminalist] testified that he'd found "high-velocity blood spatter" on both men's clothes—the type of spatter that could only have come from being in close proximity during the shooting of victim Raymond Oliver.

He said [at trial] a renowned blood-spatter expert had agreed with his conclusion, something the expert later denied in an affidavit.

[The criminalist] also told the jury he'd found two flakes of double-base smokeless gunpowder on Proctor's pants.

That was the only physical evidence tying the men to the crime. The rest of the prosecution's case relied on testimony from police informants, including two who later recanted their statements. . . .

DNA testing in 1994 on the 10–12 remaining blood particles determined that all but one particle did not match the victim, according to court documents.

The plaintiffs' experts attributed the one matching particle to contamination after [the criminalist] admitted during a deposition that he'd used the same ruler to scrape both the victim and suspects' clothing on the same day—and had failed to wear gloves.¹⁷

The state argued that the single matching particle was proof that Proctor was linked to the crime.

The case against Boots and Proctor totally collapsed after an anonymous tip led investigators to the real perpetrator. Richard Kuppens, whose fingerprint was later discovered on duct tape from the victim's body at the crime scene, confessed before killing himself in October 1994.¹⁸ His coconspirators told investigators they had never met Boots and Proctor.

In November 1993, after spending 8 years in prison, Boots and Proctor were set free and eventually sued the state of Oregon, settling for \$2 million in 1998 (Teichroeb, 2004).

¹⁷ This procedure is wrong when looking for trace evidence, including hairs and particularly fibers, because microscopic fibers could adhere to the ruler at any time. The ruler must be cleaned or preferably a different one utilized. Also, wearing gloves is a safety issue, and they should always be worn when handling evidence. The gloves must be changed when going from one garment to another even from the same person.

¹⁸ Remarkably, during closing arguments, Proctor's defense attorney argued that this unidentified fingerprint belonged to the real killers [see *State v. Proctor*, 767 P.2d 453, 455 (Or. App. 1989)]: "An unidentified fingerprint was recovered from the masking tape used to bind the victim. Defense counsel contended in closing argument that the fingerprint on the masking tape, which belonged to neither defendant nor to the victim, was most probably the fingerprint of the actual killer."

Stephen Casey

George Castelle (1999), a public defender from West Virginia, provides another excellent example. This is a case from the files of the infamous criminalist Fred Zain.¹⁹ Stephen Casey was arrested and charged with sexually abusing a 5-year-old child. Prior to the West Virginia crime lab obtaining the physical evidence, Zain resigned from the lab and accepted a position with the Bexar County Medical Examiner's Office in San Antonio, Texas. Once the West Virginia crime lab received the physical evidence, technicians who examined a carpet sample could not identify any semen stains on the carpet. Investigators had hoped that the carpet sample would contain the offender's semen (Mr. Casey's semen).

Undeterred by the crime lab's failure to discover inculpatory evidence, investigators sent the carpet sample off to Zain in San Antonio. The carpet sample was accompanied by the following letter (Castelle, 1999, p. 12):

Mr. Zain:

This is the carpet that we discussed via Public Service. The W. Va. State Police Lab was unable to show any evidence of sperm or blood being present on it.

The suspect was arrested for 1st Degree Sexual Abuse on a five-year-old female. Any evidence you can find pertaining to this crime will greatly increase our chances of conviction.

Thank you,

Det. R. R. Byard

Huntington Police Department

Like the letter sent by the criminalist in the Boots and Proctor case, the letter to Zain contains both domain-irrelevant information and expectation cues, irrelevant data being that the West Virginia lab failed to identify any semen and that the defendant was being charged with sexually abusing a 5-year-old. Both pieces of information are completely irrelevant to whether Zain can identify a semen stain and whether that semen stain is consistent with the defendant's semen. The expectation cue is fairly obvious: "Any evidence you can find pertaining to this crime will greatly increase our chances of conviction." As might be expected, Zain succeeded where his West Virginia counterparts had failed; he found semen.

The Fred Zain affair was perhaps the worst scandal in the history of the West Virginia State Police Crime Lab. A West Virginia State Police investigation identified as many as 182 cases that were affected by his work. Beyond the expense of investigating and prosecuting Zain, and retrying cases related to him, West Virginia has paid at least \$6.5 million to settle lawsuits by wrongfully convicted defendants. Zain was ultimately put on trial for perjury in numerous serology cases, for tests not performed ("dry-labbing"), and for fraud regarding the misrepresentation of his credentials. He died in December 2002 of colon cancer before coming to trial.

The FBI Crime Lab and the 1997 Office of the Inspector General's Report

The Office of the Inspector General's (OIG, 1997) investigation of the FBI laboratory identified various incidents in which examiners relied on domain-irrelevant information when forming their conclusions. Among the most brazen incidents detailed by the OIG's report was testimony in the World Trade Center bombing case. An explosives expert in the FBI crime lab's explosives unit claimed to have

¹⁹ See Matter of Investigation of West Virginia State Police Crime Laboratory, Serology Div., 438 S.E.2d 501 (W.Va.1993), which discusses Zain's fraudulent conduct and incompetence at length.

identified the main charge as a urea nitrate bomb. His conclusion, however, was not premised on any physical evidence from the bombing scene but on “speculation based on evidence linking the defendants to that explosive” (p. 11).

The [OIG report \(1997\)](#) condemned the practice of relying on scientifically irrelevant data (pp. 128–129):

[The expert] portrayed himself as a scientist and rendered opinions as an explosives expert. As such, he should have limited himself to conclusions that logically followed from the underlying data and the scientific analyses performed. . . . He should not have based his opinions, in whole or in part, on evidence that was collateral to his scientific examinations, even if that evidence was somehow connected to the defendants. . . . By basing his urea nitrate opinion on the collateral evidence, [he] implicitly accepted as a premise the prosecution’s theory of guilt. This was improper.

In a strikingly similar case in which a defendant was charged with creating a large quantity of explosive material by stripping it out of detonating cord, the FBI examiner ([OIG, 1997](#), p. 30)

acknowledged that his identification of PETN on the tools was based in part on the fact that stripped detonating cord was found in the defendant’s garbage. In his interview with the OIG, [the expert] observed that given this information, he presumed the material on the knife was PETN. . . . Rudolph failed to distinguish between the separate and distinct roles of an investigator and a forensic scientist.

How Much Is Too Much?

With the OIG report condemning the practice of basing what is meant to be scientific opinions on improper information, one would assume that the forensic community might respond by encouraging the practice of limiting the types of information conveyed to those forensic examiners who do not need it. Unfortunately, for the most part, the forensic community has yet to embrace such a view. Consider the following passage from a forensic science textbook ([Netzel, 2003](#), pp. 165–166):

Association with a law enforcement agency is critical to most government laboratories, but should never influence the outcome of a scientific investigation. Vital to a laboratory’s role in an investigation is access to information and physical evidence at the crime scene. Without legal access to a crime scene, a laboratory will be severely hindered in performing its function during an investigation. *Also, a free exchange of information between law enforcement agencies and the laboratory is necessary* [italics added]. Without an official association, this exchange of information could be difficult. Individuals who believe that a forensic scientist should work independently of investigative information are misled. *No scientist in any discipline should choose to work without having as much information as possible about his assignment* [italics added]. Knowledge of certain facts will assist the criminalist in determining what questions should be addressed by his examination.

. . . As a part of the criminalist’s role in an investigation, he must utilize his own ability to ask questions and investigate the information already available. A solid approach to being a case examination, particularly a major case, would include review of crime scene reports, diagrams and photographs, evidence collected, statements of suspects and/or witnesses, and, of course, information in police reports.

. . . Most of the information that aids the criminalist comes from asking questions of the law enforcement investigator. *Gaining as much information as possible about a situation will not alter scientific results* [italics added].

Specific to comparative analysis and identification procedures, it is true that more information regarding the evidence and how it was found are of vital importance. However, general

contextual information regarding the results of other forensic examinations, the statements of suspects, and the expectations of investigators is not unless a reconstruction is the desired outcome. Of course, the dangers for the reconstructionist are far greater precisely because they require all of the available contextual information and analytical results; this is discussed later. Without clear delineation between the type of information necessary to identification scientists vs reconstructionists and the type that is not, and the perils associated with it, the suggestion that any and all available information be sent their way is troubling.

A document examination textbook stated the following about what information should be considered before rendering an opinion (Dines, 1998, pp. 4–5): “Before an attempt by the examiner to identify handwriting, the investigator should consult and [obtain] as much circumstantial evidence as possible about the case.” Again, no delineation as to what should be screened and why—just send everything.

Inman and Rudin’s (2000) text advocates a somewhat similar position, although it is more upfront about the dangers this may pose (pp. 248–249):

Typically the analyst knows something about the history of the evidence up until the time it enters the laboratory, and will interpret the results based on that history. Forensic scientists are generally familiar with the need to interpret evidence in the context of the history of the sample prior to its collection and preservation. But before the results are interpreted, and even before any analysis occurs, the criminalist must define the relevant questions. *The more the analyst knows about the case, the better she can direct and refine the questions so that the answers are both useful and relevant* [italics added].

The argument, made mostly by attorneys, against the analyst knowing the circumstances of a case, is that such knowledge may introduce subconscious, or worse yet malicious bias, leading to prejudiced interpretation of the results. Superficially, this would seem to be a credible thesis. However, we believe that the advantages gained as a result of an informed analysis substantially outweigh the concerns. Furthermore, a series of checks and balances can and should be employed to *ensure that alternate explanations for the data are duly considered* [italics added]. Moreover, we submit that bias is most likely to enter a case and do the most damage at the level of the question being asked, rather than in the interpretation of results.

While we applaud Inman and Rudin for discussing the “how much should a forensic examiner know” issue, their analysis and explanation are somewhat limited.

First, it is not simply defense attorneys who make the claim that scientific observers should screen the information they consider before rendering a conclusion. Rather, cognitive psychologists have studied this phenomenon for years and have documented, time and again, that having too much biasing information can create a conscious or subconscious expectation regarding the results. These can create expectations that can easily contaminate objectivity. Instead of impartially interpreting evidence and accepting the good with the bad in terms of their stated hypothesis, the expectation, in effect, creates an internal set of blinders.

Second, unlike reconstructionists who require access to other experts’ reports and crime scene findings in order to integrate and corroborate final results, there is no reason why forensic identification examiners (e.g., DNA analysts, fingerprint examiners, tool mark examiners, or handwriting examiners) need to know as much about the case as possible. Their primary objectives are not to establish events, sequence actions, or determine the nature of broad associations like their reconstructive colleagues. Rather, they are called on to answer a basic question: Does the print, pattern, tool mark, or handwriting related to the crime associate the print, patterns, tools, or penmanship associated with the suspect, and to what degree? This question can be answered without having to refer to the results of other forensic experts working on the case and without

consideration of extraneous case theories. Relying on such information can only increase the likelihood that the identification examiner's results will be tainted.

Although neglected by many of today's practitioners and educators, this is not a new concern. Luke May, a forensic science pioneer, warned of this in his book, *Crimes Nemesis*, written in 1936. According to May:

In the classroom of the School of Scientific Police at the Palais de Justice in Paris is a truism: "The eyes see in things only what they look for, and they look only for what is already in the mind."

This might well be a universal warning in crime detection, for often the most significant bit of evidence is overlooked or misinterpreted because someone has jumped to a premature conclusion. The detective who quickly reconstructs a crime without sufficient supporting evidence is very liable to spend days, weeks, and perhaps months on a wrong scent in a vain effort to make evidence fit his personal version of what happened at the scene of the crime. Unconsciously, perhaps, he may try to convict an innocent victim who he believes committed a crime while the real perpetrator takes advantage of the wild-goose chase to make a clean get-away.

To face a crime with an open mind—a mind willing to believe and disbelieve even its own senses, sometimes willing to admit and desert one line of investigation for another, is one of the most difficult tasks of the detective. He is human, and like all other humans he is subject to personal prejudice.

Although [Inman and Rudin's \(2000\)](#) minimization of the context effect issue is problematic, they do provide an excellent illustration of how certain types of evidence or information can affect an individual's interpretation of ambiguous stimuli (e.g., bloodstain patterns) (p. 183):

One example of such an overinterpretation occurred in a case involving two suspects accused of torturing and shooting the clerk at a Stop 'N. Rob convenience store. A detective from another jurisdiction, who had attended several bloodstain pattern interpretation workshops, was retained to prepare a reconstruction based on the blood patterns at the scene. He wrote an 11-page report, including every movement of the victim and suspects over a 30- to 45-minute time period. He included in his reconstruction a 5-minute time period where all activity ceased for the three individuals, basing this on a photograph of what he interpreted as a blood clot. He concluded that the victim was shot, bled for a period of 5 minutes on the floor, and then was beaten by the assailants. How did he arrive at this detailed reconstruction? He was given one suspect's confession, who indicated that they had shot the victim, sat around eating sandwiches and mocking him for 5 minutes, and then beat him for good measure. The detective used this as a starting point for his reconstruction, and picked out stains from the crime scene photographs that appeared to him to be clotted blood. As a nonscientist, he couldn't quite comprehend the criticism that it was not possible to distinguish between a blood clot and a bloodstain based on a photograph. Happily, he did not include a reconstruction of the suspect's meal, although perhaps only because no blood was involved in it.

Although they coin this phenomenon "overinterpretation," what they are actually describing in this scenario is the "expectancy effect." This example is excellent because it illustrates what can happen when the forensic scientist is given what is probably the most prejudicial information in a case, the defendant's statement, before rendering an opinion. After reading the defendant's statement, the bloodstain expert became fixated on one explanation for events. In effect, what the bloodstain expert did was the antithesis of science, as he started with an explanation (i.e., the defendant said the crime occurred in this manner) and then dredged through the evidence to find any bloodstains or evidence that would tend to support his explanation. What he found was something that he could use to justify the conclusion, even though it was impossible to see. He saw it because he needed it to support the fore drawn conclusion.

Again, as [Luke May \(1936\)](#) warned, "The eyes see in things only what they look for, and they look only for what is already in the mind."

Contradictory Findings

When more than one forensic scientist is involved with the examination of the same physical evidence, there is the possibility that they will reach different or conflicting results. When contradictory findings are achieved, reevaluations of the evidence will typically ensue. Occasionally, after reevaluating the physical evidence, some forensic scientists will alter and even tailor their original conclusions so that all findings from each member of the forensic “team” are in accord. This form of opinion editing is easily influenced by expectation bias. Both factors that cultivate expectation bias are present—an ambiguous stimulus capable of multiple interpretations and the awareness of a desired or expected outcome.

It should be noted that under ideal circumstances, the use of multiple forensic examiners, blind to each other’s findings, can help eliminate expectation bias or findings that are too speculative (better work of a more conservative nature is done when it is known that work will actually be reviewed and compared with that of another outside one’s agency and influence).

Selective Reexamination of Evidence

The occurrence of contradictory forensic interpretations is not unheard of among government-employed laboratory analysts working separately but on the same case, as already suggested by the previous section. When this happens, prosecutors and investigators will occasionally seek out the forensic scientist whose interpretation is inconsistent with their preferred theory of the case. Once in direct contact, they will confront the contrary examiner, explaining that results are at odds with another examiner’s conclusions and the overall theory of the case. They may further emphasize that this contradiction, if not corrected, will appreciably weaken the state’s case against the defendant.

Having laid this foundation, the prosecutor or investigator will then ask the examiner to reevaluate the evidence, reinforcing the fact that if conclusion “X” is reached, the case against the defendant will be substantially stronger. The contamination present within this scenario is easily identified; by explaining to the examiner that a certain conclusion is favored (e.g., a more inculpatory finding), prosecutors and investigators are attempting to lure the examiner to tamper with initial conclusions. Once again, both factors that can nurture observer effects are present—an ambiguous stimuli capable of multiple interpretations and the awareness of a desired or expected outcome.

Although this kind of bias-inducing interaction may be fairly easy to recognize, the impartiality that it fosters is potent. The mere act of soliciting a particular examiner to reassess his conclusions will automatically distort any new conclusions. *Cherry-picking*, as it is commonly referred to, invites reconsiderations of only those conclusions that are not preferred by the police and prosecutor [see [Peterson and Conley \(2001\)](#), who discuss cherry-picking in the legal and scientific context]. Favored conclusions, which help the prosecution of the accused, are not sent back for reconsideration.²⁰

²⁰ On a related issue, state and federal labs must always be on guard when contacted by an agency that has access to a local laboratory. Are they “lab shopping,” hoping to find the results they want because the local lab did not agree with their theory? In such instances, if a case is submitted from a jurisdiction or agency that has its own lab (and the evidence is not part of an investigation into that lab), then it is advisable to require that the local lab submit the evidence along with a letter from the director explaining why the state or federal lab should perform any necessary examinations. This policy creates a record that only those shopping for results would prefer to avoid.

It is the examiner's awareness of a more desired outcome that makes this type of interaction and request terribly susceptible to observer effects. The reexamination request, along with the irrelevant information, may compel an examiner to doubt and weaken her conviction concerning initial (correct) conclusions. Worse, it may lead the examiner to abandon her original (correct) conclusion entirely and move to agree with the examiner who proffered the incorrect, yet preferred, conclusion.

Consequently, if the preferred conclusion is incorrect, selective reexaminations where the forensic scientist succumbs to observer effects inappropriately add forensic strength to a potential wrongful conviction. Also, because the incorrect conclusion is not reevaluated, it cannot be identified and corrected.

Recommendations to Blunt Observer Effects

To decrease bias, conscious and unconscious alike, the forensic science community must utilize the same checks and balances already adopted by other scientific communities. The ensuing discussion focuses on three of the more important procedural reforms that would curtail observer effects in forensic science and crime reconstruction: awareness, filtering domain-irrelevant information (blind testing), and evidence lineups.

Awareness

Awareness of observer effects, their subconscious nature and undeniable influence on perception, is a first and necessary step. Forensic scientists have a duty to understand which of these influences may persist in their environment and to adjust their professional manner and practices to guard against them when possible. This begins with admitting their potential existence and becoming more than just literate on the subject. However, awareness is only the beginning.

Filtering the Irrelevant

As already shown, too much of the wrong kind of information can bias the way that a forensic examiner perceives and interprets the evidence he or she is provided. Once the problem of observer effects is admitted and understood, forensic examiners in each forensic discipline must come to an agreement regarding which kinds of information are actually required in order to perform their analysis competently. Furthermore, they should also be able to create a list of the kinds of information that might bias or influence their analysis and whether it may be filtered or not.

The inability of any forensic examiner to perform this basic task suggests that they have become lost in the geography of observer effects and are unable to distinguish what they do as an objective form of forensic analysis with an articulable methodology.

The authors propose the following: *Identification scientists* (those forensic scientists concerned with making identifications through evidence examination and comparison) should have as little information about the extraneous circumstances surrounding any item of evidence they are given as possible. They are concerned with *what* and *who*, not *how*. To perform competent and

informed comparisons, they require the questioned evidence they are examining, its known history, the circumstances of the collection, and the known evidence to which they are comparing it. They should otherwise be as blind as possible and further barred from having or even perusing any information related to

- Victim statements and background
- Witness statements
- Suspect statements
- Investigative theories
- Attorney theories
- Results of other forensic examinations
- The nature of the offense

The DNA analyst does not actually need to know whether the suspect has confessed in order to compare STR profiles; the hair examiner does not need to know that the victim was a 5-year-old girl who was sodomized; and the fingerprint and firearms examiners do not need to know that others have already confirmed a match between two prints or projectiles.

Arguments that support the need for gathering and considering extraneous case information related to the identification scientist's examinations seek to facilitate the following: (1) locating or developing evidence that may have been missed, (2) formulating hypotheses regarding potential transfers, and (3) helping triage evidence through the lab. These are all perfectly legitimate goals that should be the function of either a forensic generalist or a forensic specialist who will not be involved in making any related identifications. That is, only disinterested forensic examiners, whose minds are necessarily blind to biasing influences, should be responsible for making forensic identifications.

With respect to proficiency testing (a.k.a. performance testing), some contend "the logistics of full-blind proficiency tests are formidable" (National Research Council, 1996, p. 79). While true in many situations, its practical implementation is by no means impossible.²¹ Likewise, developing a system that filters out all unnecessary domain-irrelevant data before identification scientists perform their evaluations is also possible.²² As with all things, if we want to get it done, we will find a way to get it done. That a solution to a big problem might be difficult is not a legitimate reason for setting it aside.²³

Generalist-reconstructionists, however, must indeed have "everything they can get their hands on" with respect to the crime scene and the physical evidence. They are concerned not with *who* but with *how* and *why*. Their task is to gather the evidence, and the results of any

²¹ Considering that the forensic community "deals mostly with inanimate objects, the blinding procedure will be simpler than in fields that work with humans and animals, such as biomedical research and psychology. Those fields must construct double-blind studies, while forensic science needs only single-blind procedures" (Risinger et al., 2002, p. 1).

²² Cook and colleagues (1998) discuss the "filtering" process system that has been developed in the United Kingdom's Forensic Science Service.

²³ Blind and nonblind testing should be standard if the lab is accredited through the American Society of Crime Lab Directors. This proposal would make blind tests far easier to administer.

subsequent examinations, and establish what may be known to separate opinion and speculation from defensible scientific fact. They may even benefit greatly from hard information about both the victim and the suspect because the issue of *what* or *who* may already be firmly established in the case at hand.

The reconstructionist should be blind, however, to information that might create an expectation regarding their findings. They should work actively to screen any theories about the case that come from human sources, such as investigators, attorneys, witnesses, and suspects. These theories will be compared against results of the reconstruction and should not be used to build it.

It must be admitted, however, that this level of screening may not always be possible. The very context of the reconstructionist's involvement in a case often precludes the ability to screen case theories as they come flowing in. This reality makes the necessity of developing and firmly adhering to scientific practice standards all the more vital to maintaining what Thornton referred to in the previous chapter as the reconstructionist's "professional chastity." It also increases the importance of being able to rely on sufficiently thorough and objective crime scene processing efforts and, as well as sufficiently blind results from forensic identification scientists, when forming reconstruction conclusions.

Evidence Lineups

A procedural reform for crime lab employees that can further minimize subconscious biasing influences among the identification sciences involves the employment of "evidence lineups" (Miller, 1987; Risinger et al., 2002). In an evidence lineup, multiple samplings are presented to the forensic examiner.

However, some samples are "foils."²⁴ Forensic examiners would be blind to which samples constitute the foils and which samples constitute the true questioned evidence. For instance (Risinger et al., 2002, p. 48):

[A] firearms examiner might be presented with a crime scene bullet and five questioned bullets labeled merely "A" through "E." Four of those bullets will have been prepared for examination by having been fired through the same make and model of firearm as the crime scene bullet and the suspect's bullet had been. The task for the examiner would then be to choose which, if any, of the questioned bullets was fired through the same weapon as the crime scene bullet had been.

As discussed already, many forensic examinations are currently the equivalent of eyewitness identification show-ups. In both situations, only one suspect or sample is presented to the examiner; because of the selective nature of this process and the often high rate of past identifications that have been positive, the environment works to reinforce the expectation of a match. Evidence lineups would serve to help resolve this particular influence and may even identify biased examiners who are unaware that they are being unduly influenced.

²⁴ Professor Saks and colleagues employ this word; see Risinger and associates (2002).

RESTRUCTURING THE PUBLIC CRIME LAB

In order to curb the conscious and subconscious influences that expectation can set against the forensic examiner's purpose, public crime labs are well advised to return to the practice of employing forensic generalists (actual forensic scientists, not lab technicians) to perform the following duties²⁵:

1. Responding to crime scenes
2. Assisting forensic specialists with processing evidence at the crime lab
3. Forensic evidence triage
4. Crime reconstruction

The crime lab should therefore be given statutory authority to respond to specific kinds of crime scenes and take sole charge of evidence-processing duties. This is not some new idea or radical concept. For example, the medical examiner or coroner is statutorily responsible for the body of the victim at the scene and for determining the cause and manner of death (arguably, to reconstruct the death). Likewise, a forensic generalist could be responsible for the body of physical evidence that establishes any element of the crime, with the lab given statutory obligation and authority to reconstruct events. This would allow police to focus on their investigative function, and it would clearly delineate the scientific investigation of the evidence from law enforcement efforts to identify and apprehend suspects.

At the crime lab, a generalist unit should take custody of the evidence. A supervising generalist, who knows the true capabilities and consequences of the lab and its analytical efforts, should be assigned to each case. Their primary function and philosophy should be to aggressively disprove every theory that is presented to them (a disconfirmatory, skeptical mindset). They would seek to resolve the following questions and to perform a forensic triage of the evidence collected:

- Which questions are pertinent to the case and whether the evidence can answer them.
- Whether the evidence is of sufficient quality and quantity for meaningful testing.
- Whether an item of evidence can be examined at the lab or must be sent to another facility.
- Which laboratory sections an item of evidence needs to be sent to.
- Which specific forensic examinations should be performed.
- Which ordering of forensic examinations will be the least destructive.

In the performance of these duties, the supervisory generalist would listen to many case theories, have contact with police investigators and attorneys, and act as a barrier between these influences and the examining criminalists in the rest of the lab. That is, the forensic specialists working in the other sections of the crime lab would be blind to the information and theories provided to the generalist from outside agencies. They would perform the analyses requested by the supervisory generalist and then render their objective results in a written fashion.

²⁵ It should be noted that, currently, nonscientific police personnel, with little or no training and education in science, forensic science, or proper evidence collection procedures, most commonly perform these duties.

Instrumental Testing

With respect to instrumentation, a technician may certainly be trained to run an instrument test and test samples under the direction of forensic scientists. This is sometimes both necessary and useful. However, a qualified forensic scientist must perform the interpretation of any results. A distinction must be made between the function of the technician and the function of the scientist. It is a distinction that is currently so blurred that many can no longer see it or even understand it.

Subsequent to specialist tests and analysis, the senior generalist would aggregate these and assign a generalist–reconstructionist from the generalist unit to perform crime reconstruction duties. This reconstruction would be based on results of the crime scene investigation, instrumental analysis, and other objective forensic examinations. As with the forensic specialists, the generalist–reconstructionists would be blind to the various case theories until the results of their reconstruction were complete. If their results failed to address specific questions of value to the case, as determined by the supervising generalist (who knows all the proposed theories), they could revisit these through directed experimentation.

It is important to bear in mind that there is room for judgment with respect to the examination of evidence submitted to the crime lab. That is, not all samples would require this level of triage and treatment. Drug analysis, blood alcohols, and serial number restorations are among the many simple tests done in the lab that do not require this level of sophistication to adequately blind the forensic specialists.

Findings

With respect to findings, both generalists and specialists must believe that they have sufficient support from their supervisors to form conclusions that do not go beyond their understanding of good science. They must know that their jobs are not at risk when they offer findings that may conflict with the expectations of others in positions of authority.²⁶

Consequently, the forensic scientists' pay, workload, hours, and job security must not be a reflection of how helpful their findings have been to police or prosecutors. This means no bonuses for assisting with an arrest and no citations of merit or promotions for assisting with a successful prosecution or a reliable track record of the same. Moreover, their performance reports should never reflect or be based on whether their findings assist or fail to assist a successful prosecution. Their performance reports should instead be based on how well they follow the scientific method; how well they present their logic, their writing skills, and their verbal skills (i.e., court testimony); and how well they meet their individual goals.

²⁶ In some jurisdictions, police and prosecutors bypass the scientists who are employed in the public laboratory. The prosecution does not want to hear that its theory is not supported by science, so it hires "outside experts" who have no scientific background, do not understand the scientific method, and can be counted on for confirmatory results. These "witnesses having other rationalized explanations" can seem very impressive until one examines their work product closely. Unfortunately, the lab scientists are not generally able to openly criticize such individuals because that would jeopardize the prosecution, the scientist's job, or the relationship with the prosecutor—not to mention the potential for being sanctioned if they step out of line and act in a manner not serving the best interests of their agency. This is a circumstance that must be remedied.

CONCLUSION

There can be doubt that observer effects exist and subconsciously influence all forensic scientists. The pervasive failure of the forensic science community to confront this and design safeguards speaks volumes with regard to what James [Starrs \(1991\)](#), professor of forensic science, refers to as “institutional bias”:

Institutional bias in the forensic sciences is manifested by the policies, programs, or practices of an agency, an organization or a group, whether public or private, or any of its personnel which benefit or promote the interests of one side in a courtroom dispute, while either denying or minimizing the interests of the other side.

To correct institutional bias, which accounts for many of the unwanted observer effects discussed in this chapter, it may be time to consider separating the forensic scientist once and for all from police culture. In other words, it may be time to consider separating all state crime lab systems physically, philosophically, and fiscally from law enforcement and to advocate for the creation of wholly independent state divisions of forensic science that are publicly funded but available to all.

The idea is not new. [Kirk and Bradford \(1965\)](#), pp. 22–23) advocated for independent crime labs four decades ago²⁷:

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

Not only is this idea feasible but also, in some states such as Virginia, it has already been done. In the end, “forensic science service must be independent, perceived to be independent, and confidently taken to be independent” ([Samuel, 1994](#)). Specifically (Peter Neufeld, Innocence Project codirector, as quoted in [National Public Radio, 2003](#)):

What [we] really want to do is not simply create an artificial independence, but [we] want to change the entire *mind-set* of the people who work in these laboratories so they can be proud that they are independent scientists and not simply cops in lab coats.

Although the United Kingdom and some government labs in Australia have embraced what may be described as an independent configuration [see [Wilson \(1994\)](#) for the various independent agencies in Australia and [National Public Radio \(2003\)](#) for the United Kingdom’s system], the U.S. forensic science community has perpetually rebuffed such an arrangement.

However, change may be forthcoming because of the increasing number of crime lab problems that continue to surface throughout the United States. For instance, Governor Ryan’s

²⁷ Similarly, Professor [Starrs \(1993\)](#) urged that the “inbred bias of crime laboratories affiliated with law enforcement agencies must be breached.” Professor [Giannelli \(1997\)](#) also advocated for independent crime labs, stating, “These laboratories should be transferred from police control to the control of medical examiner offices, agencies that are already independent of the police.”

Commission on Capital Punishment endorsed establishing an independent crime lab system in Illinois (“[Report of the Governor’s Commission on Capital Punishment](#),” 2002). Likewise, (former) Houston Police Chief C.O. Bradford and Harris County District Attorney Chuck Rosenthal have both acknowledged that the problems with the Houston Police Department crime lab may merit creating an independent statewide agency (Khanna, 2003). Moreover, independence is a key recommendation of the NAS report, which argues (p. 23):

Scientific and medical assessment conducted in forensic investigations should be independent of law enforcement efforts either to prosecute criminal suspects or even to determine whether a criminal act has indeed been committed. Administratively, this means that forensic scientists should function independently of law enforcement administrators. The best science is conducted in a scientific setting as opposed to a law enforcement setting.

The desire for scientific independence is universal in that it is shared by all of those who want the most reliable and objective examinations from the forensic scientists they employ. Only the mechanisms for achieving scientific independence seem to vary. It is hoped that this discussion of observer effects, and their remedies, has contributed to this much-needed airing of issues that continue to divide forensic scientists from themselves.

SUMMARY

Observer effects refer to a particular form of bias that is present when the results of a forensic examination are distorted by the context and mental state of the forensic scientist, to include subconscious expectations and desires. Observer effects are governed by the fundamental principle of *cognitive psychology* asserting that the subconscious needs and expectations shape both perception and interpretation. In a forensic science context, this includes what is recognized as evidence, what is collected, what is examined, and how it is interpreted. The predominant observer effects that may influence forensic examiners include prescreened evidence, single sample testing, attorney–investigator communication, contradictory findings, and selective reexamination.

The forensic science community is attenuated to the potential for extreme forms of outright fraud and overt bias; however, it tends to be wholly unaware when it comes to understanding and accepting that well-documented forms of covert bias can taint even the most impartial scientific examinations. Covert and subconscious biases represent a far greater threat to the forensic community than the small percentage of overtly biased, dishonest, or fraudulent forensic examiners.

The observer effect phenomenon should be of particular concern to forensic scientists, especially reconstructionists, because so much of their role involves the selective recognition, documentation, and interpretation of physical evidence, the meaning of which hinges on objectivity in their observations. In this regard, forensic scientists have tremendous authority and an immense responsibility. If their examinations are distorted in any fashion, the results can be catastrophic for everyone concerned.

Recommendations of procedural reforms that would curtail observer effects in forensic science and crime reconstruction include awareness, filtering domain-irrelevant information (blind testing), and evidence lineups.

QUESTIONS

1. What are observer effects?
2. List the two factors necessary for an examiner to fall prey to observer effects.
3. List three examples of observer effects that may influence forensic examiners.
4. Observer effects can be conscious and subconscious. Explain.
5. Provide one recommendation that would curtail observer effects in forensic science and crime reconstruction. Explain how.

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Practice Standards for the Reconstruction of Crime

W. Jerry Chisum and Brent E. Turvey

When the liberty of an individual may depend in part on physical evidence, it is not unreasonable to ask that the expert witnesses who are called upon to testify, either against the defendant or in his behalf, know what they are doing.

—*John I. Thornton, in Kirk and Thornton (1970, pp. v–vi)*

Key Terms

Critical thinking; Falsification; Identification (or classification); Individuation; Law of parsimony; Occam’s razor; Oversimplification; Practice standards; Scientific method; Scientific principles; Scientific theory; Socratic method

The **practice standards** for crime reconstruction are those basic foundations and precepts that regulate the limits of evidentiary interpretation. [Thornton and Peterson \(2002\)](#) provide a general starter set for all forensic scientists. They include working toward a reduction of bias, the employment of analytical logic and the scientific method, and forming definite hypotheses and conclusions only in accordance with the known evidence.

These standards appear basic and uncomplicated, with familiar terms. Yet many of those in forensic service fail to comprehend or live by them. Most of us have heard of the scientific method and understand that it is something good; most of us have heard of bias and understand that it is something bad; and most of us believe that our approach is logical—whether it is or not. However, the extent to which these concepts are truly studied, understood, appreciated, and incorporated within the forensic community leaves much to be desired (see generally [Edwards and Gotsonis, 2009](#)).

The purpose of this chapter is to provide forensic examiners with a baseline of subjects they need to study; of mental skills they should develop; and of steps they should take to better ensure accuracy, reliability, and proficiency in their findings. It builds upon concepts found in the existing literature. It is also written from the perspective that most practicing reconstructionists

would probably have a great deal of enthusiasm for strict adherence to standards that embrace diminished bias, analytical logic, and the scientific method, if only they understood what these things are.

OVERSIMPLIFICATION AND OCCAM'S RAZOR

Before we can discuss crime reconstruction practice standards, we must deconstruct the popular yet mistaken assertion that it is a simple and certain enterprise based solely on careful observation and experience. This is an oversimplification. **Oversimplification** occurs when a complex situation is described in simplistic terms that neglect its complexity. It can happen out of ignorance or out of a desire to achieve a greater measure of certainty than would be possible by a consideration of all the facts and information. These days oversimplification has become commonplace in entertainment, political rhetoric, and even journalism. But it has no place in the justice system.

Oversimplification is too common a vice in the forensic disciplines, from scene processing, to laboratory analysis, to crime reconstruction. It manifests in the supplanting of a formal scientific education with short courses, rote technical training, and learning on the job. It manifests with appeals to experience instead of a full investigation and appreciation of scientific fact. It manifests in the form of appeals to “common sense” for the sake of intellectual ease. It manifests when reconstructionists admonish others not to get “bogged down by all the facts,” when these facts provide the context needed for an informed and accurate interpretation of evidence and events. It manifests in these forms and others, wherever there is a desired conclusion and the full weight of the scientific method is perceived to be the long way or the wrong way.

The Razor

Reconstructionists with a basic notion of logic and reasoning might invoke **Occam's razor** to defend oversimplified interpretations. They might suggest that the scientific method reveals simplicity and that complexity relates directly to improbability—the more complex a theory, the less probable, given Occam's razor. This would be a misunderstanding, and an abuse, of the concept.

Occam's razor is an often-misstated principle that, ironically, has been reduced for mass consumption to the point of misapplication. Not uncommonly, it is stated as something along the lines of “all things being equal, the simplest explanation is most often the correct one.” Although this interpretation of Occam's razor sounds good and has the virtue of popping up in a television show or movie every now and again, it is inaccurate.

Pluralitas non est ponenda sine neccesitate. Translation: *Entities should not be multiplied unnecesarily or plurality should not be posited without necessity.* In the 14th century, a Franciscan friar and philosopher named William of Occam (a.k.a. Ockham; 1288–1348) used this principle so frequently in his writings that modern scientists and logicians have come to call it “Occam's razor.” It is a useful concept and has been adapted to provide a basis for scientific modeling and theory building. Generally, it may be summoned as a reminder to choose the least blended hypotheses

from any of otherwise equivalent test models or reasoning, and to remove the extraneous and the nonessential from subsequent interpretations.

The secret to applying Occam's razor is determining what of one's hypothesis is necessary to an interpretation and what is not. Occam, for example, assumed the existence of God in all modeling and theory building. Not all modern scientists would be willing to make this assumption, nor would most be eager to factor it into their reconstructions of crime.

Newton and Bigfoot

Sir Isaac Newton (1642–1727) wrote, "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances." Ernst Mach, an Austrian physicist and philosopher in the early 1800s, advocated this version of Occam's razor in what he called the "principle of economy," stating, "Scientists must use the simplest means of arriving at their results and exclude everything not perceived by the senses." Here, Mach and Newton have given us permission to ignore the possibility of extraterrestrials, Bigfoot, time travel, and other phenomenological explanations not yet proven by science when formulating an interpretation of evidence or events. In the principle of economy, the senses provide the basis for what is acceptable and necessary. Therefore, interpretations for events should first be attempted in terms of what is already known, which we call the accepted facts.

The Law of Parsimony

Today, some philosophers and scientists suggest as an axiom that "the explanation requiring the fewest assumptions is most likely to be correct." This is not precisely Occam's razor but rather a shade of the **law of parsimony**, developed by Sir William Hamilton (1788–1856), who wrote ([Hamilton, 1853, p. 580](#)):

Without descending to details . . . there exists a primary presumption of philosophy. This is the law of parsimony; which prohibits, without a proven necessity, the multiplication of entities, powers, principles, or causes; above all, the postulation of an unknown force where a known impotence can account for the phenomenon.

This is a more rational evolution of both the principle of economy and Occam's razor, and it recognizes that not all conclusions are created equal. Some involve more unnecessary details and make more unfounded assumptions than others. The key to unlocking an interpretation with the law of parsimony is deliberately cleaving established facts from irrelevant information and unfounded assumptions.

Simplified, but Not Simpler

Occam's razor demands fewer blended theories, fewer assumptions, and the eradication of phenomenology. This is a far cry from the fatuousness of "don't get bogged down by the facts" and "the simplest explanation is most likely correct." Occam's razor and its progeny are important tools, but should not be used as a substitute for reason or as an excuse to ignore relevant information because it makes a preferred conclusion easier to prove.

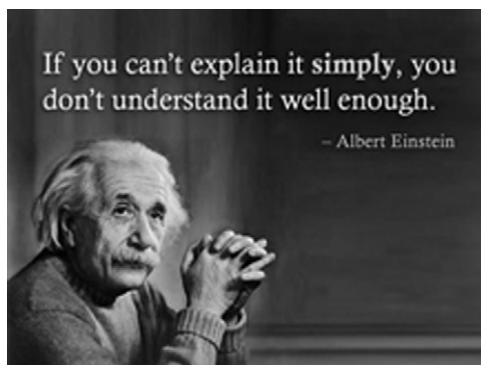


FIGURE 5.1 Albert Einstein, 1879–1955. Nobel Prize-winning physicist, philosopher, and author, widely considered by many to be the father of modern physics.

We would do better to recall Albert Einstein’s (Figure 5.1) cautionary, which provides, “everything should be made as simple as possible, but not one bit simpler.” In other words, we are encouraged to embrace both the complexity of reality and the simplicity of direct logical reasoning without irrelevant encumbrances.

Reconstruction is particularly susceptible to oversimplification because many of those currently involved, as discussed in the Prefaces, do not come from a scientific background of any kind.

Reconstruction Oversimplified; Science Unwelcome

Unfortunately, many of the reconstructionists currently practicing in the field have been trained to work within an oversimplified law enforcement model, absent the scientific method and related scientific theory. While this approach has the virtue of being undemanding and easy to teach, it encourages a disregard for the possibility of complexity, variation, and often the scientific literature. Consider this explanation of crime reconstruction from an instructional piece written by an authority on crime scene processing and investigation (Baldwin, 2005a):

The reconstruction of crime scenes is a misnomer. You are in reality interpreting the information that you find by examining and processing the scene for evidence. This evidence will then permit you to make factual statements in regards to your findings. . . .

You will be able to reconstruct the crime scene in court if you remember that the “reconstruction” is your interpretation of the factual evidence in the case.

On the surface, this may not seem like a bad way to approach a reconstruction. Go to the crime scene, look at the evidence, make observations, call them facts, and that is a reconstruction. Simple. But simplicity is actually the problem here, as several crucial steps are absent from this method. The bare observations of a crime scene technician are painted as a factual interpretation of events, and it is further suggested that this be offered as “factual evidence” of a reconstruction in court. This is not just misleading, it is dangerous to the cause of justice.

The first problem is that such an approach advocates a confirmatory mind-set, intentionally or otherwise. There is no accounting for how facts are to be separated from assumptions. There is no discussion of what is to be made of the evidence after it has been collected and sent off for

examination or how the results of that examination must be factored into the reconstruction. There is no stated concern for evidence dynamics. There is no consideration for rigorously seeking to disprove one's interpretations. In other words, the scientific method is absent. There is only blind faith in the experience and judgment of the scene technician.

This approach is explained in greater detail as [Baldwin \(2005b\)](#) goes on to further confuse reconstruction and scene processing. He explains that it is a simple, intuitive process made easy through experience, conducted solely in a place where scientists are unwelcome:

There is nothing difficult about processing crime scenes. They are actually very simple. . . . Yes we [CSIs] can "read" the scene and our experience tells us what needs to be done, no forensic scientist that sits in a lab all day can do any of this. . . .

Just because someone thinks crime scenes should be processed by only those with a scientific background doesn't necessarily mean it should be done that way. CSI's are trained to process crime scenes in there [sic] entirety while forensic scientists are trained to process and analyze evidence. Two different worlds. I don't want a FS [forensic scientist] at my crime scene, they get in the way.

Scene interpretation and crime reconstruction, in this mode of thinking, are reduced simplistically to experience-driven observation, intuition, and surmise. There is, moreover, a clear and utter disdain for science at the crime scene. Subsequently, there is no consideration for eliminating bias, theory falsification, or theory revision. Experience is heralded as the final word on interpretation, and the contributions of forensic science are scorned outright as impractical.

The process that [Baldwin \(2005a\)](#) describes is referred to as an "informal reconstruction" by author and reconstructionist Ross M. Gardner, a retired investigator for the U.S. Army Criminal Investigation Command. As explained in [Gardner \(2005\)](#), such efforts must be approached with humility as they can form inappropriate preconceived theories:

The primary responsibility of the crime scene technician is to collect pertinent evidence and document the scene, thus they report these observations and actions as lay witnesses. But crime scene analysis/reconstruction is conducted in two distinct venues on scene as the scene is processed (an informal reconstruction) and then after the fact (the formal reconstruction), when all of the forensic data is available. The second a technician arrives on scene, they begin that informal reconstruction. . . . The technician walks into a scene, typically with incorrect information (e.g., told it's a stabbing when in fact it's a shooting); they don't know the extent of the scene, they don't know squat other than something happened.

It is that informal reconstruction that most often gets police organizations in trouble. This happens when they form a consolidated theory early on and are unable or unwilling to alter it as they encounter new evidence refuting their original position.

The reason that the so-called "informal reconstruction" actually "gets police organizations in trouble" is that it is not a reconstruction at all. As explained by Gardner, it is at best a hypothesis about some of the events that may have occurred, based on untested assumptions, awaiting verification through careful forensic examination, laboratory analyses, and the delicate swing of analytical logic. Failing to appreciate this, those without a scientific background are prone to treat their initial intuitions as conclusions and then selectively process the scene or look for other evidence in a way that tends to confirm what they believe. This, in turn, affects the total picture of evidence sent up the line to criminalists at the crime lab.

A reconstruction of events is not as simple as observation and conclusion based on experience. There are steps in between that must be followed to ensure a measure of reliability and accuracy. A reconstruction must be a conclusion regarding what has or has not occurred based on a

consideration of the forensic sciences, the scientific method, and analytical logic. Anything offered without this foundation is a guess, no matter how many years of experience one stacks beneath it for support. The confusion of guesswork and intuition for forensic fact is something that the reconstructionist must remedy. The notion of “formal” and “informal” reconstruction based on experience and intuition very much misses this point, and it contributes to the problem of oversimplification by lowering the bar well beneath the watermark of sound scientific methodology.

Evidence interpretation is a complex process, and the less one understands about the nature of physical evidence, the principles of forensic science, analytical logic, and the scientific method, the simpler crime reconstruction may seem. In that spirit, we explain these and related issues further so that reconstructionists may have them available in their intellectual tool kit.

REDUCING BIAS

Bias refers to a preference or an inclination that inhibits judgment to the point of impartiality. Forensic examiners have a professional and scientific obligation to acknowledge the possibility of bias in their work, to identify any of its sources, and to seek to reduce them whenever possible. In the forensic disciplines, bias manifests itself in the form of preferences for or against particular theories, methods, suspects, agencies, or sides of the courtroom.

Although we try to be objective, we must recognize that there are factors that we do not realize are present that influence our decisions. As stated by [Kuhn \(1977\)](#), “Subjective criteria, such as ‘individual biography and personality,’ play an overwhelming role in scientific decision making.” We are not able to completely eliminate these “subjective criteria” from our thought processes, but we must be aware that they are present.

The only way to mitigate bias is to first recognize its parentage and then work toward methods that minimize common points of impact, which is no small part of what this volume seeks to accomplish.

A Pavlovian Response

Whether we care to admit it or not, bias exists and can find its way into the results of our examinations.¹ A good barometer for the presence of bias, and even inability, is anger.

Wherever there is bias or ignorance, there is also fear of its discovery. As a consequence, anger and defensiveness are a nearly universal Pavlovian response to any unwanted inspection or review. The only purpose that this response serves, aside from telegraphing fear, is to intimidate others by making them uncomfortable. In other words, it is intended to make those who question shrink away in fear. This tactic may be deliberate or unintentional, but either way it is learned because it is successful.

Anger and defensiveness are particularly sinister problems in the realm of forensic science, in which dispassion and objectivity are prized above all else. Bias, both seen and unseen, can have horrendous consequences for justice, as explained in [James and Nordby \(2003, p. 4\)](#):

¹ See previous discussion in Chapter 4: Observer Effects and Examiner Bias: Psychological Influences on the Forensic Examiner.

When emotions overcome reason, a zealous forensic scientist may intentionally or inadvertently deny real justice. Results are misinterpreted, or worse, falsified. Such flawed science may not be easy to spot, since it can only appear through the results of the scientific investigation.

Forensic scientists do not get angry at the prospect of admitting potential bias and working diligently to smother its sources. They understand that bias can creep in, and they want to see it eradicated where possible. The forensic scientist is not out to help authorities catch bad guys, protect an agency, protect a reputation, or protect a client. The forensic scientist has, first and foremost, a professional responsibility that starts with objectivity.

A Professional Responsibility

The first onus of the forensic scientist is to dispassionately establish the objective facts of a case as determined by a careful and thorough examination of the evidence. It is not to find evidence to support the theories of a particular institution, employer, or side. A forensic scientist works to establish the scientific facts and their contextual meaning with no investment in the outcome. Their job is the deliberate education of investigators, attorneys, courts, and juries with these findings, not advocacy for or against the guilt of any suspect or defendant.

The forensic sciences in general, and crime reconstruction in specific, are vital to police investigations and courtroom proceedings. Witness, victim, and suspect accounts are inherently unreliable because sometimes people forget, sometimes they are mistaken, sometimes they exaggerate, and sometimes they lie. This is true whether individuals are giving statements to police or testifying under oath in a court of law. The physical evidence and its reconstruction offer a standard against which inaccurate statements may be compared and considered.

The physical evidence, as Dr. Paul Kirk explained, cannot lie; physical evidence can only be misinterpreted and misrepresented by the less knowledgeable, the less competent, and the morally destitute (Kirk, 1953). As provided by the court in *People of the Philippines v. Aguinaldo* (1999):

When physical evidence runs counter to testimonial evidence, conclusions as to physical evidence must prevail. Physical evidence is that mute but eloquent manifestation of truth which rate high in our hierarchy of trustworthy evidence.

When evidence interpretations are biased, the most certain shield against inaccurate statements is weakened, if not shattered. The responsibility of the reconstructionist to become knowledgeable about the various forms of bias, identify it in their work and workplace, and reduce its influence over their findings is therefore considerable. Objectivity and the quality of findings suffer tremendously when this duty is ignored.

There Are No “Sides” in Science

A first step to hefting the weight of bias from professional scientific practice is accepting that forensic science as a pursuit or profession does not belong to just one side of the courtroom. It does not belong to the state, it does not belong to the court, it does not belong to the police, and it

does not belong to attorneys. Forensic science, as a course of study, may be pursued by anyone, and it ultimately belongs to objective professionals who should be working together to better their science rather than allowing politics to divide them.

Consequently, there is no “dark side” of the courtroom to serve, only partisan forensic scientists who have chosen a side inappropriately. These are forensic scientists who conceal, obfuscate, and otherwise distort forensic results behind cloaks of righteousness, false prowess, and false certainty. Such individuals are recognizable from their use of the argument that “education, training, and experience” are the sole bases for their findings.

Another step is accepting that forensic scientists serving clients on both sides of the courtroom provide a necessary balance to the process of evidentiary examination and interpretation in terms of independent evaluation, replication, and overall peer review. A forensic expert testifying for one side, with none on the other, as often occurs, can leave the courtroom in a state of imbalance. It can telegraph a message to the jury that the side with the lab coats has the best grasp of the facts and the most viable case theory.

Without an independent review of findings, the reliability and validity of any theory cannot be reasonably assured. Forensic science and evidence interpretation must not be emotional. They do not become enraged or annoyed by doubt or disbelief—they question themselves and invite skepticism through reexamination. More to its purpose, forensic science, in the absence of independent review, exists in an unrefined form that is arguably not fit for court. It is this step, after all, that has historically been proven to identify errors, ignorance, misapplications of method, and outright fraud.

The next steps involve learning how to observe, how to reflect, and how to make valid inferences. To accomplish this, we must marry the complexity of evidence discovered in the wake of criminal behavior to the simplicity of logic and reason.

PERMISSION TO REFLECT

The forensic scientist ultimately seeks to understand and explain the events related to a crime. This does not just happen with a glance: It requires an underlying base of knowledge, scrupulous observation, and time to reflect. The French philosopher Denis Diderot (1713–1784) wrote of knowledge and reflection in what may be described as his take on the scientific method ([Diderot, 1753](#)):

There are three principal means of acquiring knowledge available to us: observation of nature, reflection, and experimentation. Observation collects facts; reflection combines them; experimentation verifies the result of that combination. Our observation of nature must be diligent, our reflection profound, and our experiments exact. We rarely see these three means combined.

In the writings of Diderot, as for us all, reflection is a vital ingredient for tempering thought and reason. Thoughts and reason that surface without reflection are often the result of mental habit, personal belief, or prejudice masquerading as insight (otherwise known as intuition).

Much government-funded forensic science occurs in circumstances that do not allow for reflection, contemplation, or experimentation or for lack of funding, time, or intellectual dexterity. Consequently, a careful student of forensic casework and testimony will find no small amount of the conclusions that modern forensic scientists profess in their reports and testimony to be based

on raw experience, incomplete evidence, unchecked assumptions, untested theories, poor on-the-job training, and oversimplified arguments. These occur, and are allowed to occur, because those with vested interests and authority encourage forensic findings that serve their purposes. To paraphrase Diderot, they drink deeply from the sweet wines that flatter them, and sip carefully at the bitter taste of scientific fact.

As long as forensic science is “overseen” by vested individuals and organizations, there will remain little incentive for competence, rigor, or reflection apart from the individual professional compass (Edwards and Gotsonis, 2009; James and Nordby, 2003).

There is a responsibility to reflect on theories and findings before ascribing meaning to them, and certainly before putting them into a report of findings. Reconstruction is, again, complex. We are meant to brood and deliberate over the quality of our inferences and invite others to do the same.

CRITICAL THINKING

Critical thinking is integral to good science. There are many definitions for the term **critical thinking**. A unifying concept is that critical thinking involves identifying and questioning the assumptions in arguments that we encounter in any context, and from any authority. Paul and Scriven (2004) note that

Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

Most of the students and professionals encountered by the authors have no idea what critical thinking is, what it involves, or how it can be useful in problem solving. For the purposes of forensic science and crime reconstruction, the application of critical thinking to casework means a staunch refusal to accept any evidence or conclusions without sufficient proof. It involves the careful and deliberate determination of whether to accept, reject, or suspend judgment about any information, evidence, or related findings. It means skeptical gathering of evidence, skeptical examinations, and the skeptical interpretation of results. This includes the following:

1. Evaluating the nature and quality of any information and its source
2. Recognizing bias
3. Separating facts from opinions
4. Distinguishing between primary sources of information (unaltered—direct from the source) and secondary sources of information (altered—interpreted or summarized through someone else)
5. Synthesizing information

The problem with critical thinking is that in some circumstances it is easier, and perhaps more realistic, to accept what others have told us or shown us instead of investigating matters for ourselves. There may also be harsh consequences for questioning information or findings when they come from those who perceive themselves as our betters (or our supervisors or clients). Although this can be true as a practical matter, it does not make arguments based on uncritically accepted information or conclusions more reliable. Rather, it robs them of their scientific veracity.

The culture of science is skeptical, requires investigative curiosity, and invites criticism from all corners. It is not about making friends or impressing colleagues. Useful instructions for the forensic criminologist are found in [Kennedy and Kennedy \(1972, p. 4\)](#):

To be objective, an inquirer should be prepared to accept and record whatever facts he may encounter. He must not let personal feelings affect what he sees or hears. Although he does not need to like the nature of the information, he must be willing to investigate it. When such an investigation is begun, it must be carried through with a degree of skepticism. Skepticism does not imply cynicism or a distrust of the world. It only suggests that the [forensic examiner] must be prepared to distinguish truth from the opinion or inclinations of others.

The idea of scientific culture is explored more thoroughly in [Edwards and Gotsonis \(2009, pp. 4–11\)](#):

The methods and culture of scientific research enable it to be a self-correcting enterprise. Because researchers are, by definition, creating new understanding, they must be as cautious as possible before asserting a new “truth.” Also, because researchers are working at a frontier, few others may have the knowledge to catch and correct any errors they make. Thus, science has had to develop means of revisiting provisional results and revealing errors before they are widely used. The processes of peer review, publication, collegial interactions (e.g., sharing at conferences), and the involvement of graduate students (who are expected to question as they learn) all support this need. Science is characterized also by a culture that encourages and rewards critical questioning of past results and of colleagues. Most technologies benefit from a solid research foundation in academia and ample opportunity for peer-to-peer stimulation and critical assessment, review and critique through conferences, seminars, publishing, and more. These elements provide a rich set of paths through which new ideas and skepticism can travel and opportunities for scientists to step away from their day-to-day work and take a longer-term view. The scientific culture encourages cautious, precise statements and discourages statements that go beyond established facts; it is acceptable for colleagues to challenge one another, even if the challenger is more junior. The forensic science disciplines will profit enormously by full adoption of this scientific culture.

It has been said of science that if you are not making mistakes you are doing it wrong; if you do not correct those mistakes you are doing it very wrong; and if you cannot accept when you are mistaken you are not doing it at all. Error, doubt, and uncertainty are integral to scientific practice. Any individual or group that seeks to quell the critical mandates of science, seeing it as bad form to doubt or question, works against the essence of scientific culture. Understanding this aspect of scientific inquiry is sometimes difficult for those who have been taught to conform, to follow orders, or who must work within a structured hierarchy that forces unproved theories and assumptions upon them. Again, this is a violation of scientific culture, and forensic scientists can have no part in it without surrendering some measure of what Thornton refers to in Chapter 3 as “professional chastity.”

THE SCIENTIFIC METHOD

We invent our myths and our theories and we try them out: we try to see how far they take us. And we improve our theories if we can. The better theory is the one that has the greater explanatory power: that explains more; that explains with greater precision; and that allows us to make better predictions.

–[Karl Popper \(1965, p. 192\)](#)

The **Socratic method** is an approach to knowledge building and problem solving based on discussion and debate. Practitioners seek explanations by identifying assumptions in their

arguments and eliminating that which is not true or cannot be proven. Hypotheses are generated and conceptually tested or challenged based on what is known. It commonly involves two or more people engaged in the debate of a specific issue. In this fashion, the strongest explanations of circumstances or events survive, whereas the weakest are killed off by a succession of contradictory facts or counterexamples (Windelband, 1958, p. 96). This is the premise underlying all classroom discussion and discourse.² While the Socratic method can be a valued, integral part of the scientific method, it is by no means a substitute for it.

The **scientific method** is a particular approach to knowledge building and problem solving based on the development of empirically testable hypotheses that are then assaulted by experiments intended to falsify them. Each of the contributors to this text will discuss their application of the scientific method in the chapters that follow; however, it is useful to outline the general steps involved.

The first step in the scientific method is *observation*. An observation is made regarding some event or object. This observation then leads to a specific question regarding the event or object, such as where it originated from or how it came to possess certain traits.

The second step in the scientific method is attempting to answer the question that has been asked by forming a *hypothesis*, or a guess, regarding the possible answer. Often, there is more than one possible answer.

The third step in the scientific method is *experimentation*. Of all the steps in the scientific method, this is the one that separates scientific inquiry from others. Forensic scientists design experiments intended to disprove their hypotheses. Once again, forensic scientists design experiments intended to disprove their hypotheses, not to prove them.

At least one major forensic science text that provides readers with discussions of crime reconstruction as a process has failed to emphasize this crucial aspect of the experimentation or “testing” phase in theory development. Rather, crime reconstruction is presented in an overly simplified fashion for use by investigators looking to prove their theories (Baker and Napier, 2003, p. 538; Miller, 2003, pp. 128–129). These joined works collectively leave the door open for a confirmatory bias. Reconstruction conclusions regarding crime-related actions or events are not intended to absolutely “verify,” “confirm,” or “prove” investigative theories. Rather, they are meant to support or refute investigative theories. The words “support” and “confirm” are worlds apart. One suggests assistance, whereas one suggests finality. This difference may sound semantic to some, but it is vital to understand that it is not.

The purpose of forensic science and crime reconstruction is to test investigative theories and subsequently provide independent support or opposition. The key word is *independent*. If the job of the forensic scientist is merely to work toward confirming law enforcement theories, then there is no point in performing an analysis. Confirmation is always easy to find if that is what one looks for—all one needs to do is ignore everything that works against the prevailing theory and embrace everything that supports it even remotely. But that is not what the scientific method is about. The absolute cornerstone of the scientific method is **falsification**.

² Although it is lost in modern-day classrooms when discussion is absent because teachers instruct from texts they have not read, requiring students to regurgitate only what they have been told to receive a grade.

SCIENCE AS FALSIFICATION

These considerations led me in the winter of 1919–20 to conclusions which I may now reformulate as follows.
—*Sir Karl R. Popper (1963, pp. 33–39)*

1. It is easy to obtain confirmations, or verifications, for nearly every theory—if we look for confirmations.
2. Confirmations should count only if they are the result of risky predictions; that is to say, if, unenlightened by the theory in question, we should have expected an event which was incompatible with the theory—an event which would have refuted the theory.
3. Every “good” scientific theory is a prohibition: It forbids certain things to happen. The more a theory forbids, the better it is.
4. A theory which is not refutable by any conceivable event is nonscientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.
5. Every genuine test of a theory is an attempt to falsify it, or to refute it. Testability is falsifiability; but there are degrees of testability: Some theories are more testable, more exposed to refutation, than others; they take, as it were, greater risks.
6. Confirming evidence should not count except when it is the result of a genuine test of the theory; and this means that it can be presented as a serious but unsuccessful attempt to falsify the theory. (I now speak in such cases of “corroborating evidence.”)
7. Some genuinely testable theories, when found to be false, are still upheld by their admirers—for example, by introducing ad hoc some auxiliary assumption, or by reinterpreting the theory ad hoc in such a way that it escapes refutation. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status. (I later described such a rescuing operation as a “conventionalist twist” or a “conventionalist stratagem.”)

One can sum up all this by saying that the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability.

If a hypothesis remains standing after a succession of tests or experiments fail to disprove it, then it may become a **scientific theory**. Scientific theories that withstand the test of time and empirical study eventually become **scientific principles**. A scientific theory, developed with the assistance of the scientific method, has a greater degree of reliability and acceptance than mere observation, intuition, or speculation. With regard to crime reconstruction, this may be explained in terms of establishing what has not occurred, and what may or may not be supported by the evidence, as opposed to absolutely confirming a specific event or sequence of events.

Example: A Ball of Clay

To use a simple example, imagine a ball of clay. It is perfectly spherical except for a flattened area on one side. We theorize that the ball was dropped onto a flat surface, causing it to become flattened. To test this theory, we take several clay balls of the same diameter and weight and drop them from various heights. We then examine the flattened area on each (Figure 5.2).

When we find one with a flattened area equal to that on the original, we postulate that they were both dropped from approximately the same height. Are there alternative solutions?

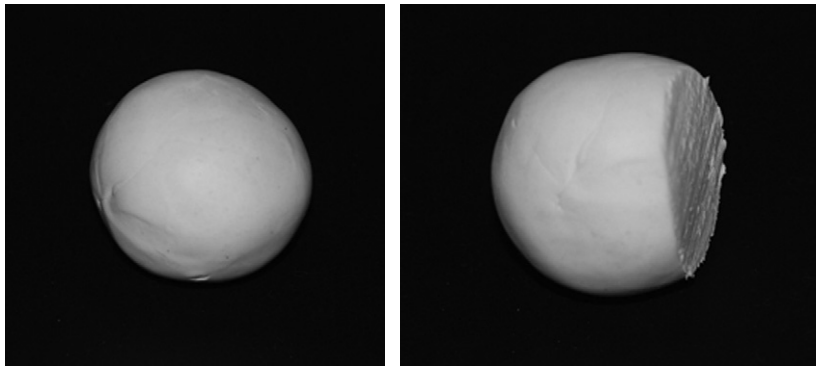


FIGURE 5.2 A ball of clay, perfectly round save one flat side. Was it dropped; if so, from what height? Was it cut; if so, with what?

Of course, the ball may have been molded that way in the first place. Could it have been pressed with a flat object? No, it would cause two flat sides—we can try this experiment to show this result. Could the area have been cut off? We can examine the surface of the clay to determine whether or not there has been a surface change. We can imagine several different ways of cutting—knife, razor blade, laser, etc. Each would change the surface characteristics in a distinctive fashion, leaving behind a particular pattern or tool mark.

To eliminate alternatives, we need to do experiments. If experiments about one part of the evidence cannot determine which alternative is correct, then we must expand our experiments to other parts of the evidence or we need to research the background of the subject. In the previous simplified example, we have two alternative solutions: The ball was made the way we found it or it fell from a determined distance. To eliminate one of the alternatives we could examine the flat surface where the ball was found. We could place preflattened balls on the surface and we could drop spherical balls from the predetermined height to the surface. We then determine if we can see a difference in the amount or type of residue remaining when the balls are removed. We may even leave the balls on the surface to determine if the time in contact makes a difference. We then look back at the original surface to see which of our experiments reproduce the characteristics we find.

When we are left with only one alternative, then we conclude our hypothesis must be true or, as stated by the fictional Sherlock Holmes, “Eliminate all other factors, and the one which remains must be the truth” (*The Sign of Four* by A. Conan Doyle, 1888).

This is the scientific method. We make observations; we theorize or state a hypothesis; and we conduct experiments that support or negate our hypothesis. The problem is designing the correct experiments; we must be able to identify alternative solutions and design the experiments to distinguish between the various hypotheses without letting our personal biases and prejudices favor one or the other.

PRACTICE STANDARDS

As already explained, all forensic practitioners have a duty to strive for objectivity, competence, and professionalism in their work. Forensic examiners should want their findings to be accurate, their methods to be reliable, and their results to be repeatable by others. This requires clearly expressed practice standards.

Practice standards define a minimum threshold of competency. They also help define a practitioner's role and outline a mechanism for demonstrating their facility. They are a compass for diligent practitioners to follow and a screen against which those who have lost their way can be delayed and educated. As this suggests, the purpose of defining practice standards is not only to help professionals achieve a level of competency but also to provide independent reviewers with a basis for checking work that purports to be competent. Practice standards set the bar and are a safeguard against ignorance, incapacity, and incomprehension masquerading as science and reason.

The major published works that cover both forensic science and crime reconstruction may be aggregated to assist in defining basic yet essential practice standards that apply to forensic practitioners of almost every kind (Bevel and Gardner, 1997, 2001; Chisum and Rynearson, 1997; DeForest et al., 1983; DeHaan, 2002; Gross, 1906; Inman and Rudin, 1999; Kirk, 1953; Kirk and Thornton, 1970; Lee, 1994; Locard, 1934; O'Connell and Soderman, 1936; O'Hara, 1956, 1970; Thornton and Peterson, 2002; Turvey, 2010). In these collected texts authored by practitioner-educators, the scientific method, analytical reasoning, and objectivity are prized above all else, whereas emotion, intuition, and other forms of bias masquerading as knowledge are shunned. With the assistance of these works, the following generally accepted practice standards may be offered.

1. Reconstructionists must strive diligently to avoid bias.

Dr. Paul Kirk wrote of crime reconstruction, "Physical evidence cannot be wrong; it cannot be perjured; it cannot be wholly absent. *Only in its interpretation can there be error*" (Kirk and Thornton, 1970, p. 4). With this simple observation, Kirk was referring to the influences of examiner ignorance, imprecision, and bias on the reconstruction of physical evidence and its meaning. The evidence is always there, waiting to be understood. However, understanding of its nature and relevance comes only through the imperfect lens of the forensic examiner.

Specifically, there are at least two kinds of bias that objective forensic examiners need to be aware of and mitigate in their casework in order to maintain their professional lens—observer bias and confirmation bias. These were discussed in previous chapters but bear repeating here for our purposes.

Observer bias may be described as the conscious or unconscious tendency to see or find what one expects to see or find. In a practical sense, this means that the forensic examiner can develop an expectation of findings based on information and opinions he or she learned from popular media, witnesses, and opinions and/or findings of others. These influences are particularly insidious because, unlike overt fraud, they can be subconscious. Unless intentionally screened or recognized by the examiner in some fashion, influences can nudge, push, or drag examiner findings in a particular direction.

Confirmation bias may be described as the conscious or unconscious tendency to affirm previous theories, opinions, or findings. It is a specific kind of observer bias in which information and evidence are screened to include those things that confirm a position and to actively ignore, not look for, or undervalue the relevance of anything that contradicts that position.

It commonly manifests itself in the form of looking only for particular kinds of evidence that support a given case theory (i.e., suspect guilt or innocence) and actively explaining away evidence or findings that are undesirable. As stated previously, this can be the selection of evidence to examine by persons advocating a particular theory or by persons interested in "watching the

budget” so that potentially exculpatory evidence is not selected for analysis because that would cost more money or require too much time.

Wrestling with confirmation bias is extremely difficult, often because it is institutional. Many forensic examiners work in systems in which they are rewarded with praise and promotion for successfully advocating their side when true science is about anything other than successfully advocating any one side. Consequently, the majority of forensic examiners suffering from confirmation bias have no idea what it is or that it is even a problem. Many even come to believe that they are a valuable member of a prosecutor’s team and that winning a case is the measure of a job well done.

What must be understood by all forensic examiners is that the primary value of forensic science to the legal system (the forensic part) is their adherence to the scientific method (the science part), which demands as much objectivity and soundness of method as can be brought to bear. Success in the forensic science community must be measured by the diligent elimination of possibilities through the scientific method and peer review, not through securing convictions or making friends with “the team.” As Professor [Brian Parker \(personal communication, 2005\)](#) states, “The job of the crime lab is to prove the investigator wrong.”

2. Reconstructionists are responsible for requesting all relevant evidence and information in order to perform an adequate reconstruction.

Reconstructionists must define the scope of evidence and information needed to perform an adequate reconstruction, partial or otherwise, and make a written request from their client, employer, or the requesting agency.

Basic requests for information must include the following.

- a. A list of all agencies and individuals that responded to the crime scene and/or have assisted in the investigation to date.
- b. All available crime scene documentation, including collection and security logs, notes, sketches, and photos.
- c. All available investigative reports and notes from all responding/assisting agencies.
- d. All available forensic reports, notes, and laboratory findings from all responding/assisting agencies.
- e. All available medical reports and notes, including trauma-grams and injury photos.
- f. All available medical examiner reports and notes, including trauma-grams and autopsy photos.
- g. All relevant investigative and forensic testimony from any court proceedings to date.
- h. A list of all witnesses to the crime or crime scene.³
- i. Any documentation of witness and suspect statements, including recordings, transcripts, and investigative summaries.

Upon receiving the materials and evidence requested, they must determine what has been provided and what is missing. This basic task is incumbent upon every forensic reconstructionist.

³ The reconstructionist is not going to interview witnesses; however, it is useful to know whether witnesses have given statements. Therefore, a comparison of lists will help identify which interviews or items might be missing.

Missing or unavailable materials are commonplace in the context of a criminal investigation. Often this will be the result of simple and unavoidable human error. However, the authors have observed a frightening trend of underdocumentation in the law enforcement community: evidence is intentionally ignored at the scene or the scene is intentionally documented in an incomplete fashion for fear that resulting information will be used against them by the defense (rightly or not). This is especially common in cases where police investigators feel that they have strong witnesses or when the facts seem unequivocal (making evidence unnecessary or potentially harmful to prevailing case theories). Also, in less professional law enforcement jurisdictions, there may be no crime scene protocols governing scene activity or evidence collection efforts. In such cases, the reconstructionist must accept these limitations on the reconstruction and be honest about their impact on the case facts.

When the reconstructionist is not able to base findings on complete information, this must be made clear as part of any conclusions. If the evidence has not been documented properly by a thorough crime scene investigation, then not only are they limited in the strength and scope of their findings, others must be as well. The absence of proper or complete crime scene investigation efforts is in itself an important finding.

3. Reconstructionists are responsible for determining whether the evidence they are examining is of sufficient *quality* to provide the basis for a reconstruction.

The harsh reality is that crime scene processing and documentation efforts are too often abysmal if not completely absent. Crime scenes throughout the United States are commonly processed by police-employed technicians or sworn personnel with little or no training, to say nothing of formal education in the forensic sciences and crime scene processing methods. The in-service forensic training available to law enforcement typically exists in the form of half-day seminars or short courses taught by nonscientists who, on their own, in no way impart the discipline and expertise necessary to process crime scenes adequately for the purposes of reconstruction.

In order to determine whether evidence is of sufficient quality to provide the basis for a reconstruction, the most important considerations are the following.

- a. The ability to identify the item of evidence.
- b. The ability to conceptually if not literally place the item back in the crime scene where it was found in relation to the other items of evidence. This is done through competent sketches and related written and photographic documentation. Memory is not a reliable substitute for hard documentation.
- c. The ability to identify every person who handled the item subsequent to its collection. Is the chain of evidence secure and complete?
- d. The ability to identify every test that was performed on the item, who performed them, and the results.
- e. Was the packaging, transportation, and storage of the item such that the item was preserved and the integrity of it maintained?

If crime scene documentation and processing efforts are not sufficient to the task of allowing for the reconstructionist to establish the previously mentioned considerations, then those efforts were inadequate. Reconstructionists must make note of such deficiencies in their analyses and factor them into their conclusions, and may even need to explain that they cannot derive certain conclusions or eliminate various theories because of them.

It is important to note that the reconstructionist cannot know absolutely everything about any item of evidence. Nobody can. The challenge is to consider all that is known when performing a reconstruction and be prepared to incorporate new information as it may come to light. This means appreciating that new information about any item of evidence, or its history, may affect any conclusions about what it means.

4. Reconstructionists must, whenever possible, visit the crime scene.

It is highly preferable that the reconstructionist visit the crime scene before rendering interpretations of the evidence. The following are examples of the kind of information that may be learned:

- a. The sights, smells, and sounds of the crime scene, as the victim and the offender may have perceived them.
- b. The spatial relationships within the scene.
- c. Observe and experience potential transfer evidence first-hand. Vegetation, soil, glass, fibers, and any other material that may have transferred onto the victim or suspects may become evident or may transfer onto the reconstructionist, providing examples of what to look for on suspect clothing or in suspect vehicles.
- d. The reconstructionist may discover items of evidence at the scene previously missed and subsequently uncollected or undocumented by crime scene technician efforts. This is far more common than many care to admit and is one of the most important reasons for visiting the crime scene.

In many cases, it will not be possible for the reconstructionist to visit the crime scene. This occurs for a variety of practical reasons, including time limitations, budgetary limitations, legal restrictions, alteration of the scene by forces of nature, or obliteration of the scene by land or property development. If the reconstructionist is unable to visit the crime scene for whatever reason, this must be clearly noted and reflected in any findings.

The primary reason for documenting a crime scene is to provide for later reconstruction efforts. Otherwise, crime scene documentation serves little purpose. Consequently, the inability of the reconstructionist to visit a scene does not preclude reconstruction efforts across the board. Competent scene documentation by forensic technicians may be sufficient to address the issues in question. Each case is different and must be considered separately and carefully with regard to this issue.

5. Reconstruction conclusions, and their basis, must be provided in a written format.

Hans Gross referred to the critical role that exact, deliberate, and patient efforts at crime reconstruction can play in the investigation and resolution of crime. Specifically, he stated that just looking at a crime scene is not enough. He argued that there is utility in reducing one's opinions regarding the reconstruction to the form of a report in order to identify problems in the logic of one's theories (Gross, 1924, p. 439):

So long as one only looks on the scene, it is impossible, whatever the care, time, and attention bestowed, to detect all the details, and especially note the incongruities: but these strike us at once when we set ourselves to describe the picture on paper as exactly and clearly as possible. . . .

The “defects of the situation” are just those contradictions, those improbabilities, which occur when one desires to represent the situation as something quite different from what it really is, and this with the very best intentions and the purest belief that one has worked with all of the forethought, craft, and consideration imaginable.

Moreover, the reconstructionist, not the recipient of the reconstructionist’s opinions (i.e., investigators, attorneys, and the court), bears the burden of ensuring that conclusions are communicated effectively. This means writing them down. This means that the reconstructionist must be competent at intelligible writing, and all reports must be comprehensive with regard to examinations performed, findings, and conclusions.

Verbal conclusions should be viewed as a form of substandard work product. They are susceptible to conversions, alterations, and misrepresentations. They may also become lost to time. Written conclusions are fixed in time, easy to reproduce, and are less susceptible to accidental or intentional conversion, alteration, and misrepresentation.

An analyst who prefers verbal conclusions as opposed to written conclusions reveals his preference for conclusive mobility. Verbally communicated theories at the crime scene can be interpreted as real conclusions by the investigator, causing them to direct the investigation based on what they heard. Finding something later that refutes that theory can cause lack of confidence and trust, resulting in the reconstructionist being not invited to crime scenes.

Apart from their relative permanence, written conclusions also provide the reconstructionist with the best chance to memorialize methods, conclusions, arguments, and the underlying facts of the case. This includes a list of the materials and evidence examined, when they were examined, the methods used, and under what circumstances.⁴

Finally, writing is an important tool for identifying and working out any flaws or inconsistencies in the logical progression of inferred events. If a reconstruction interpretation cannot be written down in a logical form, understood easily by the intended user, then apart from having no value it is also probably wrong.

6. Reconstructionists must demonstrate an understanding of science, forensic science, and the scientific method.

The current national educational requirements for forensic scientists, which are agency specific and, therefore, nonexistent, fall short of ensuring that practitioners understand not only science and the scientific method but also basic research and statistical methods. All forensic scientists, including reconstructionists, must have a working knowledge of these subjects (see [Edwards and Gotsonis, 2009](#)). It has been said “if there is no science, there can be no forensic science” ([Thornton, 1997, p. 17](#)). Reconstruction in the absence of science and forensic science is unacceptable.

At a minimum, this means that the reconstructionist must be educated in the fundamentals of science and the scientific method by an actual scientist. According to Thornton (1997, pp. 15–16), “A measure of scientific education and a university degree in a scientific discipline will ordinarily meet that test.”

It further means that the reconstructionist must be educated in the forensic sciences by practicing forensic scientists. If their work involves the interpretation and presentation of statistical data, it means at least basic university-level coursework in that subject as well. Too many are

⁴ See also Chapter 19: Forensic Examination Reports.

learning these subjects informally, on the job, or from nonscientists and are consequently bringing their ignorance to case examination and then into court.

7. Reconstruction conclusions must be based on established facts. Facts may not be assumed for the purpose of analysis.

Many examiners are willing to provide a certain reconstruction of events based on experiential comparisons to unnamed cases, factual guesses, and assumptions or on nonexistent physical evidence. If the underlying facts have not been established through investigative documentation, crime scene documentation, examination of physical evidence, or corroborated eyewitness testimony, then any reconstruction of those facts is not a reliable or valid inference of events. This includes hypothetical scenarios that try to explain what happened by making assumptions.

8. Reconstruction conclusions must be valid inferences based on logical arguments and analytical reasoning.

In the process of establishing the facts that are fit for analysis, facts must be sifted and distinguished from opinions, conjectures, and theories. Inductive hypotheses must further be delineated from deductive conclusions, and conclusions must flow naturally from the facts provided. Furthermore, the reconstruction must be entirely free from logical fallacies and incorrect statements of fact.⁵

9. Reconstruction conclusions must be reached with the assistance of the scientific method.

The scientific method demands that careful observations of the evidence be made and then hypotheses generated and ultimately tested against all of the known evidence and accepted facts. Subsequently, the reconstructionist must be able to provide not just conclusions but all other postulated theories that have been falsified through examinations, tests, and experiments. Falsification, not validation, is the cornerstone of the scientific method. Theories that have not been put to any test or that appear in a report or in courtroom testimony based on rumination and imagination alone (i.e., experience and intuition) should not be considered inherently valid or reliable.

10. Reconstruction conclusions must demonstrate an understanding of, and clearly distinguish between, individuating findings and all others.

The concept of identification and individuation is often misunderstood. **Identification** or **classification** is the placement of any item into a specific category of items with similar characteristics. Identification does not require or imply uniqueness. **Individuation** is the assignment of uniqueness to an item. To individuate an item, it must be described in such a manner as to separate it from all other items in the universe (Thornton, 1997, p. 7).

In the presentation of findings, reconstructionists will find themselves using statements that suggest varying degrees of confidence. Vague terms or terms of art, such as “probably,” “likely,” “identify,” “match,” “consistent with,” and “reasonable degree of scientific certainty,” are among those used to qualify the certainty of findings.

⁵ See also Chapter 3: Crime Reconstruction: Ethos and Ethics, and Chapter 19: Forensic Examination Reports.

Unchecked, this language can be misleading to those it is intended to assist. Confident statements must be qualified and discussed to the point of absolute clarity. Without clarification, findings may be misunderstood, misrepresented, and misapplied. If the reconstructionist provides individuating findings of any sort, the nature of the uniqueness and how it was established must be clearly presented. When the reconstructionist has given findings, no question must remain as to whether the findings are individuating and no question as to how this was established. The purpose of presenting findings is to clarify the evidence, not muddle it.

11. Reconstructionists must demonstrate an understanding of establishing the conditions of transfer (Locard's exchange principle and evidence dynamics).

Identifying and individuating physical evidence are just part of crime reconstruction. Equally important is the need to establish the source of evidence and the conditions under which it was transferred to where it was ultimately found. Reconstructionists must not be quick to oversimplify complex issues, such as the examination and interpretation of physical evidence, or to disregard those circumstances that can move, alter, or obliterate that evidence.⁶

12. Any evidence, data, or findings on which reconstruction conclusions are based must be made available through presentation or citation.

It is not acceptable for the reconstructionist to provide conclusions based on phantom databases, phantom data, phantom research, phantom evidence, or unseen comparisons. Data, research, and evidence must be detailed to the point where others reviewing their work may locate or identify it easily. Data, research, and evidence that cannot be duplicated or identified by the court in some fashion should not find its way into forensic conclusions.

CONCLUSION

These essential practice standards should be applied to the evaluation of any method of crime reconstruction, both the general and the specialized, in order to show due diligence. If a reconstructionist is able to meet these standards, then the threshold level of professional competency has indeed been achieved. Subsequently, the recipients of their conclusions may be assured that whatever the findings, they may be independently investigated and reviewed for reliability, accuracy, and validity.

It bears pointing out that a reconstructionist who fails to climb even one of the rungs prescribed will not have reached this threshold. In failing they should have their findings questioned, as well as subsequent reports and testimony viewed with disfavor by the court. This will be echoed in the chapters that follow.

It is important to clarify that these practice standards do not leave anyone behind, but they do require everyone to show their work. Reconstructing crime is not easy or rote. Conclusions must be earned, which means that competency must be demonstrated and peer review embraced. A reconstructionist has a duty to formulate conclusions with the full reach of everything that forensic science, the scientific method, critical thinking, and analytical logic have to offer. Without

⁶ See Chapter 6: Evidence Dynamics.

these tools, reconstructionists are at risk of not being able to recognize forensic and scientific illiteracy in themselves or others.

To the uninitiated, these practice standards may seem too many or even too harsh. It may also seem as though the authors and contributors of this text are interpreting the forensic science and crime reconstruction literature in favor of objective forensic science and in opposition to everything else.

To these and similar criticisms we offer this: First, crime reconstruction is a subdiscipline of the forensic sciences because it is forensic in nature and purports to be scientific in its practice. Second, those who wish to practice any form of crime reconstruction under that umbrella are obligated to know something of both the scientific method and forensic science. Third, if it seems that the authors and contributors of this text lean quite far in favor of practicing the scientific method and impartial evidence-based analysis above all else, it is because we mean to.⁷

These practice standards may also raise the ire of some forensic examiners who have been reconstructing crime based on intuition and experience, perhaps for years, and who are unaccustomed to explaining themselves or their methods apart from stating their vast experience. If peer review and criticism are not welcome at a conclusion's doorstep, if instead such visitors are met with hostility and derision, then something other than science dwells within. To be clearer, the absence of the scientific method and logical inference in any reconstruction should not be a point of pride because it is ultimately evidence of ignorance. A reconstruction in the absence of the scientific method, analytical logic, and critical thinking is called a guess. A courtroom is no place for ignorance or guessing.

SUMMARY

A reconstruction of events is not as simple as observation and conclusion based on experience. There are steps in between that must be followed to ensure a measure of reliability and accuracy. A reconstruction must be a conclusion regarding what has or has not occurred based on a consideration of the forensic sciences, the scientific method, and analytical logic. Anything offered without this foundation is a guess, no matter how many years of experience one stacks beneath it for support. The confusion of guesswork and intuition for forensic fact is something that the reconstructionist must remedy in his or her work. The notion of "formal" and "informal" reconstruction based on experience and intuition very much misses this point and contributes to the problem of oversimplification by lowering the bar well beneath the watermark of sound scientific methodology.

Forensic practitioners have a duty to strive for objectivity, competence, and professionalism in their work. Forensic examiners should want their findings to be accurate, their methods to be reliable, and their results to be repeatable by others. This requires clearly expressed practice standards. The *practice standards* for crime reconstruction are those basic foundations and precepts that regulate the limits of evidentiary interpretation. The purpose of defining practice standards is not only to help professionals achieve a level of competency but also to provide independent reviewers with a basis for checking work that purports to be competent. Practice

⁷ See Preface to the 2nd edition, the NAS report: A Mandate for Science in Forensic Science.

standards set the bar and are a safeguard against ignorance, incapacity, and incomprehension masquerading as science and reason.

QUESTIONS

1. How does critical thinking apply to crime reconstruction?
2. What is the cornerstone of the *scientific method*?
3. What is the purpose of *practice standards*?
4. List three *practice standards* for crime reconstruction and explain why they are important.
5. Explain the difference between *identification* and *individuation*.

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Evidence Dynamics

W. Jerry Chisum and Brent E. Turvey

If we don't collect evidence and we don't store it properly,
then the science is useless.

—Richard Rosen, *Professor of Law, University of North Carolina–Chapel Hill*
(quoted in [Zerwick, 2005](#))

Key Terms

Assumption of integrity; Chain of custody (a.k.a. chain of evidence); Evidence dynamics; Fantasy; Precautionary acts; Rituals; Secondary transfer; Spoliation; Spoliation inference; Staging

Crime reconstruction is a deliberate process that often yields imprecise results while revealing evidentiary holes, sequential gaps, and equally plausible yet competing case theories. However, this is not necessarily the result of poor science or examiner inability. Forensic scientists are responsible for establishing, and reminding others, that what the evidence supports is often just as important as what it does not. Establishing and revealing evidentiary frailty are indications of scientific integrity. They are also relevant to the purposes of investigators, courts, and jurors alike.

The more we learn about physical evidence—how it can be affected by external forces and distortions—the more we come to appreciate that it is not necessarily a certain and precise record of actions and events, although it is the most objective when interpreted properly. Even under the best circumstances, however, physical evidence must be interpreted through a successive layer of necessary and uncontrollable influences. Becoming more educated and honest about the limits of physical evidence will help us prevent misrepresentation and misuse.

The purpose of this chapter is to discuss those necessary and uncontrollable influences, which we refer to as *evidence dynamics*,¹ and how reconstructionists must make efforts to both recognize and account for them in their interpretations.

¹ Evidence dynamics as a formal concept was first described by the authors in [Chisum and Turvey \(2000\)](#). Portions of that article were used to develop the current chapter.

EVIDENCE DYNAMICS

Crime reconstruction efforts are concerned with interpreting the physical evidence that results from the actions and events related to the commission of a crime. However, frequently missing from this analysis are the recognition and consideration of those things that can change physical evidence prior to, or as a result of, its collection and examination. The general term **evidence dynamics** has been developed by the authors to refer to any influence that adds, changes, relocates, obscures, contaminates, or obliterates physical evidence, regardless of intent. This term was deemed appropriate because all forms of physical evidence are constantly at the mercy of agents that inflict change, such as environmental forces, human activity, animal predation, and the effects of time.

Evidence dynamics are at work in a scene even before an event happens that requires reconstruction, waiting to confuse, mislead, and confound. They are present as physical evidence is being transferred or created, and remain a hazard during scene processing efforts, and later in forensic testing. In fact, these many agents of chaotic change continue, and do not stop, until an item of evidence has been destroyed intentionally or inadvertently.

For those who understand these forces, and account for them in their analyses, this chapter provides a useful reference when explaining the limits that they impose to others. For those who do not, it will be a necessary tutorial intended to dampen inappropriate expectations of certainty about forensic science and physical evidence that may exist as the result of the media and biased or incomplete instruction. As we will make clear, an appreciation of evidence dynamics is requisite, and often pivotal, to any evidence examinations and subsequent reconstructions of events.

THE ASSUMPTION OF INTEGRITY

Crime reconstructions are too often built on an **assumption of integrity**—that evidence left behind at a scene is guarded and vestal prior to the arrival of police investigators and other responders. This assumption extends to the mistaken belief that taping off an area, limiting access, and setting about the task of taking pictures and making measurements somehow ensure the integrity of the evidence found within. Subsequently, any conclusions reached through forensic examinations of that evidence are wrongly assumed to be a wholly reliable lens through which to view the crime. Although reconstruction is made easier with this assumption, it is not made more accurate.

CASE EXAMPLE

OK v. Richard Tandy Smith

One of the authors (Turvey) examined a postconviction case out of Oklahoma. The defendant, Richard Tandy Smith, was accused of the July 1986 murder of 28-year-old John David Cederlund. Prosecutors argued that he shot Cedarlund to rob him of money and drugs (meth). Smith was convicted at trial in 1987, based on circumstantial evidence and the testimony of two female police informants.

At trial, a highly regarded bloodstain analyst testified that he examined what he thought was high-velocity blood spatter on a car believed to be associated with a shooting death. The bloodstain analyst further testified, in the pre-DNA era, that the bloodstains on the car door almost certainly came from a shooting incident and were most likely associated with a homicidal death (Figure 6.1).

Years later, DNA proved that the substance was indeed blood, but that it did not match the homicide victim in the case. The bloodstain was unrelated to the homicide, and its origins have been lost to time.

Excepted from the reported prepared in this case, Turvey (2005):

“The testimony of [a police] Sgt. [not a forensic scientist], related to the interpretation of the bloodstain pattern on the door of the 1979 Ford Thunderbird, misrepresents the evidence and fails to adequately explain or exclude alternate sources.”

On March 12, 1987, [the] Sgt. testified under direct examination that (pp. 14–15):

“I measured the majority of these stains over here and all of them were either one millimeter in diameter or less, which would fall into the high velocity impact, which is almost always associated—not always—but almost always associated with a gunshot, when you’re dealing with a violent crime.”

He further testified (p.16):

“In the absence of [atomized blood], it would not necessarily mean that it was not a gunshot, but when you find it, there’s no question, unless there’s something else that may be around. For example, if blood was poured onto an oscillating fan blade that obviously is traveling well above this 100 feet per second that could produce what we’re looking at here.

“In this case, I certainly, obviously, for a lot of reasons, lean towards a gunshot, unless we’re able to find some fan that’s directed a specific direction at a specific angle.”

According to the literature, high velocity bloodstain patterns can result from gunshot wounds, or wounds associated with an explosion, or injury caused by high velocity machinery. While [the examiner] did suggest one of these possibilities in a very limited and dismissive fashion, he did not explain that his examinations could not confirm the association of the bloodstain with the death of John Cedarlund. In fact, he testified in precisely the opposite direction. His testimony all but conclusively associated the bloodstain on the vehicle with violent crime, and left the strong impression that the bloodstain must be related to the death of John Cedarlund. The nature of this testimony utterly misrepresents the evidence. Again, with bloodstains of this size there are several possible origins:

FIGURE 6.1 Photo taken by police investigators of this inside door from a 1979 Thunderbird. In 1987, these patterns were interpreted as shotgun-related bloodstains from a homicide victim, John Cedarlund, as reported by eyewitness testimony from female police informants. DNA testing later proved that this was not the blood of John Cedarlund.



1. Accidental discharge of a firearm
2. Intentional discharge of a firearm
3. Explosive force
4. High velocity machinery
5. Blood dripping into a pool of blood on a nearby surface
6. A sneeze with blood in the mouth or a bloody nose
7. Purposefully applied with an atomizer

[The] Sgt. did not indicate that he performed any directed experiments or investigation that might include or exclude any of these origins as a possibility (like investigating the history of the vehicle—its accident history and its involvement in criminal or injurious activity unrelated to the homicide). Consequently, his testimony on this issue is overly certain, resulting in helpful speculation for the prosecution's theories. However, it is not supported by the published forensic science literature or the scientific method.

This omission and inappropriate certainty on the Sgt's part become significant in light of the results of recent DNA testing. The report by Huma Nasir of *Reliagene* dated 9/30/2005 reveals that the blood collected from the door of the 1979 Thunderbird does not match the known STR DNA profile of the decedent, John Cedarlund. Mr. Cedarlund is the only alleged injured party this case. This report demonstrates that the bloodstain pattern interpreted by [the] Sgt. was not actually associated with this case. It also proves that no blood or bloodstain evidence associates the 1979 Thunderbird with this case.

The issue of guilt aside (which is not the issue for any forensic scientist to address), physical evidence in this case is problematic at best and was interpreted based, in part, on faulty assumptions.

At the outset, reconstructionists must accept, and anticipate, that each item of evidence collected in a crime scene will have suffered through some or all of the following:

1. A hostile or tainted scene, either with respect to
 - a. the environment itself (e.g., extreme cold, heat, wind, wetness, or dryness)
 - b. evidence from prior or ongoing human activity unrelated to the event at hand (e.g., sexual activity, criminal activity, and pedestrian traffic)
 - c. animal predation (e.g., ants, coyotes, birds, dogs, and other scavengers)
2. A violent or destructive act that results in evidence transference or creation at the scene, e.g.:
 - a. a gunshot
 - b. a stab
 - c. a fire or explosion
 - d. blunt force
3. Evidence alteration/removal/destruction/creation by the suspect(s).
4. Evidence alteration/removal/destruction/creation by the victim(s).
5. Evidence alteration/removal/destruction/creation by witnesses, e.g.:
 - a. a family member tampering with evidence to conceal the guilt of another
 - b. a parent moving or covering up the body of a dead child
 - c. accidental or purposeful activities at the scene prior to the arrival the police by witnesses unrelated to the events of the crime
6. Changes from natural entropy brought by the passage of time, e.g.:
 - a. blood and semen dry
 - b. the dead stiffen and decompose
 - c. everything not plugged into a power source will eventually equalize with the ambient temperature

7. Evidence alteration/removal/destruction/creation by professionals carrying out their duties at the scene, e.g.:
 - a. first responders carrying out their duties to protect life and search for a perpetrator
 - b. first responders walking through evidence or driving on top of it
 - c. paramedics cutting holes in clothing, moving the body or the evidence, and disrupting blood and wound patterns
 - d. law enforcement or related personnel handling items without gloves or moving things around before documentation efforts have been completed
 - e. crime scene technicians and other personnel failing to properly search for, document, collect, or package and store evidence
 - f. crime scene technicians failing to recognize and collect pertinent evidence
 - g. coroner/ME transporting a body and causing or changing injury and blood-flow patterns²
8. Evidence alteration/removal/destruction/creation by forensic scientists from the storage, examination, and testing of evidence.

Each of these influences, expected and uncontrollable alike, has the potential to affect the evidence by altering it in some irretrievable way, changing its context and meaning, or preventing it from being recognized and collected at all. Awareness is the first step. The next is proper security, including the chain of custody.

CHAIN OF CUSTODY

The use of crime scene tape and other security measures will not stop evidence dynamics from being an issue. However, informed and properly executed crime scene security protocols can furnish a measure of control. These efforts can help investigators and forensic scientists recognize the evidence dynamics at work in a given chain of evidence, limit them, and track them.

The **chain of custody** (a.k.a. chain of evidence) is the record of each person, and agency, who has controlled, taken custody of, examined, tested, or had any other kind of contact with a particular item of evidence, from its discovery to the present day. It has tremendous importance with respect to providing the context for, and a record of, any scientific examinations. It also has considerable value with respect to establishing the origins of evidence when it is presented in court. Specifically, the [National Medicolegal Review Panel \(1997\)](#) explains that it has a protective aspect (p. 20):

Ensuring the integrity of the evidence by establishing and maintaining a chain of custody is vital to an investigation. This will safeguard against subsequent allegations of tampering, theft, planting, and contamination of evidence.

² Normally, the body is transported face up regardless of how he or she was positioned at the scene. The blood runs out of the body and soaks the back of the clothing, essentially destroying any pattern or trace evidence present on the clothing. It is recommended that clothing be removed carefully at the scene by cutting along the seams and laid flat on sheets of paper to dry. The clothing can be shown to the pathologist if necessary, along with photos, to show the original position and the patterns.

As explained in the NAS report (Edwards and Gotsonis, 2009), the chain of custody is created and exists as a forensic pathway along which evidence examination, testing, and interpretation are meant to occur (p. 36):

Crime scene evidence moves through a chain of custody in which, depending on their physical characteristics (e.g., blood, fiber, handwriting), samples are analyzed according to any of a number of analytical protocols, and results are reported to law enforcement and court officials. When evidence is analyzed, typically forensic science “attempts to uncover the actions or happenings of an event . . . by way of (1) identification (categorization), (2) individualization, (3) association, and (4) reconstruction.” Evidence also is analyzed for the purpose of excluding individuals or sources.

Without a chain of sufficient strength, reliable interpretations about the evidence and its role in a given crime cannot be made. Challenges to its integrity will follow, as they should. However, breaks in the chain do not necessarily make an item of evidence inadmissible. When evidence is admitted into court without a sufficient chain of evidence, forensic scientists must be able and willing to explain how this may influence the certainty, accuracy, or relevance of their findings.

Creating the Chain

While there are proprietary “chain of evidence,” “chain of custody,” and “evidence voucher” forms in use by individual labs and agencies, the chain is actually composed of any documentation prepared in accordance with evidence recognition, documentation, collection, preservation/packing, transportation, examination, and testing efforts. We agree that there should be an actual form attached to the package containing the item of evidence, but other documentation should be available to corroborate and support the chain.

It starts with an item of evidence found at a scene. For some items, a chain of custody may not be known or reliably established prior to its recognition in relation to the crime. Investigators may have to work hard in order to determine how it got where it was ultimately found. For other items, the chain of custody prior to recognition and collection efforts may be readily evident, easily documented, and ultimately undisputed.

An official chain of custody record begins with the person who first recognized the item of evidence. It is his or her responsibility to protect the evidence and make sure that it is photographed as it lies before anyone touches it. Photographs, measurements, and any sketches of the evidence that also document its condition and location in the crime scene are an important but frequently overlooked part of the chain of custody. Those looking for doubt can, in some cases, legitimately suggest weakness in a chain of custody that does not have this level of documentation.

O’Hara (1970) gives specific instructions regarding creation of the chain, explaining the need for clearly marking and labeling evidence (p. 78):

Evidence should be properly marked or labeled for identification as it is collected or as soon as practicable thereafter. The importance of this procedure becomes apparent when consideration is given to the fact that the investigator may be called to the witness stand many months after the commission of the offense to identify an object in evidence which he collected at the time of offense. Indeed, defense counsel may require that the complete chain of custody be established, in which case each person who handled the evidence may be called to identify the object.

Once initiated, the chain of custody is continually built as the evidence leaves the scene and moves from storage areas to laboratories and back again, suffering repeated viewings, examinations, and testing.³ Each time an item of evidence is handled by a different person, the potential evidence dynamics increase. Therefore, the fewer people handling the evidence, the better. As described in O'Hara (1970, p. 69):

The number of persons who handle evidence between the time of commission of the alleged offense and the ultimate disposition of the case should be kept at a minimum. Each transfer of the evidence should be receipted. It is the responsibility of each transferee to insure that the evidence is accounted for during the time that it is in his possession, that it is properly protected, and that there is a record of the names of the persons from whom he received it and to whom he delivered it, together with the time and date of such receipt and delivery.

As long as the chain is maintained, potential sources of evidence transfer, evidence contamination, and evidence loss may be identified and accounted for.

Not everyone participates enthusiastically in the process of rendering a solid chain of evidence, as not all agencies understand and teach its importance. Even when it is considered pertinent, there is no guarantee that those responsible will know what they are doing. It is therefore not uncommon for the various chains of custody in a given case to be inconsistent, weak, and, for some items, nonexistent. This telegraphs a lack of forensic awareness and identifies a serious training need. When the chain is weak, the case is weak, and evidence runs the risk of being unknowingly tainted, lost, or forgotten.

Spoliation of Evidence

Spoliation occurs when evidence or scenes in custody are damaged, lost, defiled, or destroyed. It is a negative, destructive form of evidence dynamics. If evidence is spoliated relevant to litigation, **spoliation inference** may apply. As explained in Coddling and Bohn (2006, p. 77):

Spoliation of evidence occurs when persons or entities unnecessarily alter, lose, or destroy evidence they had the duty to protect. A finding of spoliation can result in sanctions against a party in court or even legal liability in extreme cases. For example, spoliation could happen when a person unnecessarily takes an appliance apart without notifying the manufacturer or seller; tampers with connections such as plugs and switches, which are likely related to the cause of the fire; or knowingly disposes of evidence without contacting interested parties such as manufacturers, owners, or insurance companies.

As suggested, the intent of the person responsible for spoliation is irrelevant. The legal consequences of evidence spoliation are described in Schneider (2008, pp. 242–243):

Under this “spoliation inference,” the courts “have admitted evidence tending to show that a party destroyed evidence relevant to the dispute being litigated,” such evidence permitting an inference “that the destroyed evidence would have been unfavorable to the position of the offending party.” The spoliation inference generally serves one or more of three goals: “(1) promoting accuracy in factfinding, (2) compensating the victims of evidence destruction, and (3) punishing spoliators.”

³ Or as it sits in an evidence storage area collecting dust.

The traditional common law rule, and the rule still applied in the majority of jurisdictions, provides that the spoliation inference is appropriate only where the offending party intentionally has destroyed evidence. The more modern trend, however, is that “a finding of ‘bad faith’ or ‘evil motive’ is not a prerequisite to the imposition of sanctions for destruction of evidence.” Under this view, in appropriate circumstances the inference may be applied against a reckless or negligent spoliator. In either event, it is important to bear in mind that the spoliation inference “does not prove the opposing party’s case.” Rather, the inference is just that—an inference—which if not rebutted merely permits, but does not require, the jury to conclude “that the tenor of the specific unproduced evidence would be contrary to the party’s case, or at least would not support it.”

The point here is that the concept has a history with the courts, and there can be legal consequences to altering or destroying evidence in one’s custody or care regardless of intent. For that reason, if a test will destroy or alter the evidence, the defense should be notified prior to the test. They may wish to have their own forensic expert witness perform such testing. Keeping and maintaining the chain of custody is a serious responsibility, and it is ignored at the forensic scientist’s peril.

SECONDARY TRANSFER

Transfer evidence is produced by contact between persons and objects (Cwiklik, 1999; Lee, 1995; see Chapter 10: Trace Evidence in Crime Reconstruction). **Secondary transfer** refers to an exchange of evidence between objects or persons that occurs subsequent to an original exchange, unassociated with the circumstances that produced the original exchange. In a discussion regarding fiber evidence, which can be generalized to any form of transfer evidence, Deedrick (2000) explains:

Fibers can also transfer from a fabric source such as a carpet, bed, or furniture at a crime scene. These transfers can either be direct (primary) or indirect (secondary). A primary transfer occurs when a fiber is transferred from a fabric directly onto a victim’s clothing, whereas a secondary transfer occurs when already transferred fibers on the clothing of a suspect transfer to the clothing of a victim. An understanding of the mechanics of primary and secondary transfer is important when reconstructing the events of a crime.

Secondary transfer can be caused by the actions of the victim, the offender, and witnesses prior to the arrival of first responders. It can also be caused by medical and forensic personnel in the course of their duties and can be the result of careless or improper evidence packaging and storage.

THE CRIME SCENE

This section discusses evidence dynamics that are a function of the crime scene environment and natural process, not generally resulting from the crime or the actions of individuals.

Weather/Climate

The meteorological conditions (e.g., temperature, precipitation, and wind) at a crime scene can influence the nature and quality of all manner of evidence that is left behind. This includes the destruction or obliteration of evidence, as well as the effects of climate on body temperature and decomposition.

Inclement or extreme weather in particular can destroy evidence, destroy crime scenes, and, in some cases, prevent responders from getting to the scene altogether. If too much time elapses under such conditions, the chance to locate, secure, and retrieve evidence may be lost. A corpse in the water may bloat and eventually disintegrate. A hard rain may wash away footprints in the soil.

There are rare exceptions to the destructive properties of weather, however. For example, extreme cold may inadvertently preserve the body of a murder victim that becomes frozen in an outdoor disposal scene. This may keep areas of injury from decomposing and preserve DNA evidence for testing. Extreme heat and dryness, however, may mummify a corpse and cause it to shrivel.

EXAMPLE

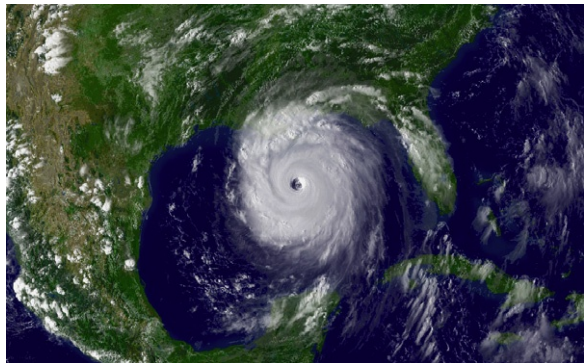
Hurricane Katrina

At 7:10 a.m. EDT on August 29, 2005, Hurricane Katrina (Figure 6.2) made landfall in Louisiana as a Category 3. Maximum winds were near 125 mph. It was the most destructive hurricane in U.S. history, obliterating, rending, and flooding buildings, homes, and lives all along the Gulf Coast. As explained in Cruz (2007):

Nearly two years after Hurricane Katrina cut its destructive path through the Gulf Coast, the NOPD has found little relief. Six FEMA trailers make up its headquarters. The traffic department and SWAT team also call several double-wide units home. Seventy-two officers have left the force this year. Of the 1,200 that remain (down from 1741 before the storm), there is only a single fingerprint examiner and only one expert firearm examiner. This year, the deadliest city in America has seen over 90 killings, eight of them in the past week and a half alone. In 2006, the city saw 161 murders (only one of which has resulted in a conviction).

The list of woes went on and on. Because of a lack of storage space, criminal evidence is still kept in the back of an 18-wheel truck. The city's crime lab just reopened after finally finding a home on the University of New Orleans campus. The resources that most major cities take for granted just haven't existed for the past 22 months. And according to [New Orleans Police Department Deputy Superintendent Anthony] Cannatella, it's not just the infrastructure—it's the manpower. Several hundred of his officers still live in temporary housing. "They live in FEMA trailers, they come to work in a FEMA trailer, and they patrol FEMA trailers," said Cannatella. "It's demoralizing. We say FEMA trailer like it's something specially built. It's not."

FIGURE 6.2 Hurricane Katrina, pictured here the day before it landed, was the costliest and among the most destructive hurricanes in U.S. history.



Hurricane Katrina also flooded entire police departments, lab facilities, and evidence storage facilities—destroying innumerable items of evidence and rendering more useless for forensic purposes.

Scene Artifacts

Before a crime occurs, the area where it eventually takes place may already contain artifacts that are “evidence” of everyday activities, such as cigarette butts, beer or soft drink cans, fibers, evidence of recent sexual activity (e.g., used condoms and undergarments), old bloodstains—the list is potentially endless. It may also occur in a location where other criminal activity, such as prostitution, drug-related activity, or even shootings, has taken place. The reconstructionist has a responsibility to (1) identify these sources of confounding evidence and differentiate between pre existing artifacts and actual evidence of the crime or (2) admit when this is not possible.

EXAMPLE

Todd Alan Reed

Three victims were found murdered in Forest Park, in the hills above Portland, Oregon: Lilla Moler, 28, was found on May 7, 1999; Stephanie Russell, 26, was found the next day, only 80 yards away. The decayed body of Alex “Tomorrow” Ison, 17, was found farther away, down a service road, in the woods, on June 2. It had been taken apart by animal predation. All three women were prostitutes and drug addicts. They were found nude and had been drugged and strangled (Figure 6.3).

One of the authors (Turvey) was consulted on the case by the defense. He examined all of the evidence and visited the crime scenes with other forensic experts. The suspect used a condom, which he left behind at the scene near one of the bodies. However, the location was one frequented by many prostitutes, including the victims themselves. There were many condoms found at and around the body; some shared DNA from the victim and other “clients.” Using a condom from the scene to associate that victim with the offender and that location would not be difficult, but associating the defendant with the crime to the exclusion of all other possible “clients” (all equally viable suspects) would be nearly impossible. However, a mixture of the defendant’s and victim’s DNA was found on the thigh of one of the other victims. These compounding associations and other factors led Todd Alan Reed, 32, to plead guilty to all three slayings in February of 2001. He was sentenced to life in prison without parole.

Each item of evidence collected must somehow be associated with the crime in order to be considered in the reconstruction. The association of evidence with the crime may not be assumed merely by establishing its presence in the scene. This would be a *cum hoc, ergo propter hoc* fallacy of logic.⁴

Insect Activity

The actions of flies, mosquitoes, ants, beetles, and other insects can obliterate or mimic criminal injury on a body. They can also move, remove, or destroy transfer evidence.

⁴ See Chapter 19: Forensic Examination Reports.

FIGURE 6.3 Todd Alan Reed confessed to disposing of two of his victims in this area of Forest Park overlooking the Willamette River in Portland, Oregon. The area was just off the roads and hiking trails; it had been cleared for power lines and was popular because of the view. It was also an area frequented by prostitutes and their customers in the evening.



One of the authors (Chisum) was called to the scene of a “double torture murder” by the chief of detectives. There was an elderly couple lying on the ground in a remote area off the highway. A .25 automatic pistol was discovered in the man’s hand. Both had been shot at near contact.

The chief said that acid had been poured on both victims before they were shot. The author asked where. He stated, “Right there, where the ants are, you dumb. . . .” Ants, in fact, secrete formic acid. They can leave trails on human bodies that resemble acid burns.

Insect activity must be documented at the scene, near the body, and at the site of any injuries. This will allow for forensic scientists to consider whether and how they may have left artifact evidence that could mimic injury or just alter evidence in general (Figure 6.4).

Animal Predation

The feeding activities of all manner of indigenous wildlife, from ants to mice, coyotes, and bears, can relocate body parts, obliterate patterns, and further obscure, obliterate, or mimic criminal injury to a body. The authors have worked numerous cases involving outdoor scenes where a body has been disposed of and then interfered with by animals. They are notorious for unearthing shallow graves, eating the dead, and scattering bones for miles around.

Decomposition

Naturally occurring rates of decomposition can obscure, obliterate, or mimic evidence of injury to a body. Because of this, in combination with the odor and revulsion experienced by examiners, there is a perception that everything else has decomposed as well. Consequently, clothing from a decomposed body will normally receive less attention for trace or transfer evidence. This may be a mistake because hair, fiber, and other synthetic transfer evidence can endure well beyond biological material.

As mentioned previously, the rate of decomposition is affected by climate. With respect to body temperature, it changes to meet room or environmental temperature after death. In a cold



FIGURE 6.4 This child victim of sexual homicide was discovered nude, beneath a blanket from her bedroom, in her backyard. She died from manual strangulation. Examiners initially believed that the injuries evident on her neck were consistent with abrasions and bruising from manual strangulation. Upon close inspection of the photograph, it becomes clear that the pronounced “abrasions” are actually postmortem ant activity. The ants are actually visible in the photo and have characteristically focused their attention on the tissue damaged during the attack, including her neck. The dark areas of “bruising” are actually fingerprint powder left behind from an attempt to develop latent prints.

environment or a freezer, this means a decrease; in a heated indoor or outdoor environment, this means an increase. This change affects the rate of decomposition, as well as the onset and duration of both rigor mortis and livor mortis (Knight, 1996). All of these variables can confound time of death estimates if not properly factored in to such estimates.

FORENSIC PROTOCOLS

This section discusses evidence dynamics that are a function of investigative and forensic protocols.

The First Responder/Police Personnel

The primary duty of the first responder on the scene is to protect life, not to preserve evidence. They must first protect their own life and then the lives of others. They accomplish this by searching for, apprehending, or neutralizing suspects at the scene and giving first aid to any injured parties. That is, the officer cannot protect public safety if incapacitated; therefore, the officer must first ensure his or her own safety by searching the premises for suspects, bombs, or other hazards. The officer cannot always protect the evidence during this search and may even destroy some. After that, the officer must render aid to victims and establish that the scene is secure from further danger. This, too, may alter the physical evidence. Only then does protecting the physical evidence become a priority. Ideally, the first responding officer should be mindful of the physical evidence and avoid its destruction or alteration when possible, but this is not a realistic expectation under circumstances that involve immediate threats to life or safety.

Once all threats have been dealt with, detectives and other law enforcement personnel should know to refrain from touching evidence or even walking into the scene before it is documented properly. When possible, a strict “hands in the pockets” policy must be enforced among those not saving lives, documenting, or collecting evidence. Their actions may relocate evidence, obliterate patterns, cause transfers, and add artifacts to the scene.

When relevant, the reconstructionist must study all reports and notes detailing such activities to prevent misinterpretation. If no such documentation exists, the reconstructionist must acknowledge that there is a serious gap in the reliability of the evidence. Moreover, it is arguably the duty of the reconstructionist to document and report the absence of such vital scene documentation, as well as any other failings or shortcomings in scene-processing efforts. In this way, misrepresentations of the evidence by overly certain examiners or legal professionals may be prevented.

Fire Suppression Efforts

In cases involving fire, suppression efforts may be made by a responding fire department. These efforts typically involve the use of high-pressure water, heavy hoses, and perhaps chemicals. The job of fire suppression personnel is to put out the fire; evidence is secondary to this concern. Any of these activities, alone or in concert, can relocate or destroy the evidence, obliterate patterns, cause potentially misleading transfers, or add artifact evidence to the scene.

The Emergency Medical Team

The actions of emergency medical personnel engaged in life-saving activities at the crime scene may relocate and destroy evidence, obliterate patterns, cause transfers, tear clothing, and add artifacts. Additionally, they may intentionally inflict therapeutic injuries to the victim, such as cuts or punctures. This is expected and necessary.

Should a victim be transported to a medical facility, treatment rendered there can also change the nature of injuries. This will cause problems for subsequent examination and interpretation of the injuries at autopsy. Again, this is expected and should not be misinterpreted.

When relevant, as with first responders and law enforcement personnel discussed previously, the reconstructionist must study all reports and notes detailing these activities to prevent misinterpretation. If no such documentation exists, the reconstructionist should request that interviews of medical personnel be conducted to address these issues.

Security

Proper scene security must be maintained at all times. This means limiting access to only necessary personnel and controlling it by means of a security officer who logs entry times, exit times, reason for entry, and duties performed of each person who passes through the tape. This basic concern is part of every scene-processing training course and program that the authors have encountered. However, it is still ignored regularly.

Supervisors and administrators are a continual problem. They may think that there are legitimate reasons for passing unchecked into or through the tape even though they are not involved directly in the processing effort. This is entirely mistaken and can add to the evidence or even obliterate it.

An example taken from one of the author's case files (Chisum) includes the following [excerpted from a report by one of the authors (Chisum) in a case worked on behalf of the federal defender].

CRIME SCENE SECURITY

The crime scene was not secured before it was contaminated/changed. There were 4 security guards in the scene when Officer P arrived. She made them back out of the alley (pp. 70, 74). Security guards are not trained in crime scene protection or how to preserve (not contaminate) physical evidence.

Officer P had to move her car to allow the ambulance with the EMS personnel access to the body. They checked the pulse and left. No photos or documentation of the bloodstains had been undertaken (p. 82). Evidence is not a concern of medical technicians that are there to treat injuries and remove the injured.

P testified that the departmental protocol was not followed and the "call out list" was not used (p. 79). No crime scene log was kept (p. 82). The Chief of Police and a Captain B went into the scene. Crime Scene Tape was used; however, the police ignored it (p. 84).

The lack of crime scene security compromises any physical evidence at the crime scene. Once Officer P arrived, *only those* involved in documenting the crime should be allowed to enter. The exception to this rule is that one EMS be allowed to enter by a secure route avoiding the evidence to check for signs of life; if the victim was alive the ambulance could have completed the entry. The primary investigator should enter the scene by the same route taken by the EMS. The other investigators should remain at the perimeter until all the evidence is documented and collected (at least that evidence that is likely to be altered). All persons entering a crime scene are to sign in and give a reason for being there, then sign out upon leaving.

The Captain and Chief have no legitimate reason to enter the crime scene. They are commanders and should be kept informed. They are ultimately responsible for crime scene security yet they violated the security and compromised the scene by entering.

The evidence in the bar was collected while the bar was open with customers inside according to Officer M. This lack of crime scene security violates not only crime scene search protocols but common sense.

One of the victim's relatives walked through the Crime Scene according to Detective M.

Detective M stated that he had checked the suspect's clothing in the bar and did not find any blood even with the ALS (alternate light source) (p. 176).

Detective M states (P.10 -11 3/16), in response to a jury question, that it is impossible to get prints off a leather wallet. This is not true. Redwop[®] powder (fluorescent) with a feather duster will reveal prints on leather. This powder has been available since the early 90's. He says that leather has amino acids so it can't be printed. Amino acids react with ninhydrin; this only means you can't use ninhydrin for the detection of latent prints. The Redwop powder has been used by the undersigned on wallets and there are other techniques as well.

The placement of crime scene security tape by first responders sets into motion a series of expectations and events that define the scope of all evidence processing efforts. Under the best circumstances, first responders may fully grasp the complexity of the crime scene and the involvement of surrounding areas; they may be limited by natural barriers in the environment, such as active freeways, cliffs, or bodies of water; they may have inaccurate preconceived ideas about where the crime occurred; or they may simply be misinformed about the nature of events. Under the worst circumstances, they may simply lack proper training or concern with regard to the importance of the physical evidence.

This concern is explained in plain but effective language by Joe Delery, then a forensic examiner for the New Orleans Police Department's crime lab⁵:

Every time I roll up on a scene and see the tape coming off the back of a patrol car, tied to a telephone pole or something like that, I just shake my head. Everybody's so worried about searching inside that tape, by the time they realize the crime took place on the other side of it they've walked all over the evidence. And that's if they didn't park their vehicle on it.

The limiting effect of crime scene tape is tremendous. First responders have a duty to understand and implement competent barrier efforts; scene technicians have a responsibility to understand and implement competent search and collection efforts. Each must grasp the dangers of setting up the tape and working only on one side of it.

When relevant, the reconstructionist is advised to consider whether the tape accurately defined the scene and whether subsequent evidence search and collection efforts reflect the most informed picture of the evidence given the nature of the crime. If, for example, evidence was found outside the tape and search efforts were not expanded accordingly, this might suggest an incomplete investigative and processing effort (Figure 6.5).

⁵ Personal communication with Turvey (July 23, 2005).



FIGURE 6.5 One of the authors (Turvey) worked a case in Las Vegas from 2001, where a man was killed in a garbage dumpster enclosure behind a bank. He was found on the ground inside the enclosed area next to the dumpster, buried beneath trash that had been removed from it. Police arrived while it was still dark and drove a patrol car right up to the opening of the enclosure in order to use its lights for illumination and its hood as a staging area for processing efforts. In doing so, they necessarily parked on top of bloody footwear transfer that the offender left behind as he exited the enclosure and did not recognize or collect it. They also collected bloody items of evidence from the body and the surrounding enclosed area into several large bags, without documenting it in situ first, allowing for secondary transfer. These bags were then transported back to the police station where they were sorted through, and much of it discarded. There is no record of this activity in any police report; rather it came out under cross-examination. It is interesting to note, also, that no crime scene tape was used at this scene.

Failure to Search or Recover

Even under the best circumstances, it is still possible that crime scene personnel may fail to adequately recognize the full scope of the scene and perform an adequate search for evidence. This can result in areas at or related to the scene that are searched and documented insufficiently to support reconstruction interpretations. It can also result in evidence that is missed entirely.

The nature of this kind of influence is to deprive the police investigation and the forensic investigation of the most complete picture possible. The failure to recognize evidence, the failure to conduct a complete and thorough search the first time through, and the failure to document the entirety of the scene each represents a missed opportunity to learn more about the crime. Recovering from these can be time-consuming, expensive, and, to some extent, impossible.

Premature Scene Cleanup

When a crime occurs in a public place, especially one that is highly visible or well traveled, there is sometimes an irresistible urge to clean up any signs of extreme violence left in the wake, including bloodshed, body parts, and brain matter. Cleanup efforts should not be started until forensic protocols have been completed and the crime scene is released.

In some cases, the crime scene is released and cleaned before forensic personnel are sent to conduct their examinations. In such cases, the chain of custody is not just weakened, it is broken. Consider the following excerpt from such a case worked by one of the authors (Turvey). It involves an alleged rape and subsequent scene processing efforts (or lack thereof). Excerpted from [Turvey \(2006\)](#):

The crime scene in this case [a second story apartment] was ignored at the time of the alleged attack, except for a weak attempt to take a few photographs where the complainant suggested that offense activity occurred [a closet]. This is extremely poor crime scene procedure.

- Standard protocols for securing the scene do not appear to have been followed (no barrier tape; no security log; no keeping people out of scene while it is processed);
- Standard protocols for searching the scene for evidence do not appear to have been followed (no police report detailing such a search in or around the scene is known to this examiner—though it is suggested that a search revealing nothing was performed on the interior);
- Standard protocols for photo documenting the scene and specific items of evidence do not appear to have been followed [no photos of the closet where the alleged attack took place or the alleged victim's bedroom];
- Standard protocols for diagramming the scene, to measure precise locations of activity, suspected activity, evidence discovery and evidence collection do not appear to have been followed (no police crime scene diagram is known to this examiner, only a sketch of the closet interior by criminalist Peer).

In fact, Det. Munoz did not request that the carpet in the walk-in closet be examined and processed by crime lab personnel until Nov. 18, 2005—8 days after the [alleged] assault, and well after the complainant had been moved to another apartment.

In this case, the apartment had been emptied, cleaned, and vacuumed before a criminalist was sent there to perform any search for evidence.

Evidence Technicians

Evidence technicians [a.k.a. crime scene investigators (CSIs)] are charged with evidence recognition, preservation, documentation, collection, and transportation. They are expected to locate and protect physical evidence without damaging it, without causing potentially misleading transfers, and without adding artifact evidence to the scene. They are expected to document and preserve, as much as possible, any pattern evidence. They are also expected to collect and package the evidence in a manner that preserves it for subsequent analysis and interpretation.

An important step in this process is documenting the scene before entering so that any changes that do occur as a result of their efforts are evident to those interpreting the documentation at a later time.

Coroner/Medical Examiner

The actions of the coroner or medical examiner while removing the body from the scene can alter evidence, obliterate patterns, cause potentially misleading transfer, and add artifact evidence to the scene. Influential events include physical removal of the body from the location where it was discovered, placement of the body into a "body bag," transporting the body from the scene, storing it, and reopening it for examination at a later time. These actions may change pattern evidence on the body and clothing of the victim, cause injury or fluid discharge, and relocate or destroy potentially valuable transfer evidence.

Packaging/Transportation

As already suggested throughout this chapter, the manner in which evidence is packaged and transported will have an effect. Clothing evidence with wet stains, for example, should not be folded in such a manner as to transfer the stains to other parts of the garment. They must be removed and dried or preferably wrapped in butcher paper so the stains cannot transfer. Also, whenever possible, avoid placing multiple items of evidence in a single package, under a single number. This provides for potential cross-contamination and confusion with evidence tracking. Svensson and Wendel (1974, p. 35) offer further suggestions:

Evidence which is to be sent to a laboratory for further examination should be packaged in such a way that it does not run the risk of breaking, spoiling, or contamination which might destroy its value as evidence. Containers should be tight and, depending on the nature of the material, strong enough that they will not break in transit. If the evidence consists of several objects they should be packaged in separate containers or wrapped individually in paper. Each item should be clearly marked as to contents and then packaged in a shipping container. Loose evidence is thereby kept from contaminating other evidence. In some cases, it may be necessary to fix articles to the container separately so as not to come in contact with each other. Bottles and other glass vessels which contain liquids should not be packaged with other evidence, since they may break and contaminate other material.

Whatever specific evidence collection guidelines are adopted, they must preserve the evidence in transport, prevent cross-contamination, prevent spoilage, and provide for later identification. If evidence collection guidelines fail in any of these respects, then they are insufficient to the purposes of forensic science in general and crime reconstruction in specific.

Storage

Evidence storage is a subject that is discussed infrequently because it is often the source of extreme angst for police departments and their respective crime labs. Commonly, they do not have enough space to store the evidence they collect or sufficient and qualified personnel available to keep it inventoried properly. Deficiencies in this area can be disastrous, resulting in evidence lost or destroyed and in cases dismissed.

The following examples are taken from the public record. Although they may be embarrassing to some, the authors believe that we must read them and be aware that the public is reading them as well. They portray an image of forensic science that the community is uninformed and inattentive—an image that is spreading and creating a credibility gap. It is our job to learn from these examples and take steps to prevent further occurrences.

In Revere, Massachusetts, inclement weather and flooding during 2004 unexpectedly disrupted evidence storage at one particular police storage facility. This was an unforeseeable event that nevertheless left a mark on the evidence while in storage (Rosinski, 2004):

Torrential downpours that flooded roads and rivers also poured into the Revere police station yesterday, soaking boxes of evidence from unsolved homicides and rapes, authorities said.

“Shelves of evidence of major felony cases—homicides and sexual assaults—were damaged and destroyed. The water is dripping on them like a shower,” Revere police Capt. Dennis Collyer said. “Frankly, it’s a disgrace.”

Water was dripping from the ceiling onto boxes of evidence stored in a second floor room, including one sealed box of physical evidence from a 1979 double fatal shooting and multiple rape kits.

The situation in Massachusetts, as described, is quite different from the circumstances uncovered at the Houston Police Department (HPD) crime lab. Problems in the HPD system are representative of chronic, system-wide laboratory failure. Apart from their many other problems, the HPD crime lab has suffered from evidence storage nightmares that range from evidence overcrowding to incompetent storage practices and even to rats. According to the independent investigator’s report (the following are selected outtakes from Bromwich, 2005)⁶:

In March 2002, Mr. Bolding estimated that there were 19,500 sexual assault kits received by HPD that had never been processed, some dating as far back as 1980.[53] During our tours of the Property Room, we were struck by the number of unprocessed rape kits currently being stored in the Property Room’s freezers.[54] The Property Room is located at 1103 Goliad Street and is comprised of two main areas. One area houses central receiving; the evidence tracking system; the administrative area; file storage; a vault for high value evidence; and property storage areas for firearms, knives, digital equipment, and small item evidence. Although this area is air-conditioned, it remains susceptible to high heat and humidity.

The second, and much larger, component of the Property Room consists of a large, single-floor warehouse and an annexed three-story warehouse, known as the Volker Building. Most of this area has shelving containing evidence and property stored in bins and boxes, as well as tools, bicycles, and other large items of evidence. We observed that some of the boxes stored in this area are marked with biohazard labels. This area is not air-conditioned and is subject to extreme heat and humidity. The floors are dirty and dusty. Currently, the area lacks space for the storage of additional property.[60] This area also houses two walk-in freezers containing sexual assault kits and other biological evidence.[61]

The Property Room facility has two major deficiencies as a property storage facility—(1) inadequate storage space and (2) lack of humidity and temperature control. In addition, the facility has had major ongoing

⁶ The independent investigator’s reports are posted on the investigation’s Web site at www.hpdlabinvestigation.org.

maintenance problems over the last 15 years, which have included roof leaks, faulty electrical wiring and lighting, inoperable elevators, asbestos concerns, and the need for new windows and doors. Managers of the Property Room have documented these major facility issues.

The roof at 1103 Goliad Street was repaired in 2004, but many of the other problems with the facility still exist. Even if repairs are made to the present facility, it may not be adequate for the proper storage and handling of evidence due to the lack of temperature and humidity control and inadequate storage space. . . .

Beginning in the early 1980s, the Property Room allowed various divisions of HPD to store items on the third floor of the Volker Building. The items stored on the third floor were considered to be under the control of the divisions that deposited the items and were not logged or inventoried by the Property Room. The Crime Lab was one of the divisions that stored items on the third floor of the Volker Building. The items stored by the Crime Lab included evidence as well as nonevidentiary items, such as excess office furniture. The evidence was stored in envelopes and boxes placed inside larger white boxes, which were stacked against a wall and under several windows.

In the 1980s and 1990s, the Volker Building's roof was in poor condition and experienced leaks. Rainwater leaked through the windows and roof, damaging some of the evidence stored by the Crime Lab. In addition, rats were present on the third floor, and they ate through a number of envelopes and boxes containing evidence.

In early 2000, the Property Room began to run out of space to store the evidence in its custody. Divisions storing property on the third floor of the Volker Building were asked to remove their property to free up space. When Crime Lab personnel came to the Property Room to remove the Lab's property, they took the contents of the damaged white boxes of evidence and placed the items in 283 new, large cardboard boxes. Each of the 283 boxes contained multiple pieces of evidence from multiple cases. Some boxes contained evidence from as many as 100 cases. The evidence dated from the 1960s to the early 1990s.

Once the evidence had been placed into the 283 boxes, Crime Lab personnel tagged the boxes to transfer custody to the Property Room so that the boxes could remain there. In doing so, the Crime Lab personnel identified each box by the incident number related to only one of the many items of evidence contained in each box, which misleadingly suggested that each box contained evidence related to only a single case. In fact, each box contained evidence relating to many cases. At some point, two of the 283 boxes were checked out of the Property Room by Crime Lab personnel. The pieces of evidence contained in these two boxes were individually tagged as individual pieces of evidence, and checked back into the Property Room. Thus, these two boxes ceased being part of the original 283-box collection.

On September 21, 2000, the Property Room received a routine destruction order to dispose of certain evidence. The evidence subject to the order was contained in one of the 281 remaining boxes. Coincidentally, the incident number related to the evidence subject to the destruction order was the incident number that happened to be listed on the outside of the box. Because the Property Room personnel believed, based on the box's label, that the box contained evidence related only to the one incident identified in the destruction order, Property Room personnel destroyed all of the box's contents. Subsequently, it was determined that this box contained evidence from 33 cases in addition to the one case identified on the box label.

In November 2003, the remaining 280 boxes were moved from the Property Room to a section of the 24th floor of the HPD headquarters, located at 1200 Travis Street, to protect the evidence from further degradation. On August 1, 2004, the Inspections Division began cataloguing and tagging the evidence contained in the original 283 boxes of evidence. Approximately 8000 individual evidentiary items have been identified in the boxes. We will continue reviewing this area, and we will provide additional information regarding Project 280 in future reports. . . .

The storage of biological evidence has been an ongoing problem for the Property Room. The primary issue is the lack of sufficient temperature-controlled space for the storage of such materials. Prior to 1998, the Property Room stored sexual assault kits and other bodily fluid evidence in a freezer for a period of 18 months. After 18 months, the evidence was moved to air-conditioned areas within the Property Room for long-term storage. By 1998, the Property Room was running out of space in the freezers as well as the air-conditioned storage area. In March 1998, the head of the Property Room, Ron Cobb, asked Mr. Bolding if it was necessary to provide air-conditioned storage for this evidence after the initial 18-month period of storage in the freezer. In a March 18, 1998, memorandum to the captain of HPD's Homicide Division, Mr. Cobb relayed the response he had received from Mr. Bolding: "[T]here is **NO** need to provide air-conditioned storage for any type of body fluid evidence after the original freezer period of 18 months. [Mr. Bolding] related that he has taken evidence that was stored on the third floor of this building (which reaches extremely high temperatures in the summer), and has achieved successful DNA testing."

On April 1, 1998, in reliance on the information received from Mr. Bolding, Property Room personnel began relocating sexual assault kits and other biological evidence to general property storage areas. The general property storage areas are not air-conditioned and, therefore, are subject to high humidity and temperatures. Both of the Property Room's freezers are overloaded and additional storage space is needed. Some biological evidence is commingled with other general evidence and stored in the general property room storage areas. This practice raises serious concerns about proper storage of biological evidence.[62] HPD has advised us that it expects delivery very soon of an additional freezer, which has been on order for several months, to the Property Room.

53. In a letter to Council Member Shelley Sekula-Gibbs, M.D., dated May 22, 2002, Chief Bradford stated that "current estimates indicate that there are 7200 sexual assault cases dating back to 1992 with usable DNA evidence at HPD which have not been processed."

54. The Property Room freezer currently contains 2233 rape kits, most of which (2116) date from the period 2000 to present. Of the kits in the Property Room freezer, 112 are from the 1990s and 5 predate 1990. Approximately 7886 sexual assault kits are being stored at HPD headquarters at 1200 Travis Street. In sum, HPD is currently storing over 10,000 sexual assault kits.

60. HPD is attempting to address overcrowding in the Property Room by storing evidence at the 1200 Travis Street building and exploring the alternative of auctioning items through the Web site www.propertyroom.com.

61. During a tour of the Property Room, one freezer appeared not to be maintaining the proper temperature, and we observed a considerable amount of water on the floor around the freezer. HPD advised us that the freezer was subsequently inspected and that it did not malfunction. HPD has suggested that the water we observed may have been attributable to condensation.

62. For example, in May 2004, water caused damage to 10 to 12 boxes of evidence due to a roof leak. Nine of these boxes contained clothing with possible biological evidence. The wet clothing was removed and hung to dry before being checked back into the Property Room.

Forensic scientists from all disciplines should study the reports written by the independent investigator of the HDP crime lab. They are a model of both forensic negligence and forensic incompetence with respect to these and other more staggering revelations.

Examination by Forensic Personnel

The purposeful actions of forensic scientists will remove evidence, obliterate patterns, may cause potentially misleading transfers, and can add technical artifact evidence. Forensic examination involves opening packaged evidence, exposing it to the "lab" environment, exposing it to the forensic examiner, and submitting it to procedures that may require its physical separation or even destruction.⁷ Although the last is often unavoidable and even expected, the first two can introduce unknown, unexpected, and questionable results when proper procedures are absent or ignored.

Premature Disposal/Destruction

At some point, an item of evidence may be slated for lawful disposal or destruction. Cases may be adjudicated, statutes of limitation may run out, and biological or chemical hazards may exist that make such measures necessary. However, physical evidence must not be destroyed before proper documentation and forensic examinations have taken place.

⁷ The "lab" environment is really any place that evidence is opened and examined. This may be a secure forensic lab with forensic examiners in protective clothing or it may be a back office in a police department shared by a CSI unit with a folding table in the middle on which they examine evidence as well as eat their lunch. The reconstructionist is better off knowing exactly how the evidence was handled.

Unfortunately, those charged with the custody of evidence are commonly prone to neglect, mistakes, and ignorance with respect to the performance of these duties.

The inappropriate “house cleaning” that takes place in some crime labs has been attributed largely to miscommunication and ignorance. However, the practice of specifically targeting some types of evidence, such as untested rape kits, for destruction has been criticized as an intentional effort to prevent postconviction testing that could result in an overturned conviction or even an exoneration. This, again, raises the specter of the spoliation inference.

To account for these postdiscovery influences, a record must be kept of the people, places, and processes that the evidence has endured since the time of recognition at the scene. This record is usually referred to as the “chain of custody.” Even though a reliable chain may be established, physical evidence may have been altered before or during its collection and examination. Unless the integrity of the evidence can be reliably established, and legitimate evidentiary influences accounted for, the creation of a chain of custody does not by itself provide acceptable ground on which to build reliable forensic conclusions. It is, however, a good start, and without it evidence should not be considered sufficiently reliable for courtroom opinions.

VICTIM AND OFFENDER ACTIONS

The actions of both victims and offenders during the commission of a crime directly influence the nature and quality of evidence that is left behind. These can include precautionary acts, ritual or fantasy, staging, and the level of violence and resistance.

Precautionary acts involving physical evidence are behaviors that an offender commits before, during, or after an offense that are consciously intended to confuse, hamper, or defeat investigative or forensic efforts for purposes of concealing the identity of the perpetrator or his or her connection to the crime, or even the crime itself. This includes disposal of the body, clipping victims’ fingers or removing their teeth or fingers to prevent identification, burning the body or the scene, cleaning up the blood at the scene, picking up shell casings—essentially anything that changes the visibility, location, or nature of the evidence. This also includes methods used to restrain the victim and material used in fashioning that restraint.

Staging of a crime scene is a specific type of precautionary act intended to deflect suspicion away from the offender by manipulating the physical evidence. Staging often involves the addition, removal, or alteration of items in the crime scene to change the appearance of motive and subsequent suspect pool (see Chapter 9: Staged Crime Scenes).

Fantasy refers to the deliberate act of imagining a behavior, event, or series of events that one finds personally arousing or enjoyable. Fantasies can involve **rituals**, which are specific acts performed in an order that gives them a particular meaning. Fantasies and rituals influence the kinds of situations, environments, and behaviors that the victim may allow himself or herself to enter and engage in willingly. They also influence the kind of activity that the offender might want to participate in with the victim, consensual and nonconsensual alike.

The level of violence and resistance in a crime is not always planned or predictable. The more violence is involved, the more alteration and destruction of evidence and victim injury occur. As the victim resists, the offender may also alter or destroy evidence, and even injure the offender.

The lesson here is that both victims and offenders can do things before and during the crime to alter the physical evidence. Just because evidence is found in a particular location, and in a

particular manner, does not mean that it reflects the actions and events surrounding it accurately. Precautionary acts, such as cleanup efforts and staging, must be investigated and eliminated. Moreover, not all of the actions and events evident in the scene will be the result of offender behavior. Some of it will be the result of the victim.

WITNESS ACTIONS

The actions of witnesses can influence the nature and quality of evidence left behind in a crime scene. This includes actions taken to preserve victim dignity, as well as the deliberate theft or removal of items from the scene upon discovery of an incapacitated or deceased victim. It also includes any other well-intentioned yet destructive efforts.

EXAMPLE

The Murder of Jamie Penich

In 2001, Jamie Lynn Penich (Figure 6.6), a 21-year-old junior majoring in anthropology at the University of Pittsburgh, was in Korea studying at Kiem Yung University for a semester. Penich and seven other students had traveled to Seoul for a weekend of sightseeing. Some of them, including Penich, went dancing and drinking at Nickleby's, an expatriate bar frequented by U.S. military in Seoul's party district, to celebrate St. Patrick's Day.

Penich was found dead in her hotel room at approximately 8 a.m. on March 18, 2001. Although initial police reports indicated she was strangled, her autopsy report determined that she had been stomped to death. There were imprints of jogging shoes on her chest, and she had sustained extensive head, neck, and facial injuries. U.S. Army CID became involved because they suspected a U.S. soldier had committed the crime. They investigated the scene, the suspects, and the evidence (Figure 6.7).



FIGURE 6.6 Twenty-one-year-old anthropology major Jamie Lynn Penich.

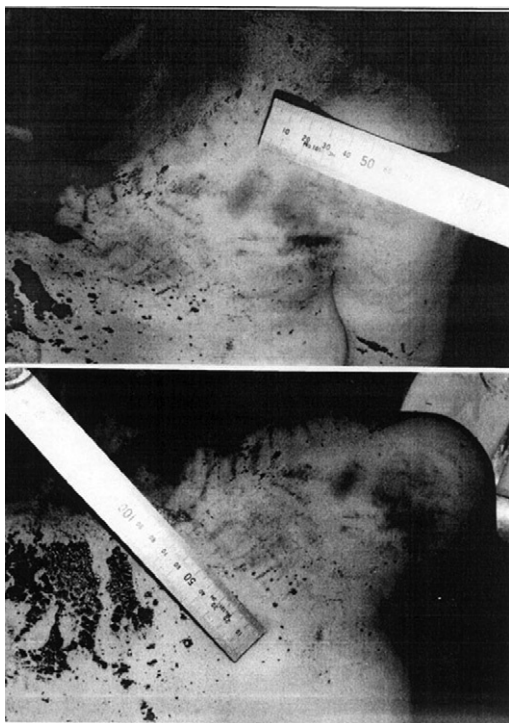


FIGURE 6.7 Autopsy photos of Jamie Lynn Penich's left shoulder reveal distinctive blunt force patterns left behind by footwear. This is action evidence consistent with stomping.

As reported in *Stars & Stripes* (Kirk, 2001):

[Forensic scientist Brent] Turvey criticized the evidence collection and investigation methods in the Penich case, citing gathering up garments from the crime scene and placing them all in the same container as irregular.

Korean police brought two pieces of evidence collected at the crime scene—a black jacket and a brown pullover—to a lab in the same bag, Korean forensic officials said. Turvey said that evidence should not have been clumped together.

"Every item of clothing—every shoe, every sock—should have its own bag," Turvey said. "You should never ever put two items in the same bag."

Penich's roommate in the hotel said the jacket completely covered Penich's face when she found the body. Two other witnesses said they remember Penich's face was covered with what they believed to be her black jacket.

The jacket is not seen over Penich's head in numerous crime scene photos shared with *Stars and Stripes*, or in the autopsy report. In some photos, the jacket is seen near Penich's body. . . .

Another area of contention is whether Penich was sexually assaulted or had intimate relations with her attacker.

Lee Won-tae, chief medical examiner and director of the Department of Forensic Medicine in Seoul, said he's worked more than 800 murder cases. He said that evidence collection hinges on the quality of the detective. "Sometimes, they [investigators] are very highly qualified," Lee said. He said he considers the Yongsan Police Department officials good at collecting evidence. Lee said his lab was unable to get a DNA fingerprint from semen samples on two pairs of underwear belonging to the Netherlands woman and Penich, respectively.

During the autopsy, investigators also took a sample from Penich's body that tested positive for semen.

Lee said it was not unusual to not recover DNA. Turvey agreed, but said it could be a case of inexperience. "I would say that's very possible [to not get DNA results] if the lab doesn't have experience doing that kind of test," Turvey said. "Another lab with more experience may be able to find something."

Turvey also questioned the role of U.S. investigators.

One soldier originally suspected in the murder told *Stars & Stripes* that U.S. Army Criminal Investigation Command, known as CID, agents came to his barracks room to check his clothing. They donned goggles, turned off the room lights, and scanned the clothes with a special light, he said.

"They told me it was to see if [my clothes] had any body fluids, traces of blood," he said.

The agents found nothing, the soldier said, and allowed him to keep his clothes.

"This is ridiculous and speaks to the horrible level of training in forensic science on the part of CID investigators," Turvey said. "The clothes should simply have been taken and submitted to a lab for analysis. Investigators should not be doing that kind of thing themselves."

Marc A. Raimondi, chief of public affairs for CID in Virginia, said CID agents are well trained.

"We are better trained than any federal law enforcement agency in the country," he said.

According to Raimondi, agents routinely use a Polilight4 to find biological fluids and stains. The light uses selected wavelengths across the visible spectrum to fluoresce or identify stains or latent fingerprints for analysis.

Turvey said that method might not show all traces of fluids that could be present. Investigators can use other methods to detect blood, and clothes can be analyzed for fibers, he said. "There are so many things they can do with evidence," Turvey said. The soldier said CID agents returned a few weeks later to confiscate his clothing.

It is flawed when evidence is not collected immediately and retained, Turvey said. Delaying evidence collection makes analysis more problematic, he said.

Eventually, the FBI reinterviewed 20-year-old Kenzi Snider, a fellow student and traveling companion who had befriended Jamie Penich during their time together at Kiem Yung University. She was back in the United States at the time. FBI agents claim that Snider ultimately confessed to the crime during their interview; however, that interview was not recorded (Arnold, 2002).

[FBI Special Agent Mark] Divittis and [U.S. Army Criminal Investigations Division Agent Mark] Mansfield conducted the two-day interview [of Snider] along with another federal investigator.

In her confession, Snider told investigators she and Penich had been in a bar on the night of March 17. The two went to the motel and into Penich's motel room, said Linwood Smith, special agent with the FBI.

The two went into the bathroom, where they began kissing and groping, Smith said. The touching led to Snider performing oral sex on Penich, he said.

When Penich attempted to unbutton Snider's pants, Snider hit her in the face and knocked her into the bathtub, Smith said.

Snider dragged her into another room and stomped on her head, he said. . . .

One sticking point for Snider's defense team is that the confession was not recorded or videotaped. The only records are signed statements by Snider and a series of notes taken by investigators.

"The FBI does not tape interviews or interrogations," Divittis said. "It is not necessary, and it would be hard on the victim's family to have to hear it. People would not even understand the interrogation."

The defense disagreed.

"Don't you think that it is important for the courts to see how a person is persuaded?" Weis asked.

The U.S. Army CID also does not tape interviews, Mansfield said.

Snider was arrested, extradited back to Korea, and put on trial for the murder of Jamie Penich. However, she was acquitted. According to published reports (Jae-Suk, 2003):

South Korean court has acquitted an American woman accused of beating to death another U.S. student for allegedly making unwanted sexual advances.

Seoul District Court Justice Kim Nam-tae said today there wasn't enough evidence to convict 21-year-old Kenzi Snider of killing Jamie Lynn Penich at a Seoul motel in 2001.

Kim said the court decided not to consider the confession Snider made to FBI and U.S. military investigators because Snider claimed she had been coerced into making it.

"There is no other evidence to find her guilty of the accused crimes. She is not guilty," Kim said.

In reviewing this case, it should become clear that the initial investigation focused on chasing after a single theory to the detriment of gathering evidence and establishing a solid chain. Furthermore,

when evidence collection efforts did take precedence, they were often late, inadequate, and uninformed. This deprived the case of the forensic evidence it most certainly could have used at trial, forcing prosecutors to rely on a confession for which there was also no reliable chain.

ESTABLISHING SCIENTIFIC UNCERTAINTY: AN EVIDENCE DYNAMICS PROTOCOL

Evidence dynamics bring uncertainty to the results of forensic examinations and subsequent interpretations. Consequently, discussions about the impact of evidence dynamics are not always a common feature of courtroom testimony, where certainty is absolutely required on the part of the state. Reconstructionists have a professional responsibility to see this change, at least in their own work, so that physical evidence is not misrepresented at trial.

As suggested previously, one way to inquire after the evidence dynamics that may be present in a given case involves a scrupulous study of the scene and of the chain of evidence. The reconstructionist must begin by establishing the known individuals, circumstances, and events that may have handled or affected the evidence in question. Then, for each item of evidence involved in the reconstruction, the reconstructionist must inquire about the history of that item by asking the following:

1. What comprises the chain of custody for a given item of evidence (notes, sketches, photos, logs, signatures, etc.)?
2. Is the chain consistent or are there gaps?
3. What were the conditions at the scene at the time of the incident and then later at the time of discovery (indoor/outdoor, raining/sunshine, humid/dry, windy/stuffy, etc.)?
4. Was any effort made to record the environmental factors that might have affected the evidence?
5. What did the item look like at the scene?
6. When was the item collected, and by whom?
7. Was the exact location of the item documented (where appropriate, in three dimensions)?
8. Was the item of evidence collected properly?
9. When and how was the item packaged?
10. Was the collection documented? How?
11. What effects did transportation have on the item?
12. Is the name of every individual and agency that has handled the item known? How?
13. Is every test or examination that has been performed on the item of evidence known? How?
14. Was the item stored properly after collection and before testing?
15. What effects has forensic testing had on the item of evidence?
16. What does the item of evidence look like now and why? How much change has been effected?
17. Has the initial officer at the scene been interviewed to determine what was done to secure the scene?
18. Have the EMTs been interviewed to determine what they observed upon entering the scene and what they did that might affect the evidence?

Obviously this is a starter list that will lead to other questions. However, the inability to answer even one of them represents a broken link in the chain of evidence and may call into question subsequent interpretations. The answers to these begin to address the issue of evidence dynamics, and subsequently a clearer picture of potential influences is established. As a result, the reconstructionist may learn whether and when uncertainty, equivocation, or reexamination is warranted.

EVIDENCE DYNAMICS: THE INFLUENCE OF FUTURE TECHNOLOGIES

As time goes forward, physical evidence may suffer its ravages. But while we have focused largely on the destructive aspect of evidence dynamics, they are not always so. As time goes forward, so does technology. Our ability to recognize, collect, preserve, and extract information from evidence grows with each technological breakthrough.

Consider the crime scene in general. The problem of documenting a crime scene as it appears upon arrival is one that troubles anyone who's had the experience. Crime scenes involve complex systems of interrelated evidence that imperfect human investigators can easily miss. This may soon be a problem no longer.

A number of companies market various tools for documenting crime scenes that record millions of points within a few minutes. Eventually, crime scenes will not require individual measurements as the computer records the positions of each of those points, and it is a simple matter to determine the distance between two points or objects. This is also done in three dimensions so there is a complete picture of the scene. Even the size and the angle of blood droplets are recorded so the point of origin can be determined.

Consider the evolution of fingerprint evidence. From powders, to chemicals, to lasers, to metals, the search for latent prints has been met with a variety of technological solutions. But now, the fingerprint itself has become evidence. Under the right conditions, scientists are able to extract DNA from cellular material left behind, and recently there has been a further development. As [Choi \(2007\)](#) explains:

Standard methods for collecting fingerprints at crime scenes, which involve powders, liquids or vapors, can alter the prints and erase valuable forensic clues, including traces of chemicals that might be in the prints.

Now researchers find tape made from gelatin could enable forensics teams to chemically analyze prints gathered at crime scenes, yielding more specific information about miscreants' diets and even possibly their gender and race.

Consider the evolution of blood and DNA evidence. First they were analyzed for blood type, then restriction fragment length polymorphism DNA, then polymerase chain reaction DNR, and now short tandem repeat DNA—with the evidence sample size needed growing smaller with each method. Now we don't even need blood. We can extract DNA from any live nucleated cell, including saliva on a cell phone or sweat left on the nose guard of eyeglasses. If there is hair evidence, you can get DNA from the root, mitochondrial DNA from the cells in the shaft, or even a toxicological history. There are currently companies engaged in forensic DNA testing for the purposes of determining race and even eye color. It may not be too long before we can render any number of characteristics from the smallest amount of DNA.

This aspect of evidence dynamics demonstrates the need for ongoing training in evidence collection and for the employment of cold case personnel—to consider not just what the evidence reveals with today’s methods and techniques, but what it could reveal with the technology of tomorrow.

SUMMARY

Crime reconstruction efforts are concerned with interpreting the physical evidence that results from the actions and events related to the commission of a crime. However, frequently missing from this analysis is the recognition and consideration of those things that can change physical evidence prior to, or as a result of, its collection and examination. The more we learn about physical evidence—how it can be affected by external forces and distortions—the more we come to appreciate that it is not necessarily a certain and precise record of actions and events.

The general term *evidence dynamics* refers to any influence that adds, changes, relocates, obscures, contaminates, or obliterates physical evidence, regardless of intent. Evidence dynamics are at work in a scene even before an event happens that requires reconstruction, waiting to confuse, mislead, and confound. They are present as physical evidence is being transferred or created and remain a hazard during scene processing efforts and later in forensic testing. In fact, these many agents of chaotic change continue, and do not stop, until an item of evidence has been intentionally or inadvertently destroyed.

Crime reconstructions are too often built on an *assumption of integrity*—that evidence left behind at a scene is guarded and vestal prior to the arrival of police investigators and other responders. This assumption extends to the mistaken belief that taping off an area, limiting access, and setting about the task of taking pictures and making measurements somehow ensure the integrity of the evidence found within.

Reconstructionists must accept, and anticipate, that each item of evidence collected in a crime scene will have suffered through influences, expected and uncontrollable alike, that have the potential to affect the evidence. Awareness of these influences is the first step. The next is proper security, including the chain of custody. The *chain of custody* (a.k.a. chain of evidence) is the record of each person, and agency, who has controlled, taken custody of, examined, tested, or had any other kind of contact with a particular item of evidence, from its discovery to the present day. Without a chain of sufficient strength, reliable interpretations about the evidence and its role in a given crime cannot be made.

Evidence dynamics can be a function of the crime scene environment and natural processes, as well as investigative and forensic protocols. The actions of witnesses may also influence the nature and quality of evidence that is left behind, as well as the actions of both victims and offenders during the commission of the crime. These can include precautionary acts, ritual or fantasy, staging, and the level of violence and resistance.

QUESTIONS

1. Define evidence dynamics.
2. Evidence dynamics are at work in a scene even before an event happens that requires reconstruction. True or false?

3. Explain the limiting effect of crime scene tape.
4. Provide three examples of evidence dynamics that are a function of environment and natural processes.
5. Provide three examples of evidence dynamics that are a function of victim and offender actions.

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Crime Scene Investigation

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CSI forensic science differs from nonfictional forensic science. Although the latter strives to minimize uncertainty, it recognizes that uncertainty can never wholly be eliminated and that science cannot produce absolute truth. Neither can it determine a suspect's culpability; Culpability can only be determined in a court of law. –*Kruse (2010, p. 88)*

Key Terms

Corpus delicti (“body of the crime”); **Crime scene investigation**; **Crime scene processing**; **Dumpsite (or disposal site)**; **Intermediate crime scene**; **Latent evidence**; **Macroscopic evidence**; **Microscopic evidence**; **Modus operandi (MO)**; **Primary crime scene**; **Secondary crime scene**; **Signature behaviors**; **Tertiary crime scene**

Crime scene investigation refers to the process of establishing the scientific facts of a case using the physical evidence that is produced in relation to suspected criminal activity (see generally *DeForest, 2005; Lee et al., 2001*). An emphasis must be placed on the investigation component, as we are required to acknowledge that until crime scene investigation efforts bear fruit, the facts of a case are unknown or uncorroborated. We investigate to establish facts and understand them, to determine whether or not actions and events genuinely occurred. We investigate not knowing the outcome, not toward predetermined findings.

The goal of crime scene investigation is to provide for scientific crime reconstruction and crime scene analysis efforts. The results may be used to answer investigative and legal questions. Each case has its own such issues that cannot be predicted; this demands a thorough effort at the outset to allow for the most complete retrospective inquiry of crime scene evidence.

Although often confused with crime scene processing efforts (discussed shortly), crime scene investigation is actually more comprehensive. As explained in *DeForest (2005, p. 113)*:

The stages of the crime scene investigation extend beyond the work at the scene. Once the evidence has been analyzed in the laboratory, the scientific interpretation of the laboratory results may lead to a reconstruction of the event.

Crime scene investigation, it is understood, occurs not only within the confines of yellow barrier tape under the watchful eye of law enforcement officers and investigators, it is a broad inquiry that seeks to establish the record of physical evidence during an event or a series of related events. It is ultimately the unified result of aggregated crime scene examination and processing efforts; forensic laboratory examinations and analyses; medicolegal examinations and analyses; and collateral victim–suspect evidence and history.

Many technical works in the literature delineate the necessity of various crime scene tasks per agency protocols or investigator experiences. Certainly the mindful student of forensic science will have read at least some of these in their ongoing efforts to better understand physical evidence and its value to forensic casework. The purpose of this chapter, however, is to educate the reconstructionist as to the nature of crime scene investigation, its role in the process of criminal investigation, and its importance to the reconstruction effort.

CRIME SCENES

A *crime scene* is defined as any area where a crime has taken place. In many cases, a crime scene is discovered because of violence that is witnessed or inferred from some fact or evidence. Others go undiscovered for lack of obvious signs or traces, either due to offender precaution or the lack of violence in the crime itself. As explained in O'Hara (1970, p. 47):

Obviously, many kinds of crime do not have a “scene” in the sense of an area where traces are usually found. Offenses such as forgery and embezzlement require no vigorous or exceptional physical activity in their commission. There is no impact of the criminal on his surroundings. Crimes of violence, however, involve a struggle, a break, the use of weapons, and the element of unpredictability. In homicide, assaults, and burglary, the criminal is in contact with the physical surroundings in a forceful manner.

However, crime does not always limit itself to a single location as this definition might imply. It is best for the reconstructionist to conceive of a given case as consisting of multiple connected scenes where different events and activities occurred related to victims and suspects alike. With this mind-set, it becomes easier to grasp the necessity for comprehensive investigation of different areas as one works to establish a timeline of events. To that end, it is also useful to understand that there are different types of crime scenes.

One of the most important considerations of crime scene investigation, reconstruction, and analysis is determining what type of crime scene has been discovered. By this, we are referring to establishing the relationship of the crime scene to the offense behavior, in the context of the offense. When determining the *crime scene type* in a particular case, the reconstructionist is warned not to use intuition or experience as a primary guide. Let the physical evidence tell the story. Work from the physical evidence out to a sound reconstruction, not from biased theories into a corner.

Consider the following types of crime scenes. These are not mutually exclusive categories.

Primary Crime Scene

The **primary crime scene** is the location where the offender engaged in the majority of his or her principal offense behavior. Principal offense behavior is determined by motive and/or criminal statute, such as homicide, sexual assault, or theft. In many instances, it is the location where

the offender spent the most time—whether by virtue of criminal behavior or cleanup. It is also likely to be where the most physical evidence was created during the offense.

In more complex, involved, or prolonged criminal offenses, the concept of a primary scene may still be applied, but not without care. If attacks on multiple victims occur within a single offense at separate locations, it is most useful to separate out these offenses with one primary scene for each victim. Similarly, if a single victim suffers multiple types of harm within a single offense, it is most useful to separate out incidents of attack with one primary scene for each.

For example, in a sexual homicide there may be a primary sexual assault scene and a primary homicide scene. If multiple victims are involved, each victim may have their own primary sexual assault scene and a primary homicide scene or they may be sexually assaulted and killed at the same location. This must be determined by a careful reconstruction of each crime and the appropriate classification applied.

Classifying the primary scene in a given case as merely the location where the offense begins misses the point of this effort and prevents meaningful investigative and forensic comparison to other offenses. It also ignores the complexity of criminal behavior. Not all offenders do just one thing with one victim at one place; some are much more developed and complex. We must acknowledge this in our classifications.

Secondary Crime Scene

A **secondary crime scene** is a location where some of the victim–offender interaction occurred, but not the majority of it. Also, a secondary scene does not involve principle offense behavior, but rather supporting behavior. There can be several *secondary crime scenes* associated with a single crime.

For example, if the victim is abducted from one location and taken to another to be raped or killed, the location where the victim was abducted from is a secondary scene.

If the scene is the location where the body is found, a secondary scene is also the *disposal site*.

Intermediate Crime Scene

An **intermediate crime scene** is any crime scene between the primary crime scene and a *disposal site*, where there may be transfer evidence. This includes vehicles used to transport a body to a disposal site after a homicide and locations where a body has been stored before final disposal. It also includes ground that has sustained drag marks of any kind. *Intermediate crime scenes* are a type of *secondary crime scene*.

Dumpsite/Disposal Site

Dumpsite, or **disposal site**, is a rough term used to describe a crime scene where a body is found. This may be the primary scene or may be a secondary scene.

More often than not, the use of this term implies that the victim was assaulted somewhere else and transported to this location after or just before death. This is an unfortunate and very dangerous investigative assumption to make. A disposal site may also be the primary crime scene;

this possibility must not be excluded by virtue of an investigator's subjective experience. It must be investigated and confirmed by the physical evidence.

Many crime scene efforts encountered by the authors seem actively disinterested in interpreting the relationship of outdoor locations to the bodies of victims found within them. Often, it will be assumed that an outdoor crime scene is both a primary scene and a disposal site, ignoring other nearby potential underwater, indoor, or vehicle locations. They will also fail to consider that the victim's home might be related to the crime and therefore miss the opportunity to include related evidence in their investigation.

Once it has been established that the crime scene at hand is a secondary disposal site, certain questions must be answered:

- How was the body transported there—was dragging, carrying, containers, wraps, or vehicles involved?
- What route was taken during transportation—direct, indirect, public, or private?
- Why was the disposal site chosen—convenience, crime concealment, evidence destruction, or emotion/fantasy?
- Why was transportation away from the primary scene necessary?

Transporting a body under any circumstance is a cumbersome and risky proposition. The body itself is heavy, unwieldy, and, in some cases, may even need to be dismembered. Just getting it out of, or away from, the primary scene under good conditions exposes the offender to innumerable risks. Consequently, there is often a good reason for moving the body—namely, that the offender is somehow associated with the primary scene and would be a logical suspect if the body had been found there.

Tertiary Crime Scene

A **tertiary crime scene** is any location where physical evidence is present but there is no evidence of victim-offender interaction. This includes locations where *evidentiary items* (e.g., a used weapon, bloody clothing) are stored after a crime has been committed. It can also include transfer evidence resulting from victim movement after the offense, such as vaginal purge subsequent to a sexual assault or bloody-hand transfer to areas and objects that are reached outside of the primary or secondary scenes while escaping or seeking help.

Example

The following example illustrates the differences among crime scene types.

An altercation occurs between a victim and offender in a high-rise apartment building. The altercation results in the victim being pushed off the balcony of the apartment. The victim's body hits numerous balconies during the fall, leaving material and biological transfer evidence (e.g., fibers, blood, hair, and skin) in the process. The offender subsequently recovers and transports the victim's body by vehicle to a rural location that dissociates the offender from the crime scene.

In this case, the *dumpsite/disposal site* is the rural location where the body is found. The apartment building where the initial altercation occurred is the *primary crime scene*. The *intermediate crime scene* is the vehicle that transported the victim's body. This is also a *secondary crime scene*. Each balcony that contains transfer evidence from the victim's fall is a *tertiary crime scene*.

Investigating and establishing the crime scene types that present in a given case, and evaluating the nature of any evidence that has been found there, will reveal the existence of other potentially related crime scenes. Failure to accurately determine the crime scene type, or to ask this question at all, can therefore result in the loss of physical evidence. It can also prevent the reconstructionist, and anyone relying on his or her analysis, from understanding what actually happened.

CRIME SCENE PROCESSING

Crime scene processing refers to the function of recognizing, documenting, collecting, preserving, and transporting physical evidence. As explained in [DeForest \(2005, p. 112\)](#):

The term crime scene processing is commonly used as a synonym for crime scene investigation. This is unfortunate and betrays an ignorance about the nature of crime scenes and what is necessary to extract the relevant information from them. Crime scene investigation should not be perceived as a mechanical process, carried out in a rote fashion. Too commonly, this is the way it is viewed by law enforcement policy makers; administrators; supervisors; and perhaps, surprisingly, those who actually “process” the crime scene. Change is necessary. . . .

In many jurisdictions, specially designated law enforcement evidence technicians (a.k.a. crime scene investigators, or CSIs) are charged with crime scene processing duties. They are expected to locate and protect physical evidence without damaging it, without causing potentially misleading transfers, and without adding artifact evidence to the scene. They are expected to document and preserve, as much as possible, the overall scene and all the physical items present. They also document any pattern evidence. They are further expected to collect and package the evidence in a manner that preserves it for subsequent transportation, analysis, and interpretation. In smaller departments, or when evidence technicians are otherwise unavailable, police officers will perform this task themselves.

Crime scenes are also attended by a multitude of responders from other various government and contracted agencies (e.g., emergency medical services, fire department, coroner/medical examiner’s office, police interns, search and rescue volunteers, and, occasionally, forensic scientists).

Each of these responding agencies should have clearly developed and written crime scene policies and procedures that detail the duties of responders, although many do not. In any case, such policies and procedures must be developed in conjunction with forensic scientists for resulting efforts to be useful and meaningful. When drafted in a vacuum, without the input of those who will be examining and testing the evidence, there is room for misunderstanding, error, and negligence.

Also, and because there are often many personnel around and in the crime scene with different objectives, there should be a clear understanding of who is charge of what in the crime scene: who is the lead investigator; who is the overall crime scene manager¹; who is in charge of scene

¹ The lead investigator usually assumes that he or she is also the crime scene manager. However, the lead investigator is in charge of the criminal investigation and should not have responsibility for the crime scene as well. If a forensic scientist/reconstructionist is present, that person is the best choice to direct scene activities. Lacking a forensic scientist, an experienced, educated CSI should assume this responsibility.

security; who is in charge of taking photos; who is in charge of the sketch; who is in charge of collection; and who is charged with keeping and maintaining the various logs of personnel, evidence, and photos that will begin the chain of custody. This requires leadership and clarity of purpose for all responders. It must happen for crime scene investigation to be thorough and informed, and it cannot happen by accident.

Duty of Care

Crime scenes are the statutory and jurisdictional province of law enforcement agencies; the agency in charge depends on what laws have allegedly been broken and where. Consequently, responding law enforcement agencies have a duty of care—an obligation to be competent custodians of the crime scene and any evidence that supports or refutes allegations of criminal activity against accused suspects. If an agency does not hold or perceive a duty of care, then they are not fit custodians of the evidence and their domain over the crime scene should be limited or eliminated.

The authors have each worked many cases, have directed crime scene investigations in many cases, and have assisted with processing many crime scenes in conjunction with law enforcement. We have also performed similar recognition and collection work for the defense, after law enforcement personnel have released the scene, only to find things that were missed. In other cases, we have examined crime scene efforts to find pertinent evidence documented but not collected; collected but not examined or tested; and examined or tested but not understood (Figure 7.1).

DeForest (2005) explains one cause of the problem and suggests a solution (p. 112):

In most law enforcement jurisdictions in the United States, scientific expertise is absent from the initial crime scene investigation. This is true for many other parts of the world as well, and it is a situation that needs to be rectified. An argument can be made that crime scene investigation should be carried out exclusively by forensic scientists, but at the very least, experienced forensic scientists should form part of the crime scene investigation team.

The NAS report (discussed in the Preface of this edition) also offers some insight regarding the need for crime scene investigation reform (Edwards and Gotsonis, 2009, pp. 56–57):

Evidence recovery and interpretation at the crime scene is the essential first step in forensic investigations. Several organizational approaches to crime scene investigation and subsequent forensic laboratory activity exist, sometimes involving a large number of personnel with varied educational backgrounds. Conversely, in some jurisdictions, a single forensic examiner might also be the same investigator who goes to the crime scene, collects evidence, processes the evidence, conducts the analyses, interprets the evidence, and testifies in court. In other jurisdictions, the investigators submit the evidence to a laboratory where scientists conduct the analyses and prepare the reports. Crime scene evidence collectors can include uniformed officers, detectives, crime scene investigators, criminalists, forensic scientists, coroners, medical examiners, hospital personnel, photographers, and arson investigators. Thus, the nature and process of crime scene investigation vary dramatically across jurisdictions, with the potential for inconsistent policies and procedures and bias. Some analysts say that the lack of standards and oversight can result in deliberate deception of suspects, witnesses, and the courts; fraud; and “honest mistakes” made because of haste, inexperience, or lack of a scientific background.



FIGURE 7.1 One of the authors (Turvey) was asked by an attorney to examine a crime scene involving an alleged burglary that resulted in a homicide. The victim had reportedly been attacked in his bedroom while still asleep. The author, and his then partner, Det. John Baeza (NYPD-ret), attended the scene several days after it had been released by law enforcement to document bloodstains and look for anything pertinent that might have been missed. We discovered a blanket, still on the victim's bed, with sharp force cuts consistent with stab injuries inflicted on the victim and corresponding bloodstains—pictured here. The victim had apparently chased the intruder from his home and died outside of the residence after a struggle. The police focused their processing efforts on the location where the victim was found, and the obvious bloodstains inside the residence, but had apparently ignored the bedroom. The item was photo documented; collected in brown paper packaging; sealed under the author's signature, date, case number, and evidence number; and submitted to the attorney as evidence. The discovery of vital evidence missed at the crime scene by police investigators is routine to this author.

Our position on the subject remains the same as published in the first edition of this text: to be blunt, modern-day crime scene processing efforts are entirely inadequate and in need of major reform. There are some notable and even heroic exceptions, but few, if any, agencies seem to regularly employ and subsequently require qualified personnel at the crime scene. Rather, it is commonly believed, and generally practiced, that new personnel can and should learn scene-processing duties on the job from other police officers, all with little or no scientific background. Also, because many in law enforcement perceive that crime scene processing is a simple task that anyone can learn and perform by rote, literally anyone is doing so.

Role Confusion

As already mentioned, none of the crime scene responders mentioned in the previous sections are necessarily forensic scientists, let alone educated or trained in the forensic sciences or evidence collection.² Forensic scientists regularly attend crime scenes in only a few jurisdictions throughout the United States. More to the point, forensic science and crime reconstruction are not generally taught to police academy cadets, and these subjects are not part of the usual training regimen for fire departments, EMS personnel, or other crime scene attendees and volunteers. This reality has not stopped some responders from suggesting otherwise, nor has it stopped some courts from believing it.

Role confusion by those working outside the process of evidence examination, with respect to forensic practice and prowess, is somewhat understandable. Police officers are associated with the forensic scientists their agencies employ, forensic scientists are associated with physical evidence examination, physical evidence is associated with crime scenes, and police-employed evidence technicians process those scenes. These associations have created and nurtured confusion about who is properly qualified to interpret physical evidence of crime scene actions and events.

Evidence technicians and police officers, most without a science or forensic science education, are commonly, and improperly, admitted in court as experts on such matters based solely on their proximity to evidence and the fact that they collected some of it. Also, forensic scientists are commonly, and improperly, questioned about their law enforcement affiliations and experience as though this establishes genuine forensic credentials when this could not be further from the truth. Forensic science and law enforcement are born of separate cultures with separate missions (Edwards and Gotsonis, 2009).

Forensic Scientists at the Scene

Given this state of affairs, the need for an objective forensic scientist at the crime scene should be apparent. Crime scene investigation is not simple; it is not something that can be learned entirely on the job, by rote, or with checklists. Unless a forensic scientist with a generalist background attends a crime scene and assists in processing efforts, the results of crime scene processing can and do vary widely with respect to quality. To proceed otherwise risks whether the physical evidence will play a role in locating and convicting criminal offenders. In fact, it risks the acquittal of the guilty and the conviction of the innocent.

Technicians and police officers are, by and large, not educated and trained in science or the scientific method. Their understanding of the science beneath their tasks is necessarily limited by law enforcement employment practices and culture. Also, their understanding of how to collect evidence is commonly derived from, and limited to, written procedures prepared by lab scientists or other police personnel. And that's when they've read them, which is rare. Their lot is not to ask why, but to follow orders in the chain of command from nonscientist supervisors.

It is fair to say that crime scene processing is so low in priority to many law enforcement agencies that prospective scene personnel need only have a high school diploma or GED, a valid

² All save the coroner, or medical examiner, as these may or may not be properly educated and trained forensic scientists. Holding such an office is by no means a guarantee of forensic knowledge or ability (see Edwards and Gotsonis, 2009).

driver's license, and no criminal record. Once hired, crime scene technicians commonly look forward to low pay, long hours, and less than rewarding working conditions in terms of both agency politics and limited funding for equipment and training. Again, there is much room for reform in the realm of crime scene processing.

In the absence of informed judgments made by forensic scientists at the scene, processing efforts are left in the hands of police officers, police investigators, and police technicians who are largely without scientific or forensic expertise and who tend to approach evidence at the scene from a confirmatory mind-set (discussed in Chapter 4: Observer Effects and Examiner Bias: Psychological Influences on the Forensic Examiner). Although this practice is administratively useful because it is less expensive than having qualified personnel work the evidence, it ultimately results in no science or, worse, bad science.

For those who would at this point still ask "why," it is probable that no explanation would suffice. But we offer the following reasons, based on years of seeing crime scene processing done poorly or not at all in jurisdictions throughout the United States.

- The forensic generalist has the education and training to understand the science behind the chemical tests and instrumental analysis that will be performed on the evidence and knows not just what needs to be collected but also how and why.
- The forensic generalist is better qualified to interpret the meaning of evidence and subsequently recognize which evidence will be of greatest importance to both support and refute any investigative theories.
- The forensic generalist will not chase a particular theory and will engage in thorough documentation of what is at the scene, as well as what is not. The whole concept of negative documentation is something that routinely escapes police technicians for lack of understanding why they are doing what they are doing.
- The forensic generalist is free to collect evidence and speculate about the case external from the direction of a lead police investigator, who may have a strong propensity to direct collections that seek to confirm particular theories of the case without consideration of others.
- The forensic generalist has a better appreciation of the capabilities and limitations of the local government lab system, as well as those of any commonly utilized private labs.
- The forensic generalist will have a better understanding of the impact of collection and storage methods on particular kinds of evidence.

Checklists

A brief note on crime scene checklists is warranted, as many authors have a great fondness for presenting them in their written works (including this one). A checklist is a useful tool for initial instruction, but blind adherence to checklists is a vice that telegraphs ignorance and pedantic understanding of what is essentially a dynamic discipline. Checklists are a temporary stand-in prepared by someone with knowledge for someone without—to help begin the process of learning. They are not the end of it by any means.

If a CSI must rely on a checklist to do their job, this is a clear indication that they have no idea what their job is and what it means to the case. As explained in [DeForest \(2005, p. 111\)](#):

It would not be an exaggeration to assert that crime scene investigation ranks with the most intellectually challenging and difficult of human activities. It is also one of the most misunderstood. In practice, crime scene investigation is rarely carried out efficiently or effectively. Successful outcomes, when and where they occur, are often fortuitous rather than following from intelligently adaptive plans or designs. . . .

Crime scene investigation that does not embrace the dynamic nature of evidence, and the unpredictable nature of crime scene behavior and resulting traces, will most certainly misunderstand its complexity and meaning. It will also misrepresent what that means for the case to others.

Security

In Chapter 6: Evidence Dynamics, we discussed the chain of evidence and other security-related issues at length. A few additional issues must be mentioned here.

Crime scene security begins when the first responders arrive on the scene and have dispensed with their other duties. This includes:

1. The duty to protect life, their own as well as others'
2. The duty to protect society by the apprehension of suspects
3. The duty to keep and maintain witnesses

The protection of evidence is necessarily a low priority in many instances and cannot be high in consideration until these other concerns have been attended to. At that point, the first responders must secure everyone from the scene; everyone gets out and nobody goes back in until the lead investigator arrives.³

National Institute of Justice Guidelines

The National Institute of Justice's Technical Working Group on Crime Scene Investigation recommends that lead investigators should do at least the following when taking charge of any crime scene (Rau, 2000, p. 19):

1. Converse with the first responder(s) regarding observations/activities.
2. Evaluate safety issues that may affect all personnel entering the scene(s) (e.g., blood-borne pathogens, hazards⁴).
3. Evaluate search and seizure issues to determine the necessity of obtaining consent to search and/or a search warrant.
4. Evaluate and establish a path of entry/exit to the scene to be utilized by authorized personnel.
5. Evaluate initial scene boundaries.
6. Determine the number/size of scene(s) and prioritize.

³ One of the authors (Turvey) has worked numerous cases involving sexual assault where the victim was interviewed by police investigators on the bed or in the room where the assault was alleged to have taken place. This can lead to all manner of disruptive and confounding evidence dynamics, to say nothing of adding to the victim's emotional trauma by failing to remove them safely from the place where they were attacked.

⁴ Authors' comment: Pathogens don't have to be blood borne. Also consider any chemical, electrical, or physical hazards.

7. Establish a secure area within close proximity to the scene(s) for the purpose of consultation and equipment staging.
8. If multiple scenes exist, establish and maintain communication with personnel at those locations.
9. Establish a secure area for temporary evidence storage in accordance with rules of evidence/chain of custody.

Here it should be mentioned that there must be efforts taken to ensure the security of the scene, not only from the public but also from nonessential personnel. As explained in [Snyder \(1944, p. 12\)](#): “The first concern of the trained observer is to exclude everyone from the immediate area *who does not have some duty to perform in carrying out the investigation.*”

EXAMPLE

The Murder of Yvonne Layne⁵ *Ohio v. David Thorne*

On April 1, 1999, Tawnia Layne, the victim’s mother, went to Yvonne Layne’s home in Alliance, Ohio, to take one of her grandchildren to school. When she arrived, Tawnia found her daughter’s body on the living room floor. Yvonne’s throat had been cut, and her body was lying in a pool of blood. Yvonne’s five young children were also found awake in the house. Tawnia Layne called the police.

Upon taking control of the crime scene, the Alliance Police Department made numerous overt blunders from the chief on down the line. These included the following:

- Chief Lawrence Dordea, then a 25-year police veteran and graduate of the FBI National Academy, brought his date, Beth Newman, to the crime scene. She was allowed inside the yellow tape to walk around and view the body of the victim. In police reports, she was referred to as a civilian observer.
- The Alliance Police took the victim’s children out of the crime scene by having them go past the living room and her body, both of which were covered with blood. This was unnecessarily insensitive, as there was an alternative method of entering and exiting the scene.
- The Alliance Police attempted to cover the victim’s body with a blanket from the house and then later removed it. They did this to conceal the victim’s body from the children as they left the home. All they need have done is hold it up as a barrier or use the back entrance to the home as the exit. This negligent act transferred unknown material from the blanket on to the body, and from the body to the blanket, potentially fouling any future examination for trace evidence.
- Obvious items of evidence clearly associated with the crime were not collected from the residence or were collected and not tested. These relate to the frequent male visitors that Yvonne entertained⁶ and include a male ring, condom wrappers, cigarette butts, and multiple half-filled drinking glasses in different parts of the home.

⁵ This case was examined and reconstructed for the defense during the appeal in 2003 by one of the authors (Turvey). Mr. Thorne was convicted based entirely on the “confession” of a suspect who stated that Mr. Thorne hired him to kill the victim. This codefendant’s version of the crime matched the police theories of the case at the time and was completely inconsistent with the physical evidence. As of this writing, David Thorn remains incarcerated. For the complete report submitted in this case, see Appendix I: Sharp Force Homicide.

⁶ Some evidence suggests that Yvonne Lane was engaging in prostitution.

- The Alliance Police allowed suspects and family members into the crime scene to mourn and/or get clothing for children while it was being processed. Only authorized personnel should be inside the tape once the scene has been secured.
-

FOR THE RECONSTRUCTIONIST

The reconstructionist must acknowledge that any scene processed without adequate security protocols is exposed to increased evidence dynamics. They must therefore review and assess the adequacy of security measures prior to rendering their findings. Interpretations should spell out any relevant security issues clearly and highlight resulting uncertainties.

Evidence Recognition

A competent reconstruction of the crime is not possible until all of the physical evidence from the scene has been recognized, collected, examined, and identified. A great deal of vital information can be established at the scene through careful observations. According to Kirk (1974), the most important things to observe at the scene are (p. 34):

1. Displaced objects or objects in unusual locations or attitudes.
2. Distribution, indications of direction, and character of all blood traces, whether they be spots, stains, pools, or smears.
3. Presence of objects that appear foreign to the environment, for example, weapons as well as objects, traces, or materials not suitable as weapons but apparently involved with the criminal activity.

Each of these occurrences must be documented with photos and sketches in order to preserve them for later interpretation in the light of other facts revealed during the investigation.

The key is a thorough, planned, practiced execution of duties. That is to say, it is not a good idea to walk into a new scene and start collecting evidence as it is found, jumping from one place to the next as someone shouts "Over here! Look what I found!" Investigators are better served by a deliberate, patient, and systematic approach. As provided in DeForest (2005, p. 113): "Recognizing significant items among a much larger number that are ultimately irrelevant is a very challenging task. It takes time. . . . There is no need to rush into action. Observation and thought should precede action." Moreover, DeForest explains that it is not possible to find every relevant item of evidence; things will be missed in the hard work that is assessing relevance.

The best advice is to go slow and be deliberate. Do not release the scene until the physical evidence has been thoroughly documented, collected, and packaged. Keep it secure to consider all findings of evidence in context that may suggest further items for collection.

Macroscopic, Latent, and Microscopic Evidence

In terms of what we search for, consider, and ultimately visualize, there are three kinds of physical evidence in a crime scene: macroscopic, latent, and microscopic.

Macroscopic evidence refers to that which may be viewed with the naked eye and photographed with limited technical assistance. This includes firearms, knives, blunt objects covered with biological material, bodies, shell casings, and large bloodstain patterns—to name just a few.

Latent evidence refers to evidence that cannot be seen with the naked eye and is best visualized and then photographed with technical assistance (e.g., powders; chemical reagents; alternative light sources such as ultraviolet or infrared). This includes blood that has been washed away; blood dried on dark porous surfaces; many types of fingerprints; and dried biological fluid such as urine, mucus, and semen.

It is common for crime scene investigators to understand macroscopic and latent forms of evidence and to incorporate them into their processing efforts, as they are among the more traditional and often require limited training to realize.

Most crime scene investigators are not, however, trained to think microscopically. **Microscopic evidence** refers to trace amounts of evidence that cannot be visualized and discriminated with the naked eye. This kind of evidence includes soil, pollen, hairs, fibers, gunshot residue, and trace amounts of biological transfer evidence (see Chapter 10: Trace Evidence in Crime Reconstruction). Thorough crime scene investigation will involve consideration of the microscopic evidence that may be present related to the crime. We must consider it in light of what actions are evident; what traces may be present; and where we should take greater care, and also a closer look, so as not to disturb or miss what could be a crucial bit of evidence.

Preconceived Theories

As already mentioned elsewhere in this work, it is important to avoid becoming entrenched in preconceived theories about the case prior to completing crime scene investigation efforts. Preconceived theories may not only be inaccurate, they may also provide for further inaccuracy by compelling the investigator toward or away from the collection of particular kinds of evidence. As described in [O'Hara \(1970, p. 49\)](#):

The investigator must initially restrain himself from taking physical action. The natural inclination is to form a quick opinion of what happened and endeavor to verify it by physically examining various articles.

Preconceived theories are just that—possible scenarios to be investigated and disproved when possible to find the truth. Although crime reconstruction starts at the crime scene, final reconstruction interpretations can only take place after the physical evidence has been examined and the resulting facts have been established. The utility of any theory rests in the repeated attempts that investigators should make to falsify it with the complete record of that evidence ([DeForest, 2005](#)).

For the Reconstructionist

Given thorough documentation efforts, the ability to recognize evidence missed or forgotten may be possible at a later date. In fact, this is an important role for the generalist-reconstructionist. However, the collection of that missed evidence may be difficult or impossible once the scene has been released and the chain of custody broken. The best chance of collecting evidence is at the scene.

The reconstructionist must review crime scene documentation carefully for any evidence of items that should have been collected and weren't, explain their potential value to

understanding or establishing events, and provide recommendations for collection and testing if feasible. In cases where the evidence has been lost due to time or where testing is simply not feasible, the reconstructionist should be capable of explaining what limits this may put on their interpretations.

Evidence Documentation

Once an item of evidence has been recognized, and before collection efforts can begin, its location in the crime scene must be documented thoroughly. As explained in [Snyder \(1944, p. 17\)](#): “Never touch, change or alter anything until identified, measured and photographed.” The purpose of documenting an item of evidence prior to collection is to assist with establishing a chain of custody, as well as its relationship to other objects taken from and remaining in the scene. To be useful for reconstruction purposes, documentation methods should provide anyone with the ability to return to the crime scene and place the item in the same location and orientation that it was originally discovered.

However, many crime scenes are poorly documented, photographs are not taken correctly, measurements aren't made, and critical observations are not made or recorded. With the popularity of TV shows such as *CSI* and its offshoots, the general public, and most jurors, have a sense of what can and should be done with the physical evidence. When there are basic errors and omissions at the crime scene or a clear disregard for the evidence, it can make police agencies appear unprofessional, ignorant, or even biased. This can cause jurors to lose confidence in the case put on by the state and cause such cases to be lost during deliberations.

For the best reconstruction results, it would be ideal for the reconstructionist to be present at the crime scene as early as possible. This would allow one to view all evidence, including the body, in position. This makes the task of reconstruction far easier than working from the cherry-picked observations of someone else. However, this ideal is seldom obtained. Frequently, the reconstructionist is not called upon until the case is going to court, and the observations of others must be relied upon. The more complete the documentation of those observations, the more reliable the reconstruction.

The person assigned to document the evidence at the crime scene must include documentation of all observations, not only that which supports the theories of investigating officers, but also that which shows why other theories are unsupported or eliminated.

The principal means of crime scene documentation include note taking, photography, videography, and sketching.

Photography

Photographs are one of the best ways to document evidence quickly and accurately. Ideally, this would be the duty of personnel trained in the techniques of forensic photography. Consider these following basic guidelines, consistent with, but not limited to, [Rau \(2000, pp. 24–26\)](#):

1. Start each roll of film (or digital photo series) with a written placard that provides date, time, location, agency, case number, and the name of the photographer.
2. Keep a log of persons and agencies taking photographs, and note any specific items of evidence being photographed.

3. Be certain to take overall shots of the scene and associated areas; put the crime scene in a context regarding the area and its relationship to other nearby areas.
4. Take photographs of any crowds, victims, witnesses, or suspects for later identification purposes.
5. Take photographs of any associated parking areas for vehicle identification purposes. Try to get discernible plate numbers.
6. Photograph the perspective of any witness, from their height and angle.
7. Take long-, medium-, and close-range photographs of each item of evidence. This will begin to provide the necessary context for reconstruction efforts.
8. Take relational photos to show the relationship between an item of evidence and other items in the scene.
9. Work with those measuring evidence and sketching the scene. Get additional shots after a scale and evidence number have been placed with an item, prior to its collection.
10. Use side lighting to bring out texture, damage, tool marks, and any other irregularities on a surface.
11. Too many pictures are better than too few. Take many.

There is a particular limitation to photographs that is all too often ignored by those examining them, especially when pattern evidence is involved. Photographs provide only a two-dimensional likeness. This limitation is important to remember because a photograph is a flattened representation of evidence on sometimes uneven, curved, or even jagged surfaces. As a surface changes, so does the pattern that was left behind. Two-dimensional photographs may also misrepresent spatial relationships; they can distort objects and make them appear closer or farther apart than they actually are. Taking photos from multiple angles, employing detailed sketches, and using video documentation may work to alleviate this particular limitation.

It bears repeating that when using crime-scene photographs and other documentation, it should be possible for anyone to return to the crime scene and place the item in the same position in which it was originally discovered. If the original location of an item of evidence cannot be ascertained from the photo record, then it is inadequate at best.

The authors frequently encounter cases where the photo record is inadequate, disjointed, and without a clear sense of purpose, to say nothing of cases where there are only a few photographs taken. This should not be tolerated, as it signals an utter lack of appreciation for documenting the physical evidence as well as a lack of professionalism.

Videography

Video is a useful way to document crime scene elements that involve time and motion—how long something takes or how something moves. It can also be used, with photos, to get an overall perspective of the spatial relationships between objects. It also provides a means of showing the relationship to, and nature of, other areas associated with or adjacent to the scene that may be missed by the person in charge of still photos who is focusing on the scene and not around it (geographical features, buildings, streets, parking lots, etc.).

Many law enforcement agencies currently shy away from taking video of anything, let alone crime scenes and the activity that goes on within, for fear that this documentation will be used against the prosecution in court by defense counsel. Given the duty of care regarding crime scene investigation, such considerations are inappropriate. Investigators should want the truth

on the record, with all of its frailty intact. If their complete crime scene investigation efforts can survive the crucible of court, then there is some indication that a level of professionalism was achieved. If they cannot, then it should identify a training need.

However, if still photography is thorough, and time and motion are not factors at the scene, then video may not be necessary.

Sketching

The sketch is an integral part of crime scene investigation. Photography, both still and moving, is insufficient to make a complete record of the crime scene. The crime scene sketch supplements these, clarifying the location of the evidence and the relationships between items. It may be a rough drawing made at the scene with a pencil or it can be a polished (a.k.a. "smooth" or professional) document prepared for court using a CAD program.

Essentially, the crime scene sketch is a method of documentation that is a shortcut for descriptive text. The crime scene sketch isolates the items of evidence from the background. The sketch at the scene is not made to scale; however, the items should be in their relative positions and relatively proportional in size. These are your notes; make them so you can understand them. Neatness and artistic ability don't count, accuracy does.

When measurements are made by a novice, they appear directly on the sketch. This soon develops into a confusion of lines and numbers that makes the sketch incomprehensible to anyone other than the sketch artist. Scene measurements should always be placed in a table on a separate page in the investigator's notebook.

Most sketches are *overviews*, that is, they are drawn as if looking down upon the scene. This is essentially a map of the scene. They are understood easily and show the positions and relationships of objects well.

For complete understanding of the crime scene, the overview sketch may not be adequate. A side view, sometimes called an *elevation* or *projected cross-section* view, is needed to show relative heights.

Visualizing a room as a box and then cutting the sides of the box and laying it flat makes a combination of overview with side-view sketch, called an *exploded sketch*.

Drawings made to show three dimensions and perspectives are rare: they (1) require a high skill level and (2) are imitations of photographs. The *perspective sketch* is the least useful sketch for most purposes.

A *finished sketch* is one that is prepared for court; it is drawn accurately and to scale. To be able to draw to scale, the locations of all items at the scene must be documented by measuring. A clear presentation of these measurements is essential to communicate what was done at the scene to those using the sketch and the documented relationships. A sketch that is not to scale is not useful for visualizing the crime scene and may be kept out of evidence in court. To-scale sketches are now made using CAD programs. A measured line should be included at the bottom of the sketch defining the scale. The phrase "approximate scale" should be associated with the line. Due to inherent measurement limitations, a drawing should never give an exact scale.

The sketch has two basic uses. First, it is used to *rebuild* the crime scene. That is, it allows persons who have not been at the scene to visualize the location and relationships. The investigator who uses the sketch to familiarize his or her fellow officers with the relationships between items at the crime scene and the attorney who uses the sketch to show a jury are rebuilding the crime

scene. While photographs show the detail of the scene, the sketch eliminates the clutter, showing only the important items. The sketch ties the photos together, allowing the jurors to understand where items are within the location.

The second function of the sketch is for *reconstruction* of the crime. Reconstruction of actions or positions of the participants within the scene and the relationships of evidence require accurate measurements and a clear sketch. The reconstruction analyst must understand the size limitations at the scene to interpret bloodstain patterns. Measurements relating to bullet holes and/or powder patterns must be accurate for the trajectory analyses to be correct. The actions of the participants in a crime are frequently illustrated on the sketch. An example would be the location and movements of the shooter based on the trajectories of multiple shots.

To be accepted in court the sketch should meet certain legal requirements, the same as any other piece of evidence.⁷ First, someone must be available to authenticate the sketch. If it is not the original, they must testify that it represents the original truly and accurately. The witness must know the circumstances under which the sketch was produced and that it is an accurate representation of what it purports to be. To ensure the admissibility of a sketch into a court of law, the following notations need to be present (Chisum, 2000):

- The name and agency of the person doing the original sketch
- The name and agency of the person preparing the final sketch
- Case identifiers
- Date of original sketch
- Location or address
- Appropriate scale

As mentioned already, the key and the legend to the items of evidence in the sketch, and their respective orienting measurements, should be prepared and kept as a separate document.

The authors frequently encounter cases where the crime scene sketch is illegible, erroneous (e.g., evidence missing, in the wrong location, or present in the sketch but not in photos), or simply absent. This should not be tolerated and signals an utter lack of appreciation for the physical evidence as well as a lack of professionalism.

For the Reconstructionist

Reconstructionist must acknowledge that any scene processed without adequate documentation provides a limited resource for reconstruction efforts by any forensic scientist, investigator, or attorney who seeks to theorize. They must therefore review and assess the adequacy of the crime scene documentation prior to rendering their findings. Were the photos of sufficient quality and quantity and range? Was there a video and did it provide context? Is there a crime scene sketch accurate and adequate for reconstruction purposes? Interpretations should spell out any relevant documentation issues clearly and highlight resulting holes and uncertainties.

⁷ This is an ideal, as some courts will allow sketches into evidence that do not meet these standards in an effort to assist the prosecution and prevent criticism of law enforcement.

Evidence Collection and Preservation

Once an item of evidence has been documented thoroughly, it may be collected and hopefully preserved for examination and testing. Proper evidence collection techniques for everything from DNA swabs to fingerprints to arson debris are dictated by laboratory protocol. Because all physical evidence is not equal, proper methods for preserving it depend on the nature of the evidence (DeForest, 2005).

There are simple concepts to begin with. Volatile material (e.g., arson debris, drug lab chemicals, accelerants) should be packaged into airtight containers to prevent evaporation and spillage. Biological material should be dried and packaged in paper. Firearms, explosives, and drug evidence should be packaged safely. Every single item of evidence should be packaged separately—no big bags of clothing, even if taken from the same person. Every shoe, every belt, every item of jewelry should be packaged separately and identified with its own unique evidence number.

A complete reference for scene processing efforts is not intended here. However, some specific issues of concern to the authors are discussed, as they have been a regular feature in casework. In short, we keep seeing the same kinds of basic evidence-related problems and misinterpretations.

Evidence Technicians and Training

As discussed in Lee and colleagues (2001), one person should be assigned to the task of evidence collection per scene to maintain accountability for the chain of evidence and limit the potential for contamination. This individual should seek training from crime lab personnel in the proper methods of collecting, marking, preserving, and packaging the wide variety of physical evidence that will be encountered at crime scenes. If they do not have training or cannot get training, they must seek the assistance of those that do.

Crime scene personnel should not be allowed to use evidence-related technology unless they are proficient with it. This includes everything from fuming wands, to presumptive blood tests and enhancement reagents, to alternative light sources. If personnel need to read the instructions at the scene before using any piece of technology, then they probably shouldn't use it. This basic policy will prevent much evidence destruction, as well as potential misinterpretations by forensic scientists during reconstruction efforts.

Cross-Contamination

In general, it is best for all crime scene personnel to wear nitrile gloves⁸ to prevent transfer from the investigator to the evidence. The evidence technician(s) should also change gloves after handling each item of evidence to prevent cross-transfer from one item to the next. This is a basic evidence-handling procedure, yet crime scene photos commonly show scene personnel handling all manner of items within the barrier tape without protection.

Also, each item of evidence must be collected into a separate bag or container to prevent cross-contamination during transportation and storage. This cannot be stressed enough. Although it seems obvious, there is no shortage of investigators who bag areas instead of items and then claim under oath that this is acceptable from a forensic or reconstruction standpoint.

⁸ Too many people are allergic to latex, and fingerprints can be transferred through latex gloves.

Biological Material

Items of suspected biological and botanical material should not be collected into plastic or airtight containers, as these can breed bacteria and destroy the sample. They should be collected into paper packaging. Separately, and when applicable, an undisturbed or unstained sample of the surface where the material landed should also be collected. This is necessary for crime lab personnel seeking to resolve unknown or unclear results and to help identify potential contaminants. This is why it is best to collect entire objects when possible. As discussed in [Spear \(2003, p. 1\)](#):

The standard recommendation for collecting biological evidence is *not* to remove the stain from an object but rather to collect the object with the stain. The advantages of this strategy are that the entire stain is obtained, it is not necessary to collect an “unstained control” sample and there are no further manipulations required that might negatively impact the sample. If the stain is on a smooth, non-porous surface (i.e., it can be easily “flaked” off), it will be necessary to protect the stain from contact with other objects.

When collecting wet or only partially dry items, roll or wrap them first in clean paper. Then use paper bags, not plastic, for packaging as they allow the evidence to breathe. Plastic enclosures will cause condensation of moisture and promote bacterial and fungal growth. Items of evidence not completely dry should be allowed to air dry in a well-ventilated room prior to packaging when possible. Do not use a fan to move the air as it can blow dried blood, fibers, and other trace items away. It can also spread pathogens.

Never dry two people’s clothing in the same area; it is not possible to guarantee the prevention of cross-contamination under this circumstance.

When collecting dry items containing potential biological evidence, wrap the item in clean paper first and then place it inside a paper bag. In the case of biological stains on pliable surfaces (cloth, rubber, paper, etc.), it may be necessary to fold the item in some way for packaging purposes. Do not fold through visible stains, as this may damage existing biological material and hamper DNA testing efforts. And, more importantly, it can cause the cover-up of small stains or create new and modified patterns. In the case of solid objects with potential biological transfer, cover the stained area with clean paper and seal the edges down with tape to prevent loss or contamination.

In the case of immovable items or surfaces, there are three approaches: cutting, swabbing, and scraping. As discussed in [Spear \(2003\)](#), cutting is preferable (p. 1):

Some samples will need to be collected in the field. If the entire object cannot be collected then the next best way to collect biological evidence is to remove the stain by cutting it out (e.g., from a piece of carpet). Remember to use clean scissors and to cut out an “unstained” control. Scissors or tweezers can be cleaned by rinsing with clean water and then drying with tissue. Repeat this cleaning process twice prior to each sampling.

Cutting is especially important when dealing with pattern evidence, such as bloody fingerprints or bloody footwear impressions. It is preferable to preserve the entire pattern, as it was found, whenever possible.

Sometimes it is not possible to collect a stain by cutting it from an item or surface. This can include biological transfer onto items of great strength or mass, and certain types of walls, floors, or supporting structures. This leaves the remaining options of swabbing and scraping. When swabbing or scraping, it will be necessary to take unstained control samples and package them

separately (Spear, 2003, p. 2). It will also be necessary to document the stain thoroughly with photos and sketch work, as either process will destroy it and any evident patterns.

The authors do not recommend scraping, as it causes blood dust, which leads to contamination in the sensitive DNA arena. Stick to swabs, and always use a swab protector such as a SwabShield.⁹

Luminol: Limitations of Presumptive Blood Testing

Blood at the crime scene may not be immediately visible. It can be too small to see or there may have been attempts to clean it away. However, cleaning away visible blood evidence does not necessarily remove all traces of its existence. Various reagents can be used to reveal it, each suited to different conditions and requiring different levels of education and training to employ.

On that note, too many law enforcement personnel feel that they can identify blood with certainty, either by sight or by using a presumptive (nonconfirmatory) test. They assume that a stain is blood and then develop reconstruction theories based on its location and pattern. Then they collect some and submit it for laboratory analysis or they run a presumptive test and assume this gives them a definitive answer.

Luminol is among the most common blood reagent sprays, useful for visualizing and documenting weak blood-stains. However, the presence of blood must be subsequently confirmed. Luminol is presumptive only; positive results indicate only that blood might be present, as it reacts with many different things.

Consider the following scientific facts regarding luminol testing in a forensic context:

- When luminol oxidizes, it glows in a process called chemiluminescence.
- It is not the “blood” that glows in a positive luminol reaction, but rather the iron in the hemoglobin of the blood.
- Luminol oxidation has been reportedly catalyzed by the presence of certain metal ions such as variants of copper, iron, and cyanide.
- As blood dries, it turns brownish and rusty colored; Fe(2) oxidizes to Fe(3). Consequently, the older the bloodstain, the more intense the reaction with luminol.
- Luminol is extremely sensitive; studies have shown that it can detect blood in one part per million (1:1,000,000). This includes blood that may be found in urine.
- Luminol is sensitive enough to pick up minute traces of blood even when attempts have been made to wash it away with various cleaning agents such as bleach and ammonia.
- Luminol tests cannot distinguish between human blood and animal blood.
- Brass, bronze, and similar alloys containing copper can give false positives for blood when using luminol.
- Luminol is known to react with some cleaning agents, including certain bleaches, Fast Orange, The Works, Fantastic, and Babo Cleanser.
- Luminol reacts with many different kinds of fresh vegetable matter (not dried).

Scientific reconstruction cannot be based on the results of presumptive blood tests, even when multiple types of presumptive tests yield positive results. Suspected human blood must be tested for human protein as well as hemoglobin before it can be confirmed as human blood.

⁹ See www.swabshield.com.

These are laboratory tests and must be performed in the crime lab by a serologist, not in the field by a police officer or evidence technician with a kit.

Having said that, a negative luminol result can be instructive. It takes considerable effort to clean any visible bloodstain from porous surfaces such as carpet and clothing to such a degree that luminol would fail to detect evidence of its presence. Also, luminol reacts with some cleaning agents that may be used by those attempting to clean blood away. This is in no small part why [Lee, DeForest, and Gaennslen \(1983\)](#) reports that

A number of compounds have been used for the [presumptive] tests, and in particular the test is often named after the chemical compound that is used. Some of the compounds are: benzidine, phenolphthalein, leucomalachite green, ortho-tolidine, tetramethylbenzidine, ortho-dianisidine, and luminal.¹⁰ . . .

Most authorities agree that positive presumptive tests alone should not be taken to mean that blood is definitely present. A positive test suggests that the sample could be blood and indicates [the need for] confirmatory testing. On the other hand, a negative presumptive test is a reasonably certain indication that blood is absent, although in rare circumstances an inhibiting chemical could be present.

Reconstructionists must be aware of the limits of any forensic testing that they rely on in developing or eliminating their theories. With respect to identification methods, whether looking for blood, sperm, semen, or drugs, this means understanding whether they are confirmatory or presumptive, as well as their sensitivity.

Evidence Storage

Physical evidence should generally be stored in a dry, cool environment. Preferably this will be a secure evidence room or facility that has a controlled environment with limited access. The authors are aware of numerous agencies that store evidence in uncontrolled environments susceptible to heat and other damaging influences. They are also aware that some agencies store their biological samples in the same refrigerators as their staff lunches. This is not acceptable!

For the Reconstructionist

The reconstructionist must acknowledge that any evidence collected without adequate or informed collection and preservation techniques increases the risk of evidence dynamics. They must therefore review and assess the adequacy of collection and preservation efforts prior to rendering their findings. Interpretations should spell out any relevant issues clearly and highlight resulting effects (if any).

Evidence Transportation

Eventually after packaging, evidence will be transported from the scene to either a law enforcement storage facility or a crime laboratory. Transportation can change the evidence by shaking it up, knocking things loose, and moving it all around. This is true of bullets, bodies, and blood alike. Bloodstains continue to soak and transfer on clothing; trace evidence

¹⁰ Some, if not all, of these reagents are carcinogenic to one degree or another. Benzidine is extremely carcinogenic. If exposed, one should be monitored or tested on a regular basis for up to 30 years from the date of exposure.

dries up and falls off; blood purges from wounds and orifices; and there can even be continued injury and bruising.¹¹

Crime scene documentation efforts should be sufficient to compare the state of evidence collected at the scene with that under examination to note any artifacts of transportation that might interfere with an accurate reconstruction. If they are not, this may need to be noted in related findings.

VICTIMS AND SUSPECTS

In every case involving physical violence, the victim's body is an extension of the crime scene record. Any injury, or lack of injury, must be documented carefully with notes, photos, and sketches. This is a reference to the concept of negative documentation: What is not present is often just as important as what is.

In some cases, victims will need medical attention. In others, such as those involving rape or homicide, they may need to undergo a medicolegal examination. These scenarios will result in emergency room reports, autopsy reports, and/or sexual assault examination reports.

Clothing must also be documented, collected, and examined. The best practice is to remove any clothing at the crime scene, before transportation and medicolegal examinations occur, and package it in such a manner as to preserve any stains or transfer. This avoids losing or changing stain and trace evidence as the result of transport and/or body bags. The clothing should be made available to medicolegal personnel for examination as necessary, but stay in the custody of crime scene investigators.

Likewise, the suspect is also an extension of the crime scene and may require similar medical attention. In some cases, they will be injured by the victim, or injure themselves, during the attack. This will result in a corresponding emergency room report. In cases involving suspected sexual assault, victim *and* suspect examinations are part of the standard forensic protocol.¹² If suspects are still wearing the clothing associated with the crime, it should also be documented, collected, and examined.

The burden of the reconstructionist here is broad and never-ending education and training. They must become familiar with the medical and forensic examinations related to sex crimes, assaults, and homicides. They must learn to read the reports of medical forensic personnel and to understand the meaning and limitations of their findings. This will allow the reconstructionist to incorporate and account for these scientific facts in their theories of the crime.

¹¹ A well-trained forensic pathologist should be able to distinguish among postmortem, perimortem, and antemortem bruising, but many do not. It is best not to assume that this has been done unless made explicit in the autopsy report.

¹² See Chapter 16: Sexual Assault: Issues in Evidence Examination and Interpretation.

DIGITAL EVIDENCE AND CRIME RECONSTRUCTION

By Jodi Freeman

With advances in technology, the boundaries of crime scenes have been expanding to include forms of digital evidence.¹³ While cell phone records, text messages, and e-mail correspondences have all become acceptable evidence-gathering tools used in crime scene investigations, modern technological advances, such as social networking Web sites (e.g., Facebook, YouTube, MySpace), have gained enormous popularity in recent years. As these Web sites and associated technology become more a part of our lives, and the volume of shared information grows, it is becoming obvious that data posted to and extracted by the cyber-verse have tremendous and often untapped investigative value. As an extension of the physical crime scene, these threads of digital evidence have the potential to support or refute investigative theories and to provide crucial details necessary for the reconstruction of crime.

Specifically, digital evidence gained from social networking Web sites has the potential to influence the following aspects of crime reconstruction.

Timeline

Online communication and Internet postings provide a date and time stamp of online activity. This digital evidence is useful not only in determining when an individual was accessing an online Web site, but the nature of the communication may also establish an individual's behavioral timeline that may support or refute reconstructive information.

For example, photographs posted online may document the activities of a suspect (or victim) before, during, and after the commission of a crime. This may allow examiners to piece together a timeline of events. Photographs not only offer a snapshot of a specific point in time, but also provide investigatively useful information. This includes evidence of specific friends or associates and locations visited.

Victimological Information

Forensic victimology¹⁴ is an important aspect of crime reconstruction that is often overlooked. Without an understanding of the victim as a person, it is difficult to reconstruct victim behavior. Social networking Web sites may contain victimological information that provides a more complete understanding of victim risk, victim exposure, and past behavior. Victimological information that can be gained from social networking sites includes, but is not limited to, the following:

- Friends and acquaintances
- Enemies or history of conflict
- Relationship status
- History of drug/alcohol use or abuse
- Prior criminal activity
- Educational and employment history
- Locations visited routinely
- Daily schedule or routine activities

¹³ See Chapter 17: Reconstructing Digital Evidence.

¹⁴ See [Petherick and Turvey \(2009\)](#).

The level of online privacy or security set by the victim will indicate who had access to this information. Detailed victim information that is publicly available and easily searchable will ultimately influence an investigation by increasing the suspect pool drastically.

Suspect Information

Similar to victimological information, suspect information relevant to crime reconstruction can be gained from social networking Web sites. This includes photographs and online communication, posted by the suspect or others, that establishes a timeline of behavior prior to crime commission or evidences a prior association with the victim and/or the location of the crime scene. It can also provide alibi evidence.

While digital evidence may be useful to develop a reconstruction, limitations are associated with this form of evidence. Digital evidence must not be taken at face value. Without further investigation, it is insufficient to assume ownership, or that information posted online is correct or authentic, without digital alteration. Furthermore, without laws in place to govern the obtainment of information from social networking sites, a fine line is drawn between the retrieval of publicly available information and the privacy infringement of individual users.

RECONSTRUCTION

Crime reconstruction is the ultimate goal of all crime scene investigation efforts, and misunderstanding this ignores the value that physical evidence holds for every case in which it is processed. As explained in [DeForest \(2005, p. 115\)](#):

Reconstruction is the culmination of the scientific work on the physical evidence in a case. It is at this stage where the information gleaned from the examination of all the evidence is integrated and interpreted to yield an objective understanding of the event. In most jurisdictions, this activity is given insufficient scientific attention.

As explained previously, the reconstructionist should attend the crime scene if possible. However, this effort should be forensic science oriented and entirely detached from the police investigation with respect to roles and responsibilities. This approach will help preserve the reconstructionist's objectivity and avoid role strain.

If unable to respond to the scene, as is the case for most forensic scientists, the reconstructionist may still be able to visit it at a later time. It is best to do this after a thorough examination of scene documentation as well as results of any forensic analysis. Visiting the scene prior to this will waste valuable time. The more the reconstructionist knows about the crime and the evidence during such a visit, the more specific and informed questions can arise and be asked of it. Even so, the totality of the available evidence and information may or may not be sufficient to answer the questions that must be answered to adequately reconstruct one or more elements of the crime.

The authors are keenly aware that crime reconstruction is an afterthought in most police investigations—engaged primarily when there are no witnesses or after it is announced that the defense has hired an independent forensic examiner to assess some or all of the physical evidence. In most cases, even homicides, crime reconstruction simply does not happen.

This makes no sense to the authors, as the only reason to collect evidence is to examine and interpret it. In fact we have argued that the law enforcement agencies have a duty of care to ensure that this occurs. However, more and more agencies seem to be collecting and testing less and less physical evidence out of ignorance, shrinking budgets, or a combination of both. The victims, the accused, and the courts deserve much better.

CRIME SCENE ANALYSIS

As mentioned in a previous chapter, *crime scene analysis* (sometimes referred to as crime analysis) is the analytical process of interpreting the specific features of a crime and related crime scenes.¹⁵ It involves an integrated assessment of the forensic evidence, forensic victimology, and crime scene characteristics. It is an interpretive stage of crime scene investigation efforts, subsequent to crime reconstruction efforts, and provides a language for categorizing, explaining, and comparing victim and offender behavior.

The results of crime scene analysis may be used to determine the limits of the available evidence and the need for additional investigative and forensic efforts, as in a threshold assessment (discussed shortly). When sufficient behavioral evidence is available, these same results may also be used to infer offender modus operandi (MO) and signature behaviors, evidence of crime scene staging, crime scene motive, and offender characteristics, or to assist with linkage analysis efforts.

FORENSIC RELEVANCE

The relevance of crime scene investigation, and subsequent reconstruction and scene analysis, is often forgotten, ignored, or even denied in legal venues. This is problematic. The only reason for the collection of evidence is its examination and interpretation by forensic scientists. Otherwise, why bother to collect it or to submit it for forensic examinations of any kind? For that matter, why have publicly funded crime labs? The answer is that there is broad agreement by the courts, and the legal system they are meant to serve, that physical evidence has value to legal proceedings with respect to establishing scientific facts; it can aid the trier of fact in their resolution of issues or events that may be disputed.

This includes the following.¹⁶

Corpus Delicti

The **corpus delicti**, literally translated as the “body of the crime,” refers to those essential facts that show a crime has taken place. Without the corpus delicti there is no evidence of a crime, and there can be no criminal proceedings.

¹⁵ See Chapter 5: Practice Standards for the Reconstruction of Crime.

¹⁶ Adapted from [Turvey \(2011\)](#).

To establish the crime of burglary, for instance, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- Tool marks and fingerprints at the point of entry
- Broken doors or windows
- Direction of the broken glass (inside or outside) to establish an element of scene staging
- Glass in the burglar's shoes and pants from broken glass at the scene
- Ransacked rooms
- Missing valuables
- Footwear impressions on the ground outside of the residence at the point of entry

To establish a rape or sexual assault, however, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- The victim's blood at the crime scene
- The rapist's semen/sperm in the victim's orifices
- A weapon with transfer evidence of some kind
- Wound patterns on the victim
- Torn pieces of victim clothing
- Fibers from ligatures used by the rapist to bind the victim
- Hair/fibers from the victim in the rapist's vehicle
- The rapist's pubic hair on the victim or vice versa

While none of the aforementioned proves that sexual assault must have occurred, they may be used to disprove the suspect's story or find conflicts in the story from the victim. They are given weight in court to support the victim's testimony or the people's case.

Modus Operandi

All criminals have a **modus operandi** (method of operation) that consists of their habits, techniques, and peculiarities of behavior. Sometimes this MO is somewhat consistent, but often it grows and changes over time as the offender becomes more skillful, including what has been successful, excluding what has been unsuccessful (O'Hara, 1970). Physical evidence can help establish that MO.

To establish the MO in the crime of burglary, for instance, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- Tools used to gain entry (screwdriver, hacksaw, keys to the front door, etc.)
- Types of items taken (valuables versus impulse items, cash, jewelry, credit cards, sports memorabilia, clothing, etc.)
- Lack of fingerprints at the point of entry, suggesting a gloved offender

To establish the MO in the crime of rape, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- Types of restraints used on the victim, from fiber and wound pattern evidence, if any
- Tire marks nearby, suggesting the type of vehicle used, if any
- Wound patterns on the victim indicating a type of weapon used (i.e., incision marks from a knife or bite marks on the victim's back)
- Tape found on the victim's person used to cover the eyes or the mouth

Signature Behavior

Some criminals commit actions in the crime scene that may be referred to as **signature behaviors**. As described in *California v. Odell Clarence Haston (1968)*:

Professor McCormick states: "Here [i.e., in the matter of proving identity by means of other-offenses modus operandi evidence] much more is demanded than the mere repeated commission of crimes of the same class, such as repeated burglaries or thefts. The device used must be so unusual and distinctive as to be like a signature" (McCormick, Evidence [1954] 157, p. 328).

McCormick is cited again on the subject of signature behaviors in *California v. Rhonda Denise Erving (1998)*, stating that they must be:

Sufficiently distinctive so as to support the inference that the same person committed both acts. The pattern and characteristics of the crimes must be so unusual and distinctive as to be like a signature (McCormick [on Evidence (4th ed., 1992)], § 190, pp. 801–803).

Signature behaviors establish the theme of the crime; they are committed to satisfy psychological and emotional needs. Physical evidence can be used to help establish signature behaviors and their context.

To establish signature behaviors in the crime of burglary, for instance, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- Slashing clothing in closets
- Ejaculating, urinating, or defecating in specific locations
- Stealing female undergarments
- Destroying furniture
- Vandalizing vehicles in the garage

To establish signature behaviors in the crime of rape, a forensic analysis of the crime scene for physical evidence could include searching for items of evidence such as, but not limited to, the following:

- Type of ligature used
- Specific sequences of sexual acts
- Level of injury to the victim (from minimal to brutal)
- Specific type of weapon used
- Personal items taken from the victim not related to theft, such as identification, clothing, or inexpensive jewelry

Linking the Suspect to the Victim

Blood, tissue, hair, fibers, and cosmetics may be transferred from a victim to an offender. Furthermore, items found in the possession of the suspect can be linked back to the victim. Examples include the following:

- The victim's vaginal epithelial cells dried onto an offender's penis or clothing
- The victim's skin cells and hairs on a piece of rope in an offender's vehicle
- The victim's blood on an offender's knife
- The victim's artificial nails broken off during a struggle and left in an offender's vehicle

It is also possible that trace evidence can be transferred from a perpetrator onto a victim. The suspect's belongings and clothing should be examined thoroughly for this type of trace evidence. Victims and their belongings, of course, should be similarly examined.

Linking a Person to a Crime Scene

This linkage is a common and significant one provided by physical evidence analysis. Fingerprints and glove prints, blood, semen, hairs, fibers, soil, bullets, cartridge cases, tool marks, footprints or shoe prints, tire tracks, and objects that belonged to the criminal are examples of deposited evidence (Lee, 1994). Depending on the type of crime, various kinds of evidence from the scene may be carried away. Stolen property is the most obvious example, but two-way transfers of trace evidence can be used to link a suspect, a victim, or even a witness to a crime scene.

Disproving or Supporting Witness Testimony

While consideration of witness and victim statements is necessary, physical evidence is considered a more objective and reliable source of information regarding offense activity. More to the point, the forensic examiner has a duty to compare any statement regarding crime-related events against the physical evidence to test its veracity, when possible. Although an established pillar of courtroom proceedings, witness testimony has a terrible capacity for unreliability, as discussed in Miller (2008, p. 143):

The use of eyewitnesses in criminal investigations and courtroom testimony has been well established in the United States (Becker, 2000). Their usefulness for the gathering of information is often the first step in any criminal investigation when looking for who, what, when, where, and even the how and why of a crime. Their reliability, however, is often called into question (Lyman, 2008). The Innocence Project has estimated that almost 75% of the over 200 wrongful convictions in the United States have been due to mistaken identification by eyewitnesses (Innocence Project, n.d.). . . .

Physical evidence found at any crime scene can be used to corroborate the statements of witnesses, to assist investigators in determining the credibility of eyewitnesses, and to assist in the reconstruction of the events leading to the crime including the way in which the crime itself was committed (Gaensslen, Harris, & Lee, 2008).

Physical evidence analysis can indicate conclusively whether a witness's version of events is credible or whether they are in error or even being deceptive. A simple example would be a driver whose car matches the description of a hit-and-run vehicle. An examination of the car may reveal blood and other tissue on the underside of the bumper. The driver may explain

the findings by claiming to have hit a dog. A simple species test on the blood could reveal whether the blood was from a human, dog, or some other animal. If found to be human blood, a DNA test can be used to confirm the identity of its source.

Identification of Suspects

The most conclusive evidence for individuating and identifying a suspect includes fingerprints, bite-mark evidence, and some kinds of DNA. A fingerprint found at a scene or on a victim's skin or possessions and later identified as belonging to a particular person results in an unequivocal identification and individualization of that person.

In rape/sexual assault cases, DNA can be used to make identifications from the following sources (not by any means an exclusive list):

- Sperm left behind at the scene or on the victim
- Epithelial cells left behind with urine collected from the toilet
- Blood left behind at the scene from injuries inflicted by the victim
- Tissue collected beneath the victim's fingernails during defensive activity
- Pubic hair left behind at the scene or on the victim

In rape/sexual assault cases, bite-mark evidence can sometimes be used to make identifications from the following sources (not by any means an exclusive list):

- Bite marks inflicted on the victim's back during the victim's struggle to make the victim compliant
- Bite marks made to victim's genital areas as part of the sexual attack
- Bite marks made to the victim's face and extremities as a part of punishment (child abuse)

Providing Investigative Leads

Physical evidence analysis can be helpful in directing an investigation along a productive path. In a hit-and-run case, for example, a chip of paint from the vehicle can be used to narrow down the numbers and kinds of different cars that may have been involved. In a rape/sexual assault case, DNA evidence can be used to quickly exclude suspects as they are generated. And in a homicide, fingerprints found on a weapon can establish association with a suspect.

SUMMARY

Crime scene investigation refers to the process of establishing the scientific facts of a case using physical evidence that has been gathered in relation to suspected criminal activity. Crime scene investigation does not occur only within the confines of yellow barrier tape under the watchful eye of law enforcement officers and investigators, it is a broad inquiry that seeks to establish the record of physical evidence during an event or a series of related events. It is ultimately the unified result of aggregated crime scene examination and processing efforts; forensic laboratory examinations and analyses; medicolegal examinations and analyses; and collateral victim-suspect history.

One of the most important considerations of crime scene investigation, reconstruction, and analysis is determining what type of crime scene we are presented with. A *crime scene* is defined as any area where a crime has taken place. Crime scene types include the following: *primary crime scene*, *secondary crime scene*, *intermediate crime scene*, *tertiary crime scene*, and *dumpsite*. Failure to accurately determine the crime scene type, or to ask this question at all, can therefore result in the loss of physical evidence. In cases involving physical violence, both the victim's body and the suspect may be considered an extension of the crime scene.

Crime scene analysis should not be confused with *crime scene processing*, the function of recognizing, documenting, collecting, preserving, and transporting physical evidence. Crime scene processing duties include locating and protecting physical evidence without damaging it, without causing potentially misleading transfers, and without adding artifact evidence to the scene. Technicians are expected to document and preserve, as much as possible, any evidence found at the crime scene and any evidentiary relationships observed. They are also expected to collect and package the evidence in a manner that preserves it for subsequent transportation, analysis, and interpretation. Unfortunately, it is commonly believed, and generally practiced, that new personnel can and should learn scene-processing duties on the job from other police officers, all with little or no scientific background. Also, because many in law enforcement perceive that crime scene processing is a simple task that anyone can learn and perform by rote, literally anyone is doing so. Given this state of affairs, the need for an objective forensic scientist at the crime scene should be apparent.

The goal of crime scene investigation is to provide for scientific *crime reconstruction* and *crime scene analysis* efforts. A competent reconstruction of the crime is not possible until all physical evidence from the scene has been collected, examined, and identified. In terms of evidence we can see, there are three kinds of evidence in a crime scene: macroscopic, latent, and microscopic. Evidence documentation must also take place once an item of evidence has been recognized and before collection efforts begin. The principal means of crime scene documentation include note taking, photography, videography, measuring, and sketching. Once an item of evidence has been documented thoroughly, it may be collected and preserved for examination and testing. Eventually, and after packaging, evidence will be transported from the scene to either a law enforcement storage facility or a crime laboratory.

Crime scene analysis is the analytical process of interpreting the specific features of a crime and related crime scenes. It involves an integrated assessment of the forensic evidence, forensic victimology, and crime scene characteristics. It is an interpretive stage of crime scene investigation efforts, subsequent to crime reconstruction efforts, and provides a language for categorizing, explaining, and comparing victim and offender behavior. When sufficient behavioral evidence is available, results of a crime scene analysis may be used to infer offender modus operandi and signature behaviors, evidence of crime scene staging, crime scene motive, and offender characteristics, or to assist with linkage analysis efforts.

QUESTIONS

1. Explain the difference between a *primary crime scene* and a *disposal site*.
2. Provide two reasons why there is a need for an objective forensic scientist at the crime scene.
3. List three means of crime scene documentation.

4. Explain two issues associated with evidence collection and preservation.
5. Explain the difference between *macroscopic evidence*, *latent evidence*, and *microscopic evidence*.

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Methods of Crime Reconstruction

W. Jerry Chisum and Brent E. Turvey

To know that you do not know is the best. To pretend to know when you do not know is a disease. —*Lao-Tzu, Chinese philosopher (604–531 BC)*

Key Terms

Action evidence; Associative evidence; Behavioral evidence; Behavioral evidence analysis; Contact evidence; Crime scene analysis (or crime analysis); Directional evidence; Equivocal forensic analysis; Forensic victimology; Historian reconstructionist; Inferred evidence; Limiting evidence; Locational (or positional evidence); Mind mapping; Ownership evidence; Psychological evidence (or motivational evidence); Reenactment; Role-playing; Scientist reconstructionist; Sequential evidence; Temporal evidence; Truth table (or veracity table); Vanity reconstruction

Crime reconstruction requires the ability to put together a puzzle using pieces of unknown dimensions without a guiding picture. The first logical question is only this: How? It is a question that should occur to everyone and should be asked frequently of any reconstructionist. The answer is not always apparent from the results. More accurately, the answer is not always forthcoming when asked. This is in no small part because competent and proficient reconstruction comes to some forensic scientists with ease, to some with difficulty, and to others not at all.

There are several different approaches to the problem of reconstruction. However, the specific approach used by the reconstructionist is not the entire answer to the question. There is consideration of ethics, bias, practice standards, the crime scene investigation, evidence dynamics, and other issues that inhabit the pages of this text. Each shapes and influences the methods used and the inferences made. The purpose of this chapter is to describe some of the more successful conceptual approaches to crime reconstruction and, ultimately, provide more organization to the reconstructionist's toolbox.

CRIME RECONSTRUCTION AND EXPERIENCE

The most common method of crime reconstruction is to base interpretations on experience. Dr. [Hans Gross \(1924\)](#) emphasized the importance of learning from experience in the late 19th century. He wrote that the scientific investigator must take pains to learn from everything he observes, not only in his work but also in his daily life. And question everything; question why something has happened, or what has caused it to happen—then investigate.

The reconstructionist, Gross posited, must learn to see effects from causes and then reverse the process and establish causes from the effects. When similar events occur at a later time, the reconstructionist should then be able to extrapolate what has been learned about effects and infer the potential causes responsible. The learning and the discipline urged by Gross should make it clear that he was not advocating the value of raw and uneducated experience but, rather, experience tempered with extensive learning and what he referred to as an “encyclopaedic knowledge.”

As this suggests, experience is not unimportant, but it can lead the naïve, ignorant, or inept reconstructionist astray when taken in isolation. Regardless of the quality of our experiences, and our capacity to learn from them, they prepare us to make inferences about the possible causes of the effects we see. But only when we seek to learn from them. Consequently, the use of one’s experience as a knowledge base for developing reconstruction hypotheses and theories, or for inferring the cause from an examination of the effects, is commonplace. However, not all experience is equal, not all experience is sufficiently instructive, and not everyone learns from experience.

For these same reasons, it is also unacceptable to argue “in my experience” as a sole premise to explain how and why an event must have occurred. Any inference regarding an action or event must be supported by factual details submitted to thoughtful analysis and rigorous logic. Reconstructionists will also prepare citations from the published literature in support of their interpretations when necessary, as they may be asked for the basis of their knowledge in court. Purely “experience-based reconstructionists” may give examples of their conclusions to demonstrate how they reconstruct, but often will not be able to show the logic and science behind their methods. They will also be unable to cite the literature in support of their findings. The absence of such “long division” in a work product is in effect an absence of science.

Perhaps one of the more valuable discussions of this issue can be found in the writings of Dr. [John Thornton \(1997, p. 17\)](#)¹:

Virtually everyone agrees that an expert’s bare opinion, unsupported by factual evidence, should be inadmissible in a court of law. And yet, precisely that sort of testimony is allowed every day in courts throughout the country by judges who believe that every statement uttered by a person with a scientific degree or employed by an agent, called “scientific” is therefore a scientific opinion. Courts permit expert testimony from those with specialized knowledge. But how is a court to gauge such knowledge? The answer generally lies in the education and experience of the prospective witness. A convenient means is to look for a measure of scientific education, and a university degree in a scientific discipline will ordinarily meet that test.

With an educational requirement satisfied, a court will then look at experience. But experience is very difficult to evaluate. The more experience the better, but rarely is there any effort exerted to distinguish between 10 years of experience and 1 month of experience repeated 120 times, or 1 month of experience spread out over 10 years. Furthermore, some experts exploit situations where intuition or mere suspicions can be voiced under the guise of experience. When an expert testifies to an opinion, and bases that opinion on “years of experience,” the practical

¹ See Chapter 3: Crime Reconstruction: Ethos and Ethics and Chapter 10: Trace Evidence in Crime Reconstruction.

result is that the witness is immunized against effective cross-examination. When the witness testifies that “I have never seen another similar instance in my 26 years of experience . . .,” no real scrutiny of the opinion is possible. No practical means exists for the questioner to delve into the extent and quality of that experience. Many witnesses have learned to invoke experience as a means of circumventing the responsibility of supporting an opinion with hard facts. For the witness, it eases cross-examination. But it also removes the scientific basis for the opinion. . . . s

Testimony of this sort distances the witness from science and the scientific method. And if the science is removed from the witness, then that witness has no legitimate role to play in the courtroom, and no business being there. *If there is no science, there can be no forensic science.*

Experience is neither a liability nor an enemy of the truth; it is a valuable commodity, but it should not be used as a mask to deflect legitimate scientific scrutiny, the sort of scrutiny that customarily is leveled at scientific evidence of all sorts. To do so is professionally bankrupt and devoid of scientific legitimacy, and courts would do well to disallow testimony of this sort. Experience ought to be used to enable the expert to remember the when and the how, why, who, and what. Experience should not make the expert less responsible, but rather more responsible for justifying an opinion with defensible scientific facts.

Failure to appreciate the limitations of bare experience untempered by analytical logic, critical thinking, and the scientific method can lead some analysts to wrongly believe that they should learn and be able to conclusively “read” the events that have transpired in a crime scene simply by standing in it and looking around. It may further confuse some analysts into believing that scientific examinations and scientific inquiry are an impractical investigative burden, as opposed to a necessary form of theory validation or exclusion. This kind of **vanity reconstruction**, based on presumed expertise from years of experience performing various tasks, is simply that—vanity substituting for scientific inquiry. Courts that allow any form of reconstruction testimony to proceed along these lines contribute mightily to stalling the development of crime reconstruction as a scientific discipline. They must demand more of their witnesses.

REASON, METHODS, AND CONFIDENCE

Here is my lens. You know my methods. What can you gather yourself . . . ? –Sir *Arthur Conan Doyle* (1892)

Stuart Kind (1986) suggests that there are two kinds of reconstructionists—the **scientist** and the **historian**. He defines the historian as the intuitive reconstructionist who, based on his experience, will see the overall picture and form a theory of what happened. On the other side of the reconstruction coin is the *scientist*, who will see the pieces and traces of events and arrange them carefully into a whole. The historian will look at a crime scene and describe what happened, and then he or she will search for the details that prove that “theory.” The scientist will look at the details and piece them together until he or she has the overall scene reconstruction. Either way, the methodology used must be fully understood by the reconstructionist and be explained easily to a jury. Therefore, it must be premised on clear logic and relate to what is known by people without the benefit of investigative scientific knowledge.²

² One of the authors (Chisum) was asked on the witness stand about the clotted blood on the suspect’s clothing. Could it have been from rinsing the knife used by the other defendant? He replied, “No, as any parent knows who has rinsed a child’s cut under the faucet. The bloodstains that might splash back on the clothing are very different in nature from these stains.” The jurors nodded their heads; they could relate to a cut being rinsed.

More important is that all of the evidence encountered must either support or fail to nullify the reconstructionist's final conclusions. This cannot be emphasized enough. The interpretation of an individual item of evidence must be consistent with the other known items. If it is inconsistent, then that interpretation must be eliminated as a possible explanation for the events. Simple theories are useless when they are not supported or outright contradicted by the facts.

As detailed in Chapter 5: Practice Standards for the Reconstruction of Crime, the reconstructionist must be capable of critical thinking.³ That is, the reconstructionist must have the ability to discern fact from speculation, must be able to postulate or theorize alternative solutions for events, must be able to connect facts together, and must further make informed judgments about what questions are important to ask of the evidence in the case at hand.

The process may be regarded as something like this:

1. Observe the evidence of events and related clues.
2. Determine what might be learned of events from each observation.
3. Postulate what the clue or observation means in light of the crime.
4. Propose alternative explanations for events.
5. Eliminate alternatives with analytical logic, critical thinking, and experimentation.
6. Sequence established events until the evidence is exhausted to reveal the most complete picture

Put this way, it seems deceptively simple.

Sir Arthur Conan Doyle, through his fictional characters Sherlock Holmes and Dr. John Watson, showed how one could derive information regarding events from close observation and attention to detail. He claimed it was a form of deductive logic. Although no offense is meant to Doyle, it is relatively easy to use deductive logic when you can contrive the facts to fit a single theory of "whodunit" in a fictional story. The use of deduction in actual casework, in which multiple theories may explain known events, is much more difficult.

Henry Rhodes

In 1933, [Henry T. F. Rhodes](#) described a case from 1817 England and proposed how "modern criminal investigation" could have solved the crime (p. 54):

Nothing more is really claimed for the reconstruction quoted here than that it illustrates how scientific methods can be linked to the reconstruction of a crime real or supposed. It illustrates too the elementary process indicated by Sherlock Holmes—when you have eliminated all the impossible solutions then the solution or one of the solutions remaining, however apparently improbable, must be the right one.

He wrote of his approach (p. 58):

It is merely a question of fitting the known parts together and endeavoring to fill in the missing parts as far as possible and is so far as those unknowns are directly and inevitably deducible from the known. This is a

³ Critical thinking is a purposeful, reflective, and goal-directed activity that aims to make judgments based on evidence rather than conjecture. It is based on the principles of science and the scientific method. Critical thinking is a reasoned, interactive process that requires the development of strategies that maximize human potential (Old Dominion University, School of Nursing faculty minutes, 1997).

scientific conception. Neither in mathematics nor chemistry, nor criminal investigation is it always necessary to establish all the facts independently. If it is given that $x + y = 2$ it cannot be said that we know everything about x and y , but we can demonstrate as a matter of certain fact that $x + y - 2 = 0$.

That is the object of this kind of reconstruction. If certain facts are definitely established it may well and generally be true that certain conclusions are inevitably deducible from them. There are even circumstances in which a picture of the affair, accurate in all essentials, can be reconstructed from comparatively few facts.

Rhodes claimed that the reconstruction of events should become obvious using his method. His explanations for events, however, are really more of a reductive justification of his theories. This is because life and events are not always susceptible to explanation through an equally balanced equation. One event can have multiple causes, and even with the best evidence it is not always possible to distinguish which of those actually happened.

Edward Oscar Heinrich

Perhaps Edward Oscar Heinrich, the famous “Wizard of Berkeley,” was familiar with the work of Rhodes. He practiced crime reconstruction in the 1930s and 1940s. He consulted on cases throughout the world and was sought after for his ability to identify clues, put them together, and explain events through discrete forensic evidence with great clarity. He described his methods to the press after working a missing person case in San Francisco (as quoted in [Block, 1958, pp. 42–44](#)):

Crime analysis is an orderly procedure, it's precise and it follows always the same questions that I ask myself. Let's consider what they are:

Precisely *what* happened? Precisely *when* did it happen? Precisely *where* did it happen? *Why* did it happen? *Who* did it?

The average investigator seems to give immediate attention to the *why* and *who* but he takes what happened for granted We simply must analyze the method of the crime before we can analyze its purpose and look for the criminal

It's like a mosaic, and every fact must be evaluated before it can be fitted into the pattern. In that way, every fact as it is developed and equated becomes a clue. . . .

One clue always is present after the commission of a crime. That one is the criminal's method. Every person in his every act in daily life leaves some impress of his method of procedure. So the criminal. Although he aims to keep his character and his identity a secret, yet the mechanism of the crime, that is, precisely how it was committed, exposes his knowledge, his skill, and his habit. Among these, typical, symptomatic actions appear that limit an investigation to a particular individual or to a small group. . . .

In the test tube and crucible or through the lens of the microscope and camera I have found in my own practice the evidence of poison, the traces of the deadly bullet, the identity of a clot, the source of a fiber, the telltale fingerprint, the differing ink, the flaw in the typewriter, the slip of the pen upon which have turned in dramatic scenes of our courts the rightful title to an estate, of the liberty, even the life, of an individual. . . .

This work of mine—it is not mysterious. It is a matter of understanding the scientific aspects of ordinary phenomena. Rarely are other than ordinary phenomena involved in the commission of a crime. One is confronted with scrambled effects, all parts of which separately are attributable to causes. The tracing of the relationship between isolated points of fact, the completion of the chain of circumstances between cause and effect, are the highest functions of reason—to which must be added the creative imagination of the scientist.

As this passage demonstrates, Heinrich used more than just scientific laboratory analysis in his investigations. He employed the natural sciences to establish facts, develop reconstruction theories, and solve cases. But he also combined this with an early form of criminal profiling

as well. He understood, like Gross before him, that the more one understood of the criminal's actions, the more one understood of the crime.

Both Heinrich and Gross argued that the physical evidence could tell a great deal about possible suspect characteristics and narrow the investigative field of suspects to a more manageable level.

Charles O'Hara

Charles O'Hara was a New York City police detective who turned to writing textbooks out of sincere frustration regarding both the lack of objectivity and the lack of basic investigative knowledge among his contemporaries. In 1956, he wrote *Fundamentals of Criminal Investigation*, which was adopted for use in both police academies and colleges throughout the United States. In that text, he states (p. 55):

Subsequent to the search of the scene of the crime an effort should be made to determine from the appearance of the place and its objects what occurred and, particularly, what were the movements and methods of the criminal, since this latter constitutes part of the modus operandi. The process of ascertaining the circumstances of a crime is known as reconstructing the crime. . . . From a study of the evidence in this manner it is often possible to make useful inferences which may be synthesized into a reasonable theory.

O'Hara goes on to describe what he calls *physical reconstruction* as the reconstruction of the physical appearance of the scene, involving both evidence and any available witnesses as participants. This is separate from *mental reconstruction*, in which the investigator tests his theory for logic and consistency. He cautions (p. 56):

No assumptions should be made concerning actions which are not supported by evidence. The theory finally developed by the investigator should provide a line of investigative action but should not be stubbornly pursued in the face of newly discovered facts which are not consistent with it.

O'Hara has given his method as observation, hypothesis, and testing against the evidence—this is a crude form of the scientific method. This is also the same basic process suggested by Conan Doyle. O'Hara does not, however, try to explain how reconstructionists should develop, formulate, or falsify hypotheses.

Chisum and Rynearson

In 1983, Joe Rynearson and W. Jerry Chisum published the first edition of their text, *Evidence and Crime Scene Reconstruction*, for a course they had been teaching on the subject since 1976. Rynearson has continued to update the text periodically. One of the primary changes in each edition has been the treatment of how reconstruction is actually performed. Early efforts were primarily case oriented, showing examples and hoping the students could understand the process. The text discussed the "Sherlockian" philosophy of finding and eliminating alternatives. Then it explained the logic used by putting it into flowcharts. It further discussed the roles that evidence plays in reconstruction as a classification scheme. This scheme is discussed later because it is the basis for understanding reconstruction. It was introduced at several forensic science professional meetings and conferences throughout the late 1970s and early 1980s.

Subsequent to the Chisum and Rynearson text, other reconstructionist practitioners began to write about what they thought the process of crime reconstruction should involve. For example, Jerry Findley and Craig Hopkins wrote an overview of reconstruction in 1984. [Chisum and Rynearson \(1983\)](#) describe it as (pp. 3–4)

the process of applying logic, training, experience, and scientific principles to:

- (1) The crime scene itself (i.e., location, environment, condition, etc.)
- (2) Physical evidence found at a crime scene.
- (3) The results of examinations of physical evidence by qualified experts.
- (4) Information obtained from all other sources in order to form opinions relative to the sequence of events occurring before, during, and after the criminal act.

In essence, reconstruction is the sum total of the investigation demonstrated in its tangible form.

[Findley and Hopkins \(1984\)](#) discuss the degrees of certainty on a scale of 1 to 10, with 1 being mere speculation and 10 absolute certainty. They suggest that the larger the information base, and the better the information, the closer the reconstructionist can be to a 10; however, reconstructions will usually fall short of this ideal goal.

They also enumerate the concepts that they explain ([Findley and Hopkins, 1984, p. 12](#)): “There are 5 sources of information, 5 tests of a witness’ story, 2 types of reconstruction, 7 requirements and 3 goals of a reconstruction.” They further stress caution in reconstructions, stating, “The investigator must not try to reconstruct with insufficient or unreliable information or jump to a conclusion before all the data is available” (p. 15). We have a great deal of enthusiasm for this specific sentiment, which is in accordance with our previously rendered practice standards.

However, we reserve a measure of respect for the practice of assigning a specific numeric value to the confidence of what is ultimately an opinion. Numeric values look a lot like math, and many consider math among the purest of the natural sciences. This and similar practices may have the unintended (or perhaps intended) consequence of making opinions look more certain or reliable than they actually are without the burden of showing any underlying work. This is due to the fact that there is no established means of consistently assigning numeric value to reconstruction certainty—such an assignment is a function of the reconstructionist’s subjective judgment and experience, not a function of any particular mathematics. Assigning a numeric value, or even a statistical probability, to reconstruction certainty is ultimately misleading.

In reality, the known evidence in a case does one of the following:

- Supports a reconstruction theory
- Does not support a reconstruction theory
- Refutes a reconstruction theory
- Is inconclusive

Consequently, of any theory, a reconstructionist may say only that it is

- A. Supported by/consistent with the physical evidence and known circumstances.
This is used for describing results that favor a particular theory or explanation of events.
- B. Inconsistent with/eliminated/disproved by the physical evidence and known circumstances.
This is used for describing results that show the facts are out of alignment with a particular theory or explanation of events.

- C. Inconclusive or not disproved/not eliminated by the physical evidence and known circumstances. This is used for addressing alternatives that remain untested or examinations that result in inconclusive findings.

Event Analysis

Tom Bevel and Ross M. Gardner initially wrote separate articles regarding the technique they use to perform crime reconstruction. They advocate the methods espoused by the military, based on naval research. They have since published these in *Bloodstain Pattern Analysis, with an Introduction to Crime Scene Reconstruction*, 3rd ed. (2008), which has been updated every few years. In this text, they describe what is referred to as *event analysis*. They state (p. 20), "Reconstruction is the end purpose of analysis; it requires not only the consideration of the events identified, but whenever possible the sequence of those events." Bevel and Gardner delineate event analysis as follows:

- Collect data.
- Establish specific event segments (time snapshots).
- Establish which event segments are related to one another.
- Sequence these event segments, establishing a flow for that event.
- Consider all possible sequences, auditing the evidence when necessary to resolve contradictions.⁴
- Based on the event segment sequence, final order the events themselves.
- Flowchart the entire incident and validate the sequence.

One caution that is made by Bevel and Gardner is that there is no way to be certain of one's conclusions regarding a reconstruction. The analysis may be logical and based on scientific facts, but, like the conclusions of an archeologist, there is no true standard to which we can compare our results.

This is certainly true, and it is perhaps one of the greatest limits of crime reconstruction. There are always unknowns with regard to the evidence—holes in the sequence of known events, or gaps of time, that cannot be filled. The physical evidence provides a record, but it is ultimately limited to itself. For instance, we may be able to say a person is in a certain location at one time, then in a different location at another time. However, it may be impossible to determine the precise route taken from one place to another, the time elapsed, or the manner of travel.⁵

"Multilinear events sequencing" (MES) methodology is more complicated than Bevel and Gardner have proposed. For a full description of the methodology, see the self-help manual by Ludwig Benner, Jr., the founder of MES methodology (Internet address: <http://www.starlinesw.com/product/Guides/MESGuide00.html>).

⁴ Does this mean you eliminate evidence if it doesn't fit the theory? That is not a scientific approach.

⁵ This is why computer-generated animations of crime events are more prejudicial than helpful. One cannot generally know the details presented in such recreations with the precision suggested. What such animations present are usually but one set of possibilities, not the only possibility.

Barriers to a Full Reconstruction

In most cases, there is no undisputed record of the total event that we can consult to ascertain whether our conclusions are valid. We have only our science, or logic, and our reasoning to guide us through the evidence so that we may explain its strengths and limits to others. Ultimately, what cannot be shown, demonstrated, or proved with the evidence is just as important as what can.

Apart from an incomplete record in the evidence, another barrier to full reconstruction is complexity combined with enormity: the amount of evidence and the sequence of events may simply be too overwhelming for the examiner to grasp. To combat the mental fatigue that this reality can cause, we take a somewhat different approach. We consider the physical evidence based on its role in the crime. We further break down the crime into segments, as will be explained later. This sectioned approach makes complex fact and evidence patterns more manageable, and ultimately allows for a more informed and comprehensive reconstruction.

THE ROLE OF EVIDENCE: RECONSTRUCTION CLASSIFICATIONS

Information can only be received where there is doubt; and doubt implies the existence of alternatives—where choice, selection and discrimination is called for. —*Colin Cherry (1914–1979)*

The essence of analysis is the breaking down of complex problems and information into their component parts. In crime reconstruction, information exists in the form of physical evidence, and the complex problem to resolve is what happened during the commission of the crime.

Crime reconstruction requires that evidence be broken down and examined in a different mode, and with a different goal, than may be familiar to many forensic specialists. Most classification schemes that describe forensic evidence are based on the type of analysis being performed, the section of the laboratory involved (e.g., trace evidence, biological evidence, serological evidence, drugs, firearms, toxicology), or even the type of crime that produced it. These classifications may assist with the process of triaging evidence as it comes into the crime lab, and perhaps even shed some small amount of light on its context. In crime reconstruction, however, these classifications are not very informative.

The reconstructionist needs to consider evidence with regard to the role it plays in the crime and what it can establish regarding the events that have taken place. The following evidence classification provides basic types of evidence in terms of the fundamental “who,” “what,” “when,” “where,” “how,” and sometimes “why” questions that are the focus of crime reconstruction:

1. Sequential
2. Directional
3. Locational
4. Action
5. Contact
6. Ownership
7. Associative

8. Limiting
9. Inferential
10. Temporal
11. Psychological

It should be noted that one piece of evidence may and likely will fit into more than one of these categories in any given case.

Sequential evidence is anything that establishes or helps establish when an event occurred or the order in which two or more events occurred.

Examples:

- A footprint over a tire track shows that an individual person was present subsequent to the vehicle passing.
- Blood found under the glass from a broken window at a burglary/murder establishes that the window was broken after the blood was deposited. This may call witness statements into question and begin to suggest the possibility of staging (this phenomenon is discussed in Chapter 12: Reconstruction Using Bloodstain Evidence).
- Radial fracture patterns in plate glass from multiple gunshots used to establish the firing sequence.

Directional evidence is anything that shows where something is going or where it came from.

Examples:

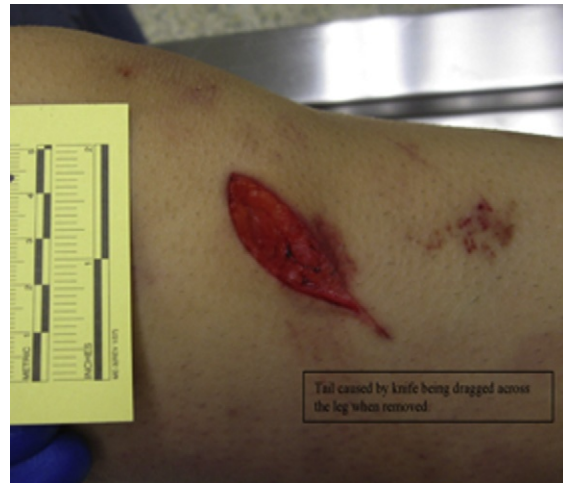
- Footprints may be used to help indicate potential direction of travel.
- Projectile trajectory analysis can help establish the origin and direction of bullets, spears, arrows, and other missile weapons.
- Bloodstain pattern analysis can be used to determine the direction of blood that is dripped, cast, smeared, spattered, wiped, or swiped.
- Wound pattern analysis can be used to determine the direction of abrasions and other injuries to the skin via an examination of piled epithelium; the epithelium piles in the direction of the object traveling across the skin that created the abrasion; or the direction of a knife by the tail at the end of the incision (Figure 8.1).

Locational/positional evidence is that which shows where something happened, or where something was, and its orientation with respect to other objects at the location.

Examples:

- A single fingerprint inside the passenger window could indicate that a particular person was inside a vehicle at some point. However, if the fingerprint is pointed down and at the top of a window that rolls down, it may only mean that the person reached inside the glass to speak to the driver.
- The orientation of a tool mark on a door or window may indicate a potential point of entry into a scene and subsequently suggest the need to look for other transfer evidence from the offender at that location.
- Bloodstains or spatters can indicate where a victim was injured or where the victim, offender, or even bystanders may have been standing, sitting, or lying. They can also be used to help determine where intermediate objects may have been located by virtue of void patterns.

FIGURE 8.1 This stab wound to the leg shows a tail at the bottom. This is due to the knife being pulled out of the wound and across the leg. This may be caused by the perpetrator or by the victim twisting or pulling the leg away from the knife.



- Livor mortis is the settling of the blood in the lower (dependent) portion of the body, causing a purplish-red discoloration of the skin. When the heart is no longer beating, red blood cells sink in accordance with gravity into the tissue. This discoloration does not occur in the areas of the body that are in contact with the ground or another object because the capillaries are compressed. Livor mortis becomes fixed after roughly 10 hours and may be used to determine whether or not a body has been moved subsequent to this if inconsistent with the victim's final resting position.
- Indentations in a carpet show where a chair was normally sitting and can indicate that it was moved.
- A pile of cigarette butts in one location can show the location of someone lying in wait.

Action evidence is anything that defines anything that happened during the commission of the crime. This may seem a basic issue, but it is crucial when establishing the elements of a crime as required by law. Misinterpretation of action evidence at any point during the reconstruction can provide for criminal charges brought against an innocent defendant and failure to charge a guilty party with the totality of the crimes that have been committed.

Examples:

- Bloodstains and patterns indicate an injury to the offender or a victim or that a blood source was moved rapidly, resulting in cast-off patterns.
- Gunshot wounds, bullet holes, and cartridge casings indicate that a firearm was discharged.
- Sharp force injury indicates that a sharp force weapon was used (knife, sword, razor, box-cutter, etc.).
- A broken window with glass on the floor next to the door lock indicates that the window was broken to gain entry (of course, this can be staged as well).

Contact evidence is something that demonstrates whether and how two persons, objects, or locations were at one point associated with each other (the importance of contact and association is discussed more thoroughly in Chapter 10: Trace Evidence in Crime Reconstruction).

Examples:

- Trace evidence such as hairs, fibers, soil, and glass may be used to suggest an association among persons, objects, and locations.
- A fingerprint on a glass can be used to indicate that a particular person was holding it at one point.
- The victim's blood on the soles of the suspect's shoes indicates contact with a location where the victim was bleeding.

Ownership evidence is something that helps answer the "who" question with a high degree of certainty. It includes any evidence that may be connected to, or associated with, a particular person or source. It also includes individuating forms of physical evidence.

Examples:

- Written signatures
- Driver's licenses
- Credit cards
- Computer IP addresses
- PIN numbers
- Mail
- E-mail
- Serial numbers
- Vehicle identification numbers
- DNA
- Fingerprints

Associative evidence is usually a form of trace evidence that can be identification or ownership evidence. The finding of common materials on the suspect and victim, the suspect and the scene, or the scene and the victim is used to suggest contact, in accordance with Locard's exchange principle. Although associative evidence indicates certain or potential contact between persons or environments, it cannot by itself indicate when that contact occurred. This requires the presence of other circumstantial evidence.

Examples:

- A bloody footprint on linoleum places a person at the scene.
- Fibers found on a body that match the fibers in the trunk of a vehicle.
- Double-base gunpowder found on both the suspect and the victim.
- Vegetation found in the trunk of a vehicle suspected of hauling a body consistent with vegetation found at the crime scene and on the body.

Associative evidence takes on a higher degree of importance when there is more than one type involved. For example, if all the previous examples were discovered in one case, the reconstructionist would first be inclined to postulate that the vehicle (associated with the crime via fibers and vegetation) was used to transport the body. If the owner of the vehicle was also the person whose bloody footprint was discovered on the floor, and the blood belonged to the victim, the tightening circle of associations would increase the importance of this evidence.

Limiting evidence is that which defines the nature and boundaries of the crime scene. Determining the nature and limits of the crime scene is perhaps one of the most difficult tasks in crime

reconstruction. It is made difficult by the fact that reconstruction is performed most often after the scene is released and that first responders, without any forensic training, often determine scene limits by arbitrarily throwing up barrier tape wherever it seems appropriate. This may or may not reflect the actual limits of the scene and the evidence. By the time crime scene investigators (CSIs) realize that there is evidence outside of the tape, it is often already trampled upon by a variety of well-meaning crime scene personnel.

Examples:

- Points of entry and exit to and from a scene
- Walls inside a building
- Doors inside a building
- Geography and landscape of an outdoor scene
- Fences on a piece of property
- Location of the known scene (indoor, outdoor, vehicle, etc.)
- Confines of a vehicle (car, truck, boat, cruise ship, etc.)
- Beginning and end of blood trails
- Beginning and end of drag marks
- Location of items dropped by the offender when fleeing the scene
- Absence of any evidence that should be there given the known action evidence that specifically suggests a secondary scene⁶

Limiting evidence is important because it helps establish whether there are secondary crime scenes and whether the evidence search area must be expanded to include other locations.

Inferred evidence is anything that the reconstructionist thinks may have been at the scene when the crime occurred but was not actually found.

Examples:

- A contact gunshot to the face of a victim produces a quantity of blood on the table where she was sitting. A void pattern is formed on the table with a specific outline. It is inferred that the package of cocaine described by a witness was consistent with this outline and may have been removed after the victim was shot.
- A deceased victim is found without his wallet.
- A deceased married victim is found without his wedding ring.
- A deceased female is found outdoors without her underwear.
- A victim is found stabbed to death in her residence, but the knife is not found.
- A victim is found shot to death in his residence, but the gun is not found.

It is important when dealing with inferred evidence to refrain from assuming that the offender must have removed it from the scene, even when the reconstructionist knows precisely what it is. For example, a witness or even crime scene responders may have stolen a victim's cash or wallet from the victim's body, and a female victim found without underwear may simply not be in the habit of wearing underwear. These questions must be asked, and their answers known, before informed inferences regarding what the offender may or may not have removed from the scene can be made.

⁶ This includes the absence of blood at a scene where the victim has exsanguinated, the absence of teeth on the ground from a victim whose teeth were knocked out during a fight, and so forth.

Temporal evidence is anything that specifically denotes or expresses the passage of time at the crime scene relative to the commission of the crime.

Examples:

- It is known that the electricity was turned off at a main switch to a home. The victim was shot during this time. The electricity was turned back on. The clock in the bedroom reset itself to midnight. Therefore, to establish the time of death, the time that the crime lab looked at the clock was subtracted from the present time to give the time when the clock was turned back on.
- A clock is knocked off a nightstand during a struggle, affixing the time.
- A new stick candle is lit during the commission of a crime. It is discovered still burning with only half of the wax remaining. The length of time it takes to burn this candle half-way may be established via experimentation with a candle of precisely the same type.
- A bowl of ice cream is placed on a kitchen counter just prior to the commission of a murder. It is barely melted when police arrive. The more expensive the ice cream, the less air is injected into it during its manufacture and the longer it takes to melt. The length of time it takes to melt may be established via experimentation with ice cream of precisely the same brand and flavor.
- A forensic pathologist uses the decrease in body temperature, rigor and livor mortis, analysis of the vitreous humor, and examination of the gastric contents to determine a victim's approximate time of death.
- A forensic entomologist uses the life cycle of insects found on a deceased body to approximate how many days the victim's body has been susceptible to those insects.

Psychological evidence (i.e., **motivational evidence**) is any act committed by the perpetrator to satisfy a personal need or motivation. This type of evidence is more commonly the province of the criminal profiler and the behavioral scientist, but is no less valuable.

Examples:

- An offender murders his wife in their bedroom and stages the scene to appear as though it were a burglary gone wrong. This is done to conceal his otherwise obvious connection to the crime and the crime scene.
- An offender tortures his victim, sexually, to satisfy a sadistic motivation.
- An offender records his attack of a victim to both humiliate the victim and relive the event later for fantasy purposes.
- An offender beats his victim repeatedly with the butt of a pistol out of rage.
- An offender binds and gags a victim during an attack at a private location where no one would hear the screams to prevent the victim from disrupting the offender's fantasy of victim compliance.

Ultimately, there are no bright yellow lines among these evidence classifications. In fact, it may be more useful for reconstructionists to consider these more like questions to ask of each item of evidence. What can this tell us about sequence? What can this tell us about contact? What does this tell us about action? What does this tell us about ownership? In this way, evidence relationships are less likely to be lost, and the fullest picture of events may be allowed to emerge.

CREATING TIMELINES

There are several ways to create and use a timeline when reconstructing crime. [Bevel and Gardner \(2008\)](#), for example, use a relative timeline to set specific events in order. However, the reconstructionist can also use the timeline without specifying particular events.

We have found that it is often of great value to begin a reconstruction by trying to place the general elements of the crime in order. By breaking the crime down into small events, or isolating specific segments, the reconstruction may become less daunting and events may become more apparent. [Rynearson \(1997, pp. 102–104\)](#), for example, takes the approach of breaking the total sequence of the crime into “elements” that are present in a variety of crimes. This scheme is similar to that proposed by Hans Gross in the 1890s.

Rynearson and Chisum have added to and modified the approach suggested by Gross over the years. They propose that evidence is anything that assists in proving or disproving any theory about any element of the crime. All of these elements are not necessarily present in all crimes—save serial crimes with a sexual component:

- Fantasy—The person thinks about the offense and what he or she is going to do.
- Planning—The person plans what he or she is going to do.
- Contact—The person chooses a way to approach a victim.
- Control—The person takes control of the victim.
- Offense—The act against the victim.
- Defense—The resistance of the victim.
- After—What to do with the evidence of the crime.
- Flight—Leaving the scene.
- Alibi—Making an excuse for the time.
- Fantasy—Remembering what has been done; imagining it better or different; then it starts over.

Investigators at the scene tend to concentrate on the evidence of the offense and the flight. Once conceptualized, it is not typically difficult to establish the evidence of each. This is the starting point of a reconstruction ([Rynearson, 2002, pp. 171–176](#)).

Subsequently, a timeline allows the reconstructionist to conceive and maintain focus on the overall picture of the crime, without forgetting that there are details requiring attendance. When the reconstructionist identifies a discrete event, it is placed where it fits within the elements of the crime. This provides the foundation for the sequence of events and keeps them in order. In this fashion, the timeline expands from a sequence of general elements to a sequence of discrete events.

With this basic concept of elements forming a skeletal timeline, the next steps of the reconstruction require synthesizing knowledge from the evidence and keeping it organized in a meaningful fashion. The reconstructionist must exercise personal choice here and utilize those methods that are most useful and appropriate to his or her own intellectual dexterity. Consider the following.

Mind Mapping

Mind mapping is a method of linking seemingly random and unconnected thoughts to create a diagram of what one knows about a subject. This approach is useful for getting one’s ideas together when the evidence is unclear and the picture of the crime is essentially fuzzy.

Most commonly, a single piece of paper is used on which the reconstructionist writes down the primary problem (a blank whiteboard will also do), for example, a decedent's name.

Next, one writes down clothing, weapon, injuries, activities, and times as starter categories for information around the name. Then the reconstructionist can add one-word descriptors of what is known in those categories. Other categories may surface. It is important to let one's mind wander during this process, to reflect and ruminate about the known evidence and the scene. To that purpose, scene photos and diagrams should be handy.

Finally, the reconstructionist can connect these thoughts and impressions with lines to show relationships or time sequences. The result is a collection of ideas regarding what one knows or needs to know about the evidence in one's case. These may be used to direct further investigation, create hypotheses, and construct experiments.

Mind mapping is a visual technique used to gather ideas for the solution of a problem or to establish relationships. It uses one word to stimulate thoughts and ideas, and it goes in any direction necessary. It is recommended that the reconstructionist utilize color markers, diagrams, charts, and other necessary visual aides to stimulate ideas. This same basic practice can also be accomplished with 3×5 cards or with photos. A line of one color shows relationships, such as "this blood is from the victim (red), this blood is from the suspect (blue)," or it can be a combination of various photos, report quotes, and relationships.

This same approach can be used in a group setting by "brainstorming" over the evidence. Faye Springer, a criminalist with the Sacramento District Attorney's Forensic Laboratory, uses 3×5 cards in her alternative method of mind mapping. She writes a description of an item of evidence on a card. Then she writes down what can be determined regarding that item. When all the evidence is listed, she determines if there are relationships between items; included in the relationships are exclusions as well as positive relationships. She then proceeds with the scientific method by eliminating the impossible through logic and reasoning.

The methodology is simple, requiring nothing more than a package of 3×5 cards, a pen, and plenty of room to spread the cards out.

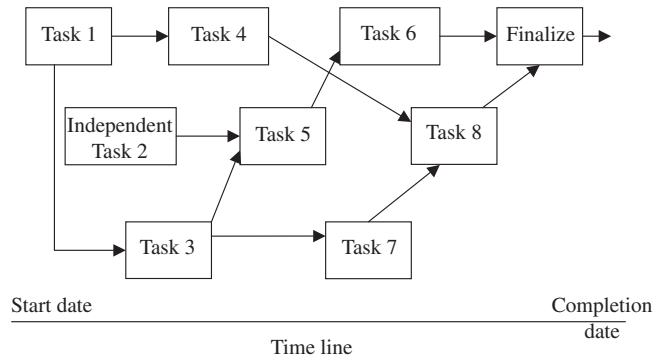
Additionally, The Brain (available at www.thebrain.com) is a software package that allows the reconstructionist to mind map a case on the computer. This software has been used extensively by one of the authors (Chisum). Facts are put into "thoughts," and relationships become easier to see as these thoughts are connected to each other. Text, photos, and references can be added either as notes or as files. It is a very useful way of organizing, preserving, and perpetuating the mind mapping process throughout a case.

PERT Charting or Flow Diagram

The Program Evaluation and Review Technique (PERT) is a project management tool first developed by the U.S. Department of Defense's U.S. Navy Special Projects Office in 1958 as part of the Polaris submarine-based ballistic missile project. It is essentially a method for analyzing tasks involved in completing a given project, specifically the time needed to complete each task, in order to identify the minimum time needed to complete the total project (Figure 8.2).

The PERT chart technique can be adopted for crime reconstruction. This technique is a method of putting the "events" in order. The chart would be simpler than that shown in Figure 8.2 but it would also reflect decisions or alternatives to each box.

FIGURE 8.2 This is an example of a PERT chart with two different beginning tasks and a total of nine tasks to be completed in the order indicated by the arrows. The dates for each task would be indicated on the timeline.



CASE EXAMPLE

W. Jerry Chisum

Several years ago, I had a case involving whether a man was shot with a high-power rifle in the front of the jaw or the back of the head exiting the other side. I used a flowchart to help me reach a conclusion.

The witness changed her mind from one day to the next so that the case went from voluntary manslaughter (shot in front) to first-degree murder (shot in back). I was able to view the body prior to the autopsy, which I could not attend. However, I was able to get the body X-rayed in the time between the funeral and the interment. I had the victim's clothing and had a conversation with the detectives. One of them informed me that the sheriff/coroner had put his finger into the back of the neck to feel the size of the hole. They also showed me a photograph of a probe through the head prior to the pathologist arriving.

When I first looked at the shirt, I noted there was a hair that was protruding root first from the hole in the neck. I also noted that there was no black ring surrounding the hole in the outer layer of the shirt collar.⁷ For this reason, I became "stubborn" and wanted to conduct tests to determine for certain the true direction of the shot. The sheriff was adamant that it was to the back.

There was a small hole in the back of the neck and a large stellate hole at the point of the chin. The doctor performing the autopsy (not a forensic pathologist) concluded that the victim had been shot in the back because the tissue at the edges of the hole was tucked in and because he found dark particles in the section of tissue from the neck. He stated the particles were gunpowder. He withdrew his opinion upon learning that the wound had been probed by the sheriff and that the "gunpowder particles" were actually bits of lead as determined by a forensic pathologist (which he was not).

The first approach was to try to reenact the crime. The path of the bullet, from where the shooter was sitting through the victim's head, was established. A man of the same height was used as a model; however, the path through the head was the same if he was standing with his back to the shooter or bent over toward the muzzle. This simple experiment did not aid in the determination.

The sheriff/coroner offered that he hunted a great deal and that he had a lot of experience killing animals, and it is always little hole in and big hole out. I explained to him this generalization was not

⁷ A bullet will be wiped by the first layer of cloth (or other material) it enters. This leaves a black ring of lead, grease, and powder residues. Subsequent layers will not have this ring.

true in close shots due to cavitation, and because the shot was to the mouth there were other dynamics that could also affect the size of the hole. This is ultimately an example of “experience” giving the wrong answer because it is the wrong experience; the effects of distance shots are different from those in close shots.

The X-ray showed lead in a teardrop pattern with the V pointing toward the chin. The teeth were pushed back at an angle with the crowns pointing to the front and the roots backward. All these facts demonstrated a force starting at the apex of the V, at the chin. Therefore, I was able to conclude that the victim had been shot in the front and the defendant’s story was actually supported by the evidence.

Role-Playing

Role-playing is a process in which participants engage in animated, freeform hypothesis development and theory revision regarding the potential actions of individuals involved in an event or a series of events. They may use props; they may revisit the scene; they may approximate victim or offender choices and responses. It is an exploratory and dynamic effort intended to gauge action and event feasibility. Its greatest value is that it can assist with answering the question of whether or not something could have happened in a particular way given the known evidence and physical limitations.

CASE EXAMPLE

W. Jerry Chisum

Joe Rynearson and I were teaching in a Northern California school for law enforcement officers. The DA of the county called and asked Joe to do a reconstruction. We stayed after class and read the reports and looked at the evidence together.

The case involved a stabbing, and there were some unusual injuries to both parties. We argued each point and put ourselves through the stabbing, correcting each time we did it. After about 2 hours, the DA decided he had had enough of this “waste of his time” and left.

The next day, Joe took his report about the stabbing to the DA (I taught the class). The DA read the report and said, “How did you come up with this, it’s amazing?” Joe told him he had watched us role-playing the actions, what he thought were arguments were us working out the alternatives. The suspect pled guilty because of the reconstruction.

As the reconstructionist examines the evidence in a case there will be questions raised about many issues. For example, can an alleged victim shoot himself in a specified location with a particular gun, can he tie himself up in the manner in which he was found at the scene, or what position was the victim in when he received a particular injury or created a particular transfer pattern? These possibilities can be tested in role-play exercises.

However, the reconstructionist must remember the formation of alternative solutions. Just because the victim could not have pulled the trigger if the gun was held in the conventional manner does not eliminate the possibility of self-infliction. It may have been held or positioned in an unconventional fashion.

Here again, victimology becomes important. It would be extremely embarrassing to argue something on the stand regarding a victim's history, carriage, or deportment only to learn that his or her body mechanics would not allow such a position to be attained. The victim may be too large or too small, too tall or too short. If the victim has a physical handicap (nonfunctioning or missing limbs, inability to walk, inability to hear, etc.), the reconstructionist may be putting the victim in an impossible position. However, if the victim is an athlete (e.g., gymnast, body builder, or marathon runner), the victim may be able to achieve positions that others cannot.

To explore and eliminate alternatives, the reconstructionist may need to get into the same position as the victim was, in a similar environment, with the same type of weapon used. For example, the reconstructionist may wish to eliminate the alternative that a victim tied himself or herself up or could have broken free from certain bindings. To test either possibility, the reconstructionist can get similar material, recreate similar circumstances, and attempt to tie himself or herself up in the presence of a witness. The reconstructionist may even wish to make a video record of this effort. This is basic role-playing. However, never role-play with a loaded gun, a real knife, or subject yourself or others to a hazardous material or situation.

Attaining a plausible reenactment, or the refutation of a particular theory, is the ultimate goal of role-playing.

Reenactments

Occasionally, and once theories of the evidence have been deemed sufficiently reliable, a physical demonstration of some kind is needed to relay a proposed reconstruction fully and accurately.

A **reenactment** is a process in which the participants mimic the actions involved in a specific event or series of events. Instead of being a free-form and exploratory form of hypothesis development and theory revision, a reenactment is fixed and is intended to educate or convince others regarding the veracity of a particular theory.⁸

The danger of some reenactments, especially those involving computer animation, is that they may present a theory of the crime as though it is the one and only way that events could have happened.⁹ For this reason, the full crime must not be reenacted because this level of certainty is rarely possible. A full reenactment, it must be remembered, necessarily involves a great deal of unguarded conjecture and speculation. It is therefore more useful and objective to present the short segments of events that are firmly grounded in the evidence and not attempt to fill evidence voids with experience-oriented guesswork.

⁸ One of the authors (Chisum) had a defense attorney and his investigator climb on a table in court to demonstrate the way blood was deposited on a defendant's shirt. This was offered to disprove the theory of the prosecution regarding the manner of blood staining. When they were in the position described by the prosecution witnesses, it was impossible to deposit the blood patterns. The jury was effectively convinced by this simple reenactment.

⁹ Computer-generated reenactments, often referred to inappropriately as computer reconstruction or even as a form of crime reconstruction, are commonly produced by putting a case theory into animated form on a computer using compelling graphics and animations. The problem with this is that many who interpret the evidence for such animations are not actually trained in forensic science and present nonscientific theories in a format that appears scientific by virtue of its association with computer technology.

Truth Tables

A **truth table**, or **veracity table**, is a good method for testing the veracity of the multiple theories inhabiting a case. It is based on the previous suggestion that alternative theories for events be written down. This is accomplished by creating a table with theories across the top and then observations, clues, and physical evidence along the side. Using the case from Chapter 12: Reconstruction Using Bloodstain Evidence, these are the following case theories (Table 8.1):

1. The “victim’s” story: She was walking along the sidewalk when a car pulled up and four other women got out and threw her to the sidewalk. She was held face down and her shirt cut, then her back cut. She states she felt the blood running down her back. She struggled against them and broke free and ran home. She called the police.
2. Staged the crime, cut her shirt. Realized she needed to be bleeding when police arrived so cut herself.

The list could go on to cover all the observations made. When an “F” for “false” is present, that hypothesis is false and can be eliminated or modified. This is a simple example. A major case could have several columns of theories.

The truth table is a simple way to test hypotheses and present the results of your analysis to others. Alternative theories to an event can be tested against other events or the whole may be tested at once.

This is a useful tool for an investigation; however, caution must be exercised if it is used in court presentations. There is a fine line between determining the alternative that is best supported by the facts and using the results in an attempt to address the ultimate issue. The reconstructionist may use a truth table for testing hypotheses and developing viable theories but not for trying to show guilt or innocence. That is a legal determination and not a scientific one.

Use of a truth table is an effective tool for showing the inconsistencies of the evidence with the prosecution’s case, regardless of the side employing the reconstructionist. If this occurs, then the charges against the defendant may be modified or dropped, as was done in the previous example.

This does not always occur, however, and in such cases the reconstructionist is urged not to surrender any professional chastity, as mentioned by Dr. Thornton in Chapter 3: Crime Reconstruction: Ethos and Ethics. In the past, and even in some public lab systems today, when a

TABLE 8.1 Truth Table

Evidence	Victim’s story	Staged crime
Back is cut	T	T
Shirt is cut	T	T
Still bleeding 1.5 hours later	F	T
Clothes not scuffed or soiled	F	T
Cuts not serious	?	T
No blood on shirt	F	T

forensic examiner had a case in which the prosecutor ignored his or her findings and proceeded to prosecute, the examiner's professional ethics were tested. The dilemma that forensic scientists face as public employees is that prosecutors have tremendous influence over their jobs. If your superiors are prosecution oriented, you might lose your job if they complained or leaked any information to the defense.

Discovery laws (the compulsory disclosure of pertinent facts or documents to the opposing party in a court action, usually before a trial begins) are intended to relieve today's publicly employed forensic scientists of that problem. The defense should receive a copy of their report. If the prosecutor ignores their input, the defense can choose to call them or not depending on the strategy it has chosen. If, however, they do not complete their findings and write a report subsequent to the discovery motion, the prosecutor may not reveal it unless called on to do so by the court. Therefore, it is important that all publicly employed forensic examiners write their reports in a timely manner to help ensure that both sides are equally informed of the findings.

CASE EXAMPLE

W. Jerry Chisum

This case shows how the reconstructionist approaches a problem—how bloodstains can reveal many things about positions; how one must be careful to know just how the blood sheds from the body; and that one must weigh all stories against the physical evidence. It also demonstrates how the reconstructionist must change the answer to fit the facts and not change (or ignore) the facts to fit a particular answer. This is a civil case involving a wrongful death suit.

A young man is going home one night; it is raining and he sees a woman run across the street in front of him at a stop sign. He stops and asks her if she needs a ride. She points to his other side. He turns and sees an angry looking man approaching. Another car pulls up behind and a witness gets out.

There are two versions of the story at this point.

The defendant says the angry man jerked his car door open. The defendant jumped out and tried to intimidate the smaller man, as he was 6'2" and the angry man was approximately 5'8". They grappled; the next thing he knew, he was on the ground face down. The angry man was on his back holding him down.

The defendant claims he was grabbed by the eye and his head was pulled back. There was someone kicking him; he was afraid they would kill him if they connected with his throat or under his nose. He had a knife in his pocket. He pulled it out and opened it one handed, reached over his shoulder and stabbed at the person on top. There was an immediate release of the pressure. He rolled over and the angry man walked away.

There was a witness there who had pulled up. The defendant thought the witness was the one kicking him, so he threatened the witness with the knife by waving it back and forth. The witness drove off, so he got in his vehicle and left.

Later that night, the defendant heard that the man he stabbed had died. He turned himself and his clothing into the police. The woman, who was the girlfriend of the decedent, supported this story in her initial interview.

The witness claimed he came on the scene just after the driver had jumped out of his car. He said the driver ran over to the decedent and knocked him down, drew his knife, and plunged it into the chest of

the decedent. The witness was a bouncer and had been a martial arts student for years, so he ran over and, using a martial arts throw, reached across the chest of the assailant and threw him to the side. The witness claims he helped the decedent up but did not realize the extent of the injury. He said the crazy guy (the driver) started at him with his knife, waving it back and forth and threatening him. The witness subsequently got into his car and left the scene. He claims he drove around the next block and called 911 from a convenience store. The witness claims he then returned to the scene and rendered first aid until the paramedics arrived.

The girlfriend was told by her mother's attorney that the story she told to the police would not help her or her boyfriend. From that point on, she adhered to the story told by the witness.

The decedent was a state champion wrestler in high school. He was a very jealous person and had instigated numerous fights in response to someone looking at or flirting with his girlfriend. Additionally, the decedent and his girlfriend had been fighting that evening, and he had been drinking. She was walking away from him at the time the incident started.

The decedent was stabbed in the first intercostal space on the right, nicking the side of the aorta. He walked 85 feet before he collapsed. There was a lot of blood on the shirt of the defendant, but only three drops (it had stopped raining) between the scene and the body.

There were three phone calls to the 911 dispatcher prior to the witness's call. One of those calls was from a friend of the decedent (at whose residence the decedent had been drinking) who ran a block to the body and then ran back to call.

The witness did not drive to the convenience store; he walked. He lived just a half a block from where the incident occurred. The first officer at the crime scene knew the witness. The officer said he did not see him there and that no one gave first aid because the paramedics arrived soon after. The witness was actually a friend of the decedent and his girlfriend. They had been to the bar where he worked that evening.

The clothing was submitted to the laboratory for examination. DNA was relatively new at the time, but it was used to determine that it was the decedent's blood on the defendant, as well as on the shirt from the witness.

The plaintiff's expert witness opined that blood spurted out of the decedent's chest due to arterial pressure as the decedent lay on his back at the scene. The aorta was nicked or cut on the side. The aforementioned expert further opined that the blood would spurt as though from a garden hose as a result of that nick. There were a few small droplets on the left sleeve/chest area of the defendant. This, the expert claimed, was the spurt that follows the knife out of the injury. They had marked three of the drops as to directionality. They also claimed that the blood on the witness's shirt came from arterial spurting as well.

Figures 8.3 and 8.4 show how the droplets on the shirt were marked by the prosecution and then by the author. These drops do not go in one direction. Blood does not spurt out in a tiny stream from a chest wound as the knife is withdrawn; in fact, knives used to stab people in the chest seldom have enough blood on them to see without a microscope or with chemicals. This pattern is explained by the defendant waving his bloody hand and knife while threatening the witness. By marking only a few, the plaintiff's witness was ignoring the facts that did not fit his theory.

The witness submitted this shirt (Figure 8.5). He claimed to have reached across the chest of the defendant to throw him off. Yet there were no large transfers of blood on this shirt. There were several drops on the chest area. These are consistent with the blood cast off the knife blade when the defendant was threatening him.

FIGURE 8.3 This is the sleeve of the defendant's shirt. The directionality of some of the blood drops on the sleeve has been marked by the plaintiff's expert.



FIGURE 8.4 The directionality of additional blood drops by the author shows the different directions the blood was traveling. These different directions do not support the theory of the plaintiff's expert.



Blood does spurt out a cut artery with each heartbeat, like water out of a pulsating sprinkler. However, when the artery is cut on the side, the spurting is into the chest, not out a narrow channel that is 3 inches through muscle tissue.

The clothing of the decedent was not cut by the stab wound. His shirt and T-shirt were over the wound; therefore, they were pulled up at the time he was stabbed. The wound will drain when it is down, but when the person is standing, sitting vertically, or lying on his back, the blood will stay in the chest. This collapses the lungs and puts pressure on the heart.

The right side of the defendant's shirt (Figure 8.6) was heavily bloodstained. It was on the right sleeve and down the front of the shirt. This shows that the decedent was above the defendant at the time he was bleeding and the defendant had turned toward him. There were small drops on the back



FIGURE 8.5 This is the shirt worn by the witness. There is a lack of bloodstains that should be present if he did as he said. The small spots on the front of the shirt are “cast off” from the knife being waved in front of him.

of the outside collar. These were the first drops shed after the stabbing. The decedent stood up at this point and the blood gushed out in a couple of heartbeats. When he stood completely, he did not spurt any more blood.

The jury stated that the witness, the bouncer, was clearly a pathological liar. They also believed that he was making things up as he went along. They further suggested that they might leave the courtroom if he took the stand again. They did find for the plaintiff, however, and awarded \$1 in punitive damages.

Why was the witness lying? He had taken martial arts since he was 10 years old. He wanted to be a hero. We believe he could not face the fact that when he had a chance to become one, he fled and left a young woman with a “crazed killer,” as he described the defendant. He believed his story after he told it enough times.

This case illustrates why it is important that the reconstructionist establish the facts using the evidence and then test the stories of all the actors in whatever role they purport to take in the incident.¹⁰

¹⁰ Although the facts and the photos are correct, some of the circumstances have been altered to protect the parties involved.

FIGURE 8.6 This is the shirt worn by the defendant. The large blood pattern on the right side shows how the blood poured from the injury down onto the defendant as the decedent stood. Sent under separate e-mail.



Separating Theories

The reconstructionist must accept that witness and suspect statements are theories to test with the evidence, not inputs for the reconstruction. Corroboration is good, but scientific evidence must stand on its own in that process. Science must be used to test investigative theories and witness veracity, not the other way around.

One way to consciously separate out competing theories is by writing them down. Write a paragraph or two that summarizes the existing theories of what happened and where they came from (detectives, witnesses, suspects, supervisors, colleagues, students, patrolmen, lawyers—anyone with a theory). Now examine the videos, photos, and reports with the thought of disproving each of those theories. Ask the following: Is there any evidence that shows that any part of the theory could not have happened in the manner that the theory requires?

This approach may sound a bit backward to the uninitiated, but it is actually the scientific method being applied to a hypothesis in a logical manner. The reconstructionist who is unfamiliar with this practice will find it not only enjoyable but also revealing and even educational.

BEHAVIORAL EVIDENCE ANALYSIS (BEA)

Behavioral evidence is any physical, documentary, or testimonial evidence that helps establish whether, when, or how an action has taken place. As already mentioned, any form of physical evidence may also be behavioral evidence under the right circumstances. Footprints and

footwear impressions can indicate presence, standing, walking, or running and direction. Bloodstain patterns can indicate presence, injury, contact, or movement and direction. Fingerprints can indicate presence, contact, and use of an object. Semen and sperm can indicate presence, contact, sexual behavior, and ejaculation. Injuries can indicate weapon type, presence, contact, the amount of force, and even intent. Ligature patterns can indicate strangulation, binding, and resistance. Toxicological testing can indicate the presence of drugs, alcohol, or toxins in a victim or offender's system. These also have an impact on cognition, judgment, state of mind, and health—all of which influence behavior. Photo images and video footage from the media, security cameras, cell phones, digital cameras, and camcorders operating at the time of an event can provide limited but specific documentation of behavioral evidence. To be useful, behavioral evidence must be examined and considered as a whole, in a directed and purposeful fashion, in order to achieve meaningful results. It cannot be surmised inconsistently, without focus, or based solely on the subjective insights of experience. That's where BEA comes in.

Behavioral evidence analysis is a holistic method of crime scene analysis, crime reconstruction, and criminal profiling developed by one of the authors in 1998 (Turvey; see [Turvey, 2011](#)). It involves the examination and interpretation of physical evidence, forensic victimology, and crime scene characteristics. BEA is concerned with studying the aspects of individual cases and offenders through the lens of forensic analysis based on critical thinking, the scientific method, and analytical logic. BEA conclusions are meant to be the result of the most complete understanding of the events surrounding the commission of a crime.

Behavioral Evidence Analysis Examinations

In general, BEA involves the rendering and melding of three different examinations: forensic analysis, forensic victimology, and crime scene analysis. Each examination has its own intrinsic value to forensic casework and may result in findings relevant to court proceedings. They may also be used for other purposes, including the development of investigative strategy, criminal profiling, and case linkage (see [Turvey, 2011](#)).

Forensic Analysis (a.k.a. Equivocal Forensic Analysis)

Forensic analysis, in general, is the first step in BEA and refers to the examination, testing, and interpretation of any and all available physical evidence. As described in [Turvey \(2008, p. 190\)](#), “**equivocal forensic analysis** refers to a review of the entire body of evidence in a given case, questioning all related assumptions and conclusions.” This critical assessment of all case facts and evidence helps insulate the forensic analyst from investment in prior case theories.

An equivocal forensic analysis is a necessary and useful tool in both investigative and forensic realms, especially in those cases in which facts lend themselves to multiple conclusions. If the case at hand is referred to as rape, the forensic examiner critically reviews the evidence which is meant to establish rape, such as the crime scene evidence, the medical report, the sexual assault kit, and any victim statements; if the crime at hand is referred to as a homicide, the forensic examiner critically reviews the evidence which is meant to establish homicide, such as the crime scene, the crime scene documentation, the autopsy report, and the autopsy photos. When the evidence supports initial conclusions, the forensic examiner may move forward with additional

assessments; whenever there is a doubt, it must be noted and case theories stemming from such conclusions must be amended. Engaging in this sort of assessment at the outset of any case in which conclusions are predicated on the quality of the work done prior is necessary to avoid bias and to identify weak or nonexistent evidence.

The behavioral evidence to be established and examined in any reconstruction must come from reliable sources. It cannot simply be assumed or inferred by those without sufficient forensic education, training, and experience or by those with an agenda. This means understanding and applying the scientific method with respect to evidence interpretation. This also means settling for nothing less than established reconstruction techniques applied by qualified forensic scientists.

A competent forensic analysis requires an informed reconstruction that accounts for every examination performed on any items of physical evidence. The reconstructionist must go through every item of evidence and ask:

1. What was collected?
2. What has been examined?
3. What do the results mean?
4. What has not been examined? Why?
5. What can still be examined?

This is not meant to be as simple as it has been presented, but rather to impart a mind-set: Reconstructionists need to know what evidence they are working with, what holes exist, and what they mean.

Forensic Victimology

Forensic victimology is the scientific study of violent crime victims for purposes of addressing investigative and forensic questions (Turvey, 2011). It involves the accurate, critical, and objective outlining of a victim's lifestyles and circumstances, the events leading up to any injury, and the precise nature of any harm or loss suffered. As already suggested in this and previous chapters, this information can be used to separate out unrelated artifact evidence and injury; to give context to the behavior that is under examination; and to define the limits of what is both reasonable and possible for the victim at hand.

Crime Scene Analysis (a.k.a. Crime Analysis)

Crime scene analysis is the analytical process of interpreting the specific features of a crime and related crime scenes (Turvey, 2011). Potential crime scene characteristics that must be established or at least considered include, among many others: method of approach, method of attack, method of control, location type, nature and sequence of sexual acts, materials used, evidence of skill or planning, any verbal activity, precautionary acts, contradictory acts, modus operandi behavior, signature behavior, and the amount of time spent in the commission of the crime. Crime scene characteristics are interpreted from an integrated examination of the established behavioral evidence and victimology. As they are dependent on physical evidence, and complete evidence is not always available, not all crime scene characteristics may be established in every case.

Behavioral Evidence Analysis Purpose

Behavioral evidence analysis is a big picture approach to casework intended to give the generalist reconstructionist the clearest understanding of the relationships among the victims, offenders, and crime scenes that exist in a particular case. It also provides any user with a template for thinking about and classifying these relationships in order to better answer specific investigative forensic questions as they arise. It does not purport to suggest that every case is the same and may be approached in the same rote fashion, but rather that every case is different and must be investigated, examined, and understood as such. Those interested in learning more are encouraged to begin by studying [Turvey \(2011\)](#) and Turvey and Petherick (2009).

THE NATURE OF RECONSTRUCTION

No matter how complex, problem solving is a function of thinking and reasoning; it involves the recognition that one does not immediately know how to move from a given state (ignorance) to a desired state (enlightenment).

Crime reconstruction is a form of evidence interpretation based on the application of advanced problem recognition and solving skills; however, there are limits to our understanding of how the mind works. Far more research is necessary before we can speak with absolute certainty regarding how it is that the human mind recognizes and sorts the patterns in the evidence that help us compose our theories. Creativity and imagination, for example, are components that elude quantification. In other words, how we form and inform our hypotheses is not always understood, but how we test, support, or disprove them must be.

The tools described in this chapter are essentially methods for organizing one's thoughts and reducing complex problems to manageable ones. They will help the reconstructionist identify and answer questions about the evidence and how to explain the results of examinations to others. As presented, these tools presume an adherence to critical thinking, analytical logic, the scientific method, and the practice standards discussed in Chapter 5: Practice Standards for the Reconstruction of Crime.

There is no one true method for reconstructing crime; however, there are many valid and invalid techniques. Only a small number of them have been mentioned in this chapter. The viability of any technique is measured by the extent to which the reconstructionist adheres to the scientific method, analytical logic, ethics, and a willingness to show work and support conclusions in a way that can be understood and replicated by others. The reconstructionist has a duty to explain not only his or her results, but also how they were derived and how everything else in consideration was eliminated.

CRITICAL/CREATIVE THINKING EXERCISES

Answering the questions that present themselves in reconstruction casework requires thinking beyond the rules that we too often assume must be present. In other words, reconstructionists need to see causes and effects, actions and consequences, from multiple perspectives and

FIGURE 8.7 Exercise 1. 0 0 0

0 0 0

0 0 0

learn to think outside of the box. The following is a series of exercises designed to help the reconstructionist learn precisely that.

EXERCISE 1

Connect the nine dots in [Figure 8.7](#) using only four straight lines. The lines must be a pathway; that is, you cannot lift your pencil from the paper.

EXERCISE 2: DIRT

Calculate the amount of dirt in a hole in the ground that is 2 feet deep and 8 inches in diameter.

EXERCISE 3: MOUNT EVEREST

Before the discovery of Mount Everest, what was the tallest mountain in the world?

EXERCISE 4: CUT THE PIE

Cut a pie into eight pieces using only three cuts.

ANSWERS—SORT OF

1. Do not read into the rules what is not there. To solve this problem, you must literally think outside the box.
2. Zero cubic inches. Reread the problem. What is the definition of a hole? The dirt has been removed; if not, it is not a hole.
3. Just because something is not found does not mean it is not there. Mount Everest has always been the peak with the highest elevation above sea level.

4. Reread the rule. You assume too much. The lines do not have to be straight.

Bonus: cut the pie into eight equal pieces using three straight cuts.

SUMMARY

The most common method of crime reconstruction is to base interpretations on experience. Experience is not unimportant, but it can lead the naïve, ignorant, or inept reconstructionist astray when taken in isolation. It is unacceptable to argue “in my experience” as a sole premise to explain how and why an event must have occurred. Any inference regarding an action or event must be supported by factual details submitted to thoughtful analysis and rigorous logic.

In crime reconstruction, information exists in the form of physical evidence, and the complex problem to resolve is what happened during the commission of the crime. The reconstructionist needs to consider evidence with regard to the role it plays in the crime and what it can establish regarding the events that have taken place. The following evidence classification provides basic types of evidence in terms of the fundamental “who,” “what,” “when,” “where,” “how,” and sometimes “why” questions that are the focus of crime reconstruction: sequential, directional, locational, action, contact, ownership, associative, limiting, inferential, temporal, and psychological.

A timeline is of great value to begin a reconstruction by trying to place the general elements of the crime in order. By breaking the crime down into small events, or isolating specific segments, the reconstruction may become less daunting, and events may become more apparent. Rynearson and Chisum propose that evidence is anything that assists in proving or disproving any theory about any element of the crime. Elements of a crime include, but are not limited to, the following: fantasy, planning, contact, control, offense, defense, after, flight, alibi, and fantasy.

A timeline also allows the reconstructionist to conceive and maintain focus on the overall picture of the crime, without forgetting that there are details requiring attention. When the reconstructionist identifies a discrete event, it is placed where it fits within the elements of the crime. This provides the foundation for the sequence of events and keeps them in order. In this fashion, the timeline expands from a sequence of general elements to a sequence of discrete events.

The next steps of the reconstruction require synthesizing knowledge from the evidence and keeping it organized in a meaningful fashion. Appropriate methods of organization include mind mapping, reenactments, and truth tables.

The viability of any reconstruction technique is measured by the extent to which the reconstructionist adheres to the scientific method, analytical logic, ethics, and a willingness to show work and support conclusions in a way that can be understood and replicated by others. The reconstructionist has a duty to explain not only his or her results, but also how they were derived and how everything else in consideration was eliminated.

QUESTIONS

1. Explain why it is unacceptable to argue “in my experience” as a sole premise to explain how and why an event must have occurred.
2. Explain one barrier to a full crime reconstruction.

3. List three classifications of evidence fundamental to crime reconstruction.
4. Provide three examples of ownership evidence.
5. Define *mind mapping* and explain why this approach is useful in crime reconstruction.

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Staged Crime Scenes

Brent E. Turvey and W. Jerry Chisum

A clever murderer may very well arrange an accident, or make the death appear to be due to a suicide. Such a murderer has every opportunity of arranging matters to deceive those who treat the task of investigating the circumstances too lightly. But a systematic and accurate investigation will reveal the homicidal intent. –*Svensson and Wendel (1974, p. 293)*

Key Terms

Goddefroy's method; Simulated or staged crime scene

In 1999, the court of appeals reversed and remanded a defendant's aggravated murder conviction for the 1994 bludgeoning death of a victim at his home in Clark County, Washington (*Washington v. Kunze, 1999*). The court of appeals held that the state had not established that latent ear print identification, used to implicate the defendant, was generally accepted in the forensic science community, as required for admissibility under the Frye test for admissibility (*Frye v. United States, 1923*). However, the court of appeals let stand the trial court's discretion in allowing two police officers [one of which was a Federal Bureau of Investigation (FBI)-trained criminal profiler] to testify, based on their observations of crime scene photographs and their experience, that the crime scene in the case might have been staged to look like the homicide was the result of a burglary.

The court's decision in Kunze should remind us of the potential probative value of such opinions. It also raises some important issues that the court did not take the opportunity to explore in Kunze. First, how abundant is the literature on staged crime scenes? Second, what defines a staged crime scene, and are there any agreed upon evidentiary thresholds? Third, what skills are involved in assessing the staged crime scene that may be voir dired by the court? The purpose of this chapter is to address these questions and to lay a practical foundation for the research presented within. The hope is that this will provide criminal profilers, investigators, and forensic scientists with some preliminary tools to assist them in recognizing, investigating, and reconstructing staged crime scenes accurately, while preparing the ground for further and better research into this subject.

DEFINITIONS

A **simulated or staged crime scene** is one in which the physical evidence has been purposefully altered by the offender to mislead authorities or misdirect the investigation. Despite their regular occurrence, the majority of professional literature has failed to devote adequate efforts to their study or interpretation. A number of works have addressed the subject, but few have gone beyond superficial coverage (Douglas and Munn, 1992; Geberth, 1996a,b; Gross, 1924; O'Connell and Soderman, 1936; Svensson and Wendel, 1974).

THE LITERATURE

The formal recognition of crime scene staging as a discrete subject in the literature began with the work of Dr. Hans Gross (Gross, 1924). His insights, provided more than a century ago, resonate through the literature with conspicuous agreement: In each case, examine the forensic evidence carefully, reconstruct the crime meticulously, corroborate/compare victim and witness statements with the evidentiary findings, and assume nothing. Since that time, the only published study of the subject, beyond the various case reports that appear in the journals each year, is Turvey (2000), which is present at the end of this chapter. First, a review of the literature is necessary.

Gross

The Austrian jurist, Dr. Hans Gross, wrote (1924, p. 439):

So long as one only looks on the scene, it is impossible, whatever the care, time, and attention bestowed, to detect all the details, and especially note the incongruities: but these strike us at once when we set ourselves to describe the picture on paper as exactly and clearly as possible.

... The "defects of the situation" are just those contradictions, those improbabilities, which occur when one desires to represent the situation as something quite different from what it really is, and this with the very best intentions and the purest belief that one has worked with all of the forethought, craft, and consideration imaginable.

Here, Gross is referring to the critical role that exact, deliberate, and patient efforts at written, scientific crime reconstruction can play in the investigation and resolution of simulated, or staged, crime. Specifically, he is stating that just looking at a crime scene is not enough and that there is utility in reducing one's opinions to the form of a report. Furthermore, he is discussing the regular fallibility of offenders' efforts to stage crime scenes by virtue of their failure to leave behind the necessary and logical evidence of the crime. This occurs, Gross observes, even when an offender has planned the staging carefully. One is left to infer that this may occur from a lack of actual experience with crime on the part of the unskilled offender, but as we will address later, this may not be entirely the case.

Early in his text, Gross (1924, pp. 13–15) warns strongly against investigators being lulled in by what he refers to as their preconceived theories about a case. He discusses those who provide false reports of rape, assault, or injury, who may even engage in self-mutilation, for the purpose of extorting damages or concealing consensual sexual activity that has led to pregnancy. He then

opines on the variety of staged crimes, the eventuality of false reports, and the subsequent duty of the investigator, stating (p. 14):

Among wrongs to property, theft and arson are the most frequently simulated. In the first case, loss of fortune and breach of trust are most frequently sought to be accounted for by the pretence of theft; as a rule it is not very difficult to prove the falsity. The most important point is for the investigating officer to remind himself continually that the theft may have been a sham. In many cases the point must be elucidated; it is not necessary to make a noise about it straight away, but let him keep this idea ever before him and examine from this aspect each of the circumstances.

After considering what any fact would signify if there had been a real theft, let him ask himself what the fact would signify if the theft were only concocted. The investigating officer ought never to permit himself to abstain from making this examination by the rank and situation of the supposed victim of the theft, by the cleverness of the *mise-en-scène*, or by any other consideration. Not only must the self-made victim be exposed, but innocent people who may be suspected must be protected.

Later, Gross provides readers with several illustrative examples of what he refers to as simulated crime scenes. These include a suicide altered to appear as a homicide for profit (p. 432), a homicide altered to appear as suicide to conceal the homicide (p. 437), and a natural death altered to appear as a suicide to conceal caregiver neglect (pp. 439–440). The case studies are presented outside of the context of formal research, as anecdotal evidence of the existence of various simulated crime scenes. The work of Gross stands out as formative to the subject, built on without direct in-text citation by [O’Connell and Soderman \(1936\)](#) and [Svensson and Wendel \(1974\)](#).

O’Connell and Soderman

In their text on the various methods of criminal investigation, written primarily for the police detective, [O’Connell and Soderman \(1936\)](#) dedicate a section of Chapter 17 on the “Investigation of Homicide” to the question of distinguishing suicides from homicides (pp. 260–277). Here they discuss simulation of a suicide by hanging to conceal the crime of homicide, stating, “By hanging a murdered person practically the same marks as those caused by a strangulation may be produced” (p. 264). They specifically discuss the importance of carefully reconstructing crime scenes to establish the facts of a case, including the employment of **Goddefroy’s method** in hanging cases:

The examination of the rope used may reveal most important information. This question has been studied by the Belgian Detective, E. Goddefroy, and such examinations have led, in the last few years, to the solution of quite a few crimes on the Continent. The fibers of the rope will lie in the opposite direction of that of the pulling. If the person slides down a rope the fibers will be directed downwards. If what appears to be a voluntary strangulation is in fact a murder and the murderer has pulled the body up, the fibers will be directed upwards on that part of the rope which was pulled by the murderer, because of the contact of the rope with the substructure.

[O’Connell and Soderman \(1936\)](#) go on to relate the importance of investigating inconsistencies in injuries and wound patterns, stating (p. 266):

Traces of violence found on other parts of the body [other than the part normally associated with the apparent suicidal act] and not brought on by previous, unsuccessful attempts at suicide indicate homicide.

[O’Connell and Soderman \(1936\)](#) do provide readers with brief examples of what they have referred to as simulated crime scenes. These include a simulated fall from a height staged to conceal a homicide (pp. 269–270) and a short section on simulated burglaries (pp. 322–324).

Svensson and Wendel

In their text on the various methods of examining crime scenes, written primarily for detectives and forensic scientists, [Svensson and Wendel \(1974\)](#) discuss simulated burglaries and the question of distinguishing suicides, homicides, and accidents. Primarily, they are concerned with the systematic analysis and comparison of the different kinds of physical evidence involved in each type of crime.

On the subject of simulated burglary, [Svensson and Wendel \(1974, p. 265\)](#) state, harkening back to Gross:

To create a successful imitation of a burglary, which will deceive the police officers, the simulator must strive to carry it out as naturally as possible. Otherwise there will be gaps in the sequence of events.

This passage seems to suggest that meticulous and dedicated investigators will set upon every crime scene. These investigators will then reconstruct the physical evidence, establish the facts, and discern the truth. Thus, “simulators” must be equally meticulous and dedicated in their alterations to evidence in a crime scene.

On the subject of distinguishing suicides, homicides, and accidents, [Svensson and Wendel \(1974, p. 293\)](#) make a similar statement:

A clever murderer may very well arrange an accident, or make the death appear to be due to a suicide. Such a murderer has every opportunity of arranging matters to deceive those who treat the task of investigating the circumstances too lightly. But a systematic and accurate investigation will reveal the homicidal intent.

. . . The following questions must be answered immediately: 1. What are the causes of death? 2. Could the person himself have produced the injuries or brought about the effect which caused death? 3. Are there any signs of a struggle? 4. Where is the weapon, instrument, or object which caused the injuries, or traces of the medium which caused death?

These authors then provide a detailed discussion of the importance of crime reconstruction as it relates to answering the previous questions and others. Topics range from bloodstain pattern analysis to wound pattern analysis and the importance of determining the movement or disturbance of furniture.

Douglas and Munn

A conspicuous entry into the literature of staged crime scenes was coauthored by profiler John Douglas, then head of the FBI’s Investigative Support Unit (ISU), and ISU intern Corinne Munn, R. N. It stands out in contrast to the contributions of others because neither Douglas nor Munn has significant forensic science qualifications, reconstruction qualifications, or experience attending or processing crime scenes.¹ Not that the latter is necessary, but retired FBI profilers have made a strong point of suggesting that it is (see Chapter 3: Crime Reconstruction: Ethos and Ethics).

¹ According to [Burgess and colleagues \(1992\)](#), John Douglas holds an Ed.D., a doctorate in education, and has not been in law enforcement other than his employment with the FBI; Corinne Munn, however, held an R.N. and a B.S. at the time she coauthored the chapter, with 10 years of experience working as an intensive care nurse. These are not forensic science, crime reconstruction, or physical evidence-related qualifications. Nor are they behavioral science qualifications, for that matter.

Douglas and Munn (1992, p. 251) define the concept of staging in a way that none of the other literature agrees is acceptable—that is, they include the actions of those altering evidence to protect the victim’s reputation or that of their family:

Staging is when someone purposefully alters the crime scene prior to the arrival of the police. There are two reasons why someone employs staging: to redirect the investigation away from the most logical suspect or to protect the victim or the victim’s family.

What makes this definition problematic is that the actions of those individuals protecting the victim or the victim’s family do not have criminal intent. For staging to occur, implicit in the historical literature reviewed here, a whole new set of circumstances must be intentionally suggested or rendered through the actions of an offender, not merely the concealment of evidence or circumstances. For example, if an offender rapes and strangles a victim to death and then burns the victim’s body inside the victim’s own vehicle at the end of a dirt road, this would generally be referred to as a precautionary act. If that same offender, rather than using fire, places the victim inside the victim’s vehicle, loosens the brake line, and then pushes it over a cliff to make it appear like a single vehicle accident, then this would be referred to as staging, which is a particular kind of precautionary act.

Douglas and Munn (1992) offer their own checklist to assist with the identification of staged crime scenes, which includes the following (adapted from p. 253):

Questions

1. Did the subject take inappropriate items from the crime scene?
2. Did the point of entry make sense?
3. Did the perpetration of this crime pose a high risk to the offender?

Red Flags

4. The offender fatally assaults the wife or children while the husband escapes without injury or with a nonfatal injury.
5. The offender does not first target the person posing the greatest threat.
6. The person posing the greatest threat to the offender suffers the least amount of injury.

Douglas and Munn (1992) present no data to support any of the previously mentioned red flags; rather, they adduce case examples as needed. They also engage in a similar presentation on the subject of staged arson crime scenes (pp. 255–257). No internal citations are offered for this chapter or for any of the chapters presented in this text. Rather, all generally referenced works for all chapters are presented in one alphabetized list at the end of the text (Burgess et al., 1992, pp. 357–360), unassigned to ideas or subjects.

It is of interest that Douglas and Munn (1992), when discussing how to apply these investigative red flags, state (p. 253):

An offender who stages a crime scene usually makes mistakes because he stages it to look the way he thinks a crime scene should look. . . . Inconsistencies will begin appearing at the crime scene, with forensics, and with the overall picture of the offense. These contradictions will often serve as the “red flags” of staging and prevent misguidance of the investigation.

This language is highly reminiscent of [Gross \(1924\)](#), who also discussed at length identifying “contradictions” of the scene and rendering a picture of the scene through physical evidence.

Geberth

In the third edition of his text on homicide investigation, [Geberth \(1996a\)](#) discusses various types of crime scene stagings by describing five separate cases (pp. 20–37). He states:

The death investigator needs to be cognizant of the possibility that a crime scene may in fact be staged to mislead the authorities and/or redirect the investigation.

[Geberth \(1996b\)](#) offers his own 10-item checklist of investigative strategies, provided to benefit those investigating a potentially staged crime scene (p. 37):

1. Assess the victimology of the deceased.
2. Evaluate the types of injuries and wounds of the victim in connection with the type of weapon employed.
3. Conduct the necessary forensic examinations to establish and ascertain the facts of the case.
4. Conduct an examination of the weapon(s) for latent evidence as well as ballistics and testing of firearms.
5. Evaluate the behavior(s) of the victim and suspects.
6. Establish a profile of the victim through interviews of friends and relatives.
7. Reconstruct and evaluate the event.
8. Compare investigative findings with the medicolegal autopsy and confer with the medical examiner.
9. Corroborate statements with evidential facts.
10. Conduct and process all death investigations as if they were homicide cases.

This checklist is not only vague, but it is redundant. For example, (1) and (6) are essentially the same thing (and victimology cannot actually be assessed until it has been established, so they are out of order); (2) and (4) are part of (3) and (7); (3) and (7) are essentially the same thing; (2) is likely going to be part of (8); (5) and (7) are the same thing and can only be accomplished by doing (2) through (4), (8), and (9). As offered, this checklist has greatly diminished utility to the criminal profiler or investigator. That is not to say any one item taken by itself is bad advice. Rather this list, to have more integrity, should be either shorter and more general or longer and more specific.

It is of interest that [Geberth \(1996a\)](#) ultimately concludes that the increased number of staged crime scene cases is correlated positively with increased public access to information about homicide investigation through the news, true crime books, television, and movies. He presents no evidence to support the notion that such cases are actually on the increase, let alone that such offenses correlate positively with increased offender knowledge gained from the media sources described. In fact, there are no citations presented in this section at all, only three selected

readings offered from [Geberth \(1996a\)](#) at the chapter's end.² Conspicuously absent from this work is any reference to those who originally developed the formal concept of crime scene staging, such as [Gross \(1924\)](#) or [O'Connell and Soderman \(1936\)](#).

Literature Review Summary

Little of substance has been published on the subject of staged crime scenes outside of insights gained from the anecdotal case experience of the various authors reviewed. Yet the pronouncements of Dr. Hans Gross, given more than a century ago, still resonate through this literature with conspicuous agreement: In each case, examine the forensic evidence carefully, corroborate/compare victim and witness statements with the evidentiary findings, reconstruct the crime meticulously, and assume nothing. The concept of what constitutes staging is also fairly consistent across the literature, with the single deviation noted ([Douglas and Munn, 1992](#)) but without the development of tangible evidentiary thresholds. Finally, it is most clear that the determination of whether or not a crime scene has been staged hinges mainly on opinions born out of a reconstruction of the physical evidence. In terms of courtroom qualification, this places such determinations in the realm of the forensic scientist (generalist, criminalist, forensic pathologist, etc.), who is best qualified to engage in crime reconstruction, or perhaps even the investigator with advanced, specialized training in forensic science and crime reconstruction. To allow others to engage in rendering such expert opinions, for the purposes of the court, would seem a dangerously misplaced practice.

AD HOC RECONSTRUCTION

Based on what they have seen and gathered at the crime scene, detectives and even crime scene technicians will theorize about a case relentlessly. What happened, who did it, and why? These questions push and plague the conscientious investigator. But there must be a mechanism in place to screen bare investigative theory, separating belief, rumination, and speculation from demonstrable scientific fact. Fortunately there is, and it is called forensic science.

Approximately three-fourths of the forensic scientists working in public labs do not respond routinely to crime scenes ([U.S. Department of Justice, 2005, p. 4](#)). Rather, those who are charged with investigative or evidence collection duties are more often in attendance (although not in every case). Their presence at the crime scene during the evidence-processing interval has

² [Geberth \(1996a\)](#) advocates only three selected readings to accompany this chapter. The first reading is the second edition of the very same textbook, which contains nothing about staged crime scenes. The recommendation of the second edition is confusing as it contains either redundant or dated material in comparison with the third edition, which is necessarily in hand. The second reading is an article about staged crime scenes ([Geberth, "The Staged Crime Scene," 1996b](#)), authored by Geberth and published without any internal citations or bibliography whatsoever. At the end of the paper it does state, after the copyright information, "This material is excerpted from Third Edition of Practical Homicide Investigation." Not only, then, is this material redundant and hardly necessary as additional reading (as it comes straight from the text that recommends it), but it seems almost inappropriate for Geberth to suggest it as additional reading material, as each work is apparently being used to buttress the other. The third reading is another paper ([Geberth, 1989](#)) on the subject of homicide supervision and management.

led some to conclude that investigators and technicians must also be proficient at evidence interpretation (a.k.a. reconstruction). Subsequently, numerous courts have allowed law enforcement officers and crime scene investigators to serve as ad hoc reconstructionists and even as experts in the determination of whether or not scene staging is present.

Criminal profilers have also made a bold foray into this area, spurred on by the publication of [Douglas and Munn \(1992\)](#). The prosecution commonly brings them in to legitimize these and similar law enforcement theories, conferring on them a false aura of independent expertise. Prosecutorial agencies consult most commonly with and proffer expert testimony from law enforcement criminal profilers who have little if any forensic science background and no quantifiable experience in crime reconstruction. Perhaps recognizing this shortcoming, a growing number of profilers have openly expropriated crime scene reconstruction from the forensic sciences as an investigative function. As discussed in [Baker and Napier \(2003, p. 538\)](#):

Crime scene reconstruction is a process within CIA [Criminal Investigative Analysis] and crime analysis that provides the investigator an understanding of how the victim was reached and controlled, as well as the likely interactions between the offender and the victim. . . .

A special part of crime analysis is the ability to reconstruct and sequence criminal acts as they occurred in the interaction between the victim and offender.

The specific methods and burdens of the CIA reconstructionist, and requisite educational/training backgrounds, are not mentioned in this half-page treatment of the subject. Crime reconstruction is simply described as a practice specifically associated with the CIA process that helps “interrogate suspects with authority, and thereby gain a genuine confession which outlines how and why the crime occurred” (p. 538). There is no mention of science, forensic science, or the scientific method when forming CIA reconstruction conclusions; rather, there is reference to the “special abilities” of CIA analysts (p. 538).

These and similar circumstances have combined to result in the perhaps unintentional but ultimately inevitable consequence of removing science from the majority of staged crime scene analysis efforts. That is, this form of crime reconstruction is almost always a function of experience-driven observation, intuition, and surmise (i.e., the “special abilities” of the analyst), as opposed to an application of forensic science, analytical logic, and the scientific method. It should be of no surprise that this form of nonscientific reconstruction is also offered routinely when the physical evidence on its own cannot support the inferences needed to warrant a prosecution.

In the defense of nonscientific examiners, they may or may not have the first notion that their reconstruction opinions are unqualified and incomplete. They may also believe that presenting investigative theories in court as though they are reliable conclusions is an acceptable practice. Failure to distinguish between investigative opinions and forensic opinions (i.e., opinions that are “court worthy” or probative) is a major problem in many areas of court testimony and represents a significant training need.

“APPEARS STAGED”

Each investigator, profiler, and forensic examiner has his or her own subjective sense of those elements that, when discovered at a crime scene, indicate staging. Or at least, that is what they say in court. These can include circumstances such as the following:

There is no sign of forced entry.

Forced entry is evident.

The drawers in a room have been removed and dumped out carelessly to give a "ransacked" appearance.

The drawers in a room have been removed and stacked carefully to protect or preserve the content.

No search for valuables is apparent.

Only particular items have been stolen.

No items have been stolen.

The victim had life insurance.

The victim's death profited a family member, household member, or intimates in some way other than life insurance (anger, revenge, trust fund, unfettered access to a large bank account, etc.).

Any or all of these circumstances may raise the suspicion of the alert investigator, and there is nothing inherently wrong with suspicion. However, these circumstances also occur in cases in which there is no staging. Careful readers will note that they are not even useful as red flags because they cover almost all possibilities with respect to each particular circumstance (i.e., the point of entry will either be forced or not, items of value will either have been stolen or not, and the scene will either be ransacked or not). Suspicion justifies further investigation; it tells the investigator where to look for more evidence. Suspicious circumstances are not themselves evidence, however. They are hypotheses that must be tested with the evidence; they do not signal the end of inquiry but rather its beginning. If forensic examiners do their long division and work to disprove these theories, they may discover that what appears to be evidence of staging may ultimately be something else.

Let us consider the issue of "ransacking." If the crime scene "appears ransacked," which is used to support the inference of staging, at least the following must be established:

That the ransacked appearance is a departure from the normal appearance of the scene.

That the ransacked appearance is the direct result of offender activity, not crime scene personnel.

That the ransacked appearance was unrelated to a search by the offender for items of value (cash, checkbooks, jewelry, firearms, etc.).

That the ransacked appearance was unrelated to a search by the offender for a specific item of interest (vehicle keys, illicit drugs, prescription medications, personal items of a fetishistic value, etc.).

If the forensic examiner can eliminate these possibilities, then it can be argued that ransacking may support the inference that the scene was staged. We emphasize *may* because it is only one indication and must be considered in context with all of the other evidence.

Let us also consider the issue of "valuables." The issue of whether or not valuables have been taken from the crime scene is often a major consideration with respect to establishing the elements and motive of a crime. Some examiners are quite comfortable assuming that the offender took valuables, despite having no evidence that the item even existed, because it is helpful in promoting their theory of a case. For those examiners and all others, a certain threshold line of inquiry for each item of value is required:

What was the item? What is its value?

Where was the item located in the scene?

Who knew of the item's existence?

Who knew where the item was located?

What barriers did the offender overcome to locate and remove the item (was it hidden or in a safe; was it in plain sight on the kitchen table)?

What evidence demonstrates that it was actually removed from the scene?

What evidence demonstrates that it was the offender who removed it from the scene? Has forensic testing established a clear association of any kind?

Has the item been located? If so, where?

As already discussed, it is common for those who have staged crime scenes to appear as burglaries gone awry to forget their purpose and not remove valuables, they may simply remove a few items of value to create a superficial illusion, or the scene may not have been staged at all. For example, the following are all possibilities when considering why there are items of obvious value remaining in the scene.

The offender was interested in items of a personal or fetishistic nature; they may be removed from the scene undetected in many cases.

The offender was under the influence of controlled substances during the crime and was fixated on locating something specific.

The offender was not there to steal anything but, rather, entered to satisfy other desires, such as rape or fetish burglary, for which there may or may not be clear indications, depending on the level and quality of scene documentation.

As with any circumstance at the crime scene, the removal of valuables must be considered in context with all of the other evidence. Cash in particular is difficult because proving its existence is not always easy, although it is certainly not impossible. Seeking to answer the previous questions will set the reconstructionist on the right path and help establish the relevance of the items of value that have been stolen from the scene or that may have been left behind.

What appears to be ransacked, what appears to be missing, and what appears to have been left behind tend to be of primary concern to investigators who testify regarding crime scenes that "appear to be staged." As this section indicates, appearances may be deceiving. This is especially problematic when investigative theories and suspicions are offered in court as pseudo-expert conclusions.

Forensic reconstructionists have an obligation to test their theories against the known evidence and to do their reconstruction homework. In their final analysis, they should not be interested in how the scene appears based on their experience but, rather, in what can be established about its appearance through the physical evidence.

USE OF CRIME RECONSTRUCTION TO DETERMINE STAGING

It should be clear by now that we are concerned with preserving the science in the application of forensic science, as well as in any reconstruction-oriented examinations and testimony. As shown in the previous section, far too often reconstructions are allowed in court absent these considerations. For the forensic reconstructionist, we offer several suggestions.

The crime scene is full of information that can be used to detect staging, but even experienced investigators can miss it. Staging is undoubtedly present in more cases than it is found; however, the evidence dynamics (influences on the crime scene; see Chapter 6: Evidence Dynamics) can alter, obscure, or obliterate evidence and render it impossible to detect. In order to see through the evidence dynamics in a staged crime scene or any other, keen observation of the bloodstains, clothing, hair, body position, trajectories, and other evidentiary relationships is necessary. The knowledge, skills, and ability to interpret these evidentiary relationships are precisely the arena of the forensic generalist and reconstructionist.

However, the proper mind-set is also necessary. The easy road, followed by many, is to fit the evidence to one's theory of the crime. This is an approach that will lead to wrongful convictions and professional/departmental embarrassment. If the evidence does not fit the theory, then the theory must be reworked. None of the physical evidence may be excluded or ignored. This is especially true when witness statements and physical evidence differ. A witness's statement, like an investigator's theory, represents one person's view of the crime that may or may not be accurate. In other words, the witness statement is one more description of events to test against the physical evidence.

Staging needs to be considered as a possibility in every case. However, the forensic reconstructionist does not set out to prove that a crime scene has been staged or to prove anything else for that matter. We set out to disprove the known possibilities. Like investigative theories and witness statements, staging is one more explanation for the crime that must be tested repeatedly against any and all known evidence.

The scientific method demands that all of the known evidence in a case must fit a reconstruction theory, not just some, or the theory must be discarded. As stated better by noted historian Peter Novick (1988, p. 46), "The value of an interpretation is judged by how well it accounts for the facts; if contradicted by the facts, it must be abandoned."

What kind of evidence does the reconstructionist look for in order to detect staging efforts in a crime scene? Generally, we must look for any evidence that does not fit the acts suggested or represented by the overt circumstances. In some cases, it may be just one piece of evidence, or its absence, out of necessary step with a particular event or series of events. In others, staging may be evidenced by a system of interrelated evidentiary inconsistencies. Each case is different and must therefore be examined scrupulously.

Although not all-inclusive, the following topics are meant to help the reconstructionist begin to tackle the staging issue. The questions provided are intended to stoke the fires of reconstructionists' imagination and then lead them to new areas of inquiry. They are not meant to be exhaustive.

Point of Entry/Point of Exit

Among the most commonly staged crime scene elements is the open or broken window (Turvey, 2008). In the mind of the crime scene simulator, this creates the illusion that an offender could possibly, if not certainly, have entered the scene at that location. Examination of the point of entry and point of exit is therefore of greatest consequence to the reconstructionist. The following general guide is helpful:

Establish all points of entry and exit throughout the scene (doors, windows, paths, roads, etc.).

Establish whether or not these locations were passable at the time of the crime (e.g., some windows and doors may be barricaded or sealed permanently, and some windows may be too high).

Determine their involvement in the crime by virtue of documenting transfer evidence (blood, fingerprints, broken glass, dropped items, etc.) and negative transfer (the absence of footwear impressions in mud outside a window, the absence of any signs of forced entry, etc.).

Determine whether or not entry and exit were possible in the manner required for the crime at hand in terms of breaking in from the outside, removing any valuables, and the existence of requisite transfer evidence—this may require some experimentation by the reconstructionist.

Determining whether or not there is sufficient evidence that an offender could have entered and exited the crime scene in the manner required, with the evidence that must necessarily be altered or transferred at that location, is often the single most dispositive feature with respect to establishing crime scene staging. Most staged homicide scenes are domestic homicides committed in the victim's home. The stranger offender needs to get in, and the stranger offender needs to get out. In disproving this possibility, by virtue of an entry/exit point that is a locked double dead-bolted door or a window that is covered with undisturbed dust, what remains is the possibility of staging.

EXAMPLE

One of the authors (Turvey) was asked to help investigate the crime scene in a potential fetish burglary/death threat case. The fact summary from the author's final report reads as follows:

According to the complaint report number •• filed on 9/13/•• by Det. No. 1, a 24 year old white female living in an apartment at ••, returned home from her place of work at 2200 hours to find that her apartment had been "ransacked." As well, some of her personal belongings were broken, and others are thought to be missing. No items of value were apparently taken. She is currently employed by an off track betting facility, as well as having been a confidential informant for narcotics (contact: Det. No. 2, Narcotics) at the time of the complaint.

According to the victim's account and the account given by Det. No. 2, the victim first had two friends come over and help her investigate the apartment. Then, per her procedure as a confidential informant, she paged her contact from a pay telephone on the street. Det. No. 2, her contact, arrived at the scene shortly and spoke with her in his vehicle before he performed a canvass of the area.

According to information provided to this examiner, the offender appears to have entered the apartment through the front (living room?) window from the outside. Apparently, the front window was forced open from the outside and then laid down on the floor inside of the apartment. Attempts made by Det. No. 2 at the scene to reinstall the window were not successful. A tennis shoe footwear pattern was found on this window.

According to the victim's account, the victim's dog (a pitbull) was left secured to her front door. When she returned, she found it in the bedroom. It is apparent from the amount of damage and behavior described at this scene that the offender spent a significant amount of time there (perhaps as much as an hour). It is also apparent, given that the dog was moved that the offender preferred to spend time in the front room and bedroom without the dog present.

According to Det. No. 1, he and the victim searched the 2nd floor rooftop of the victim's building for evidence on 9/24/••. They found several seashells on the rooftop, which had belonged to a collection owned by the victim, that lead from above the victim's window to an area on •• Street above a Blimpies restaurant. A blue pen, which is consistent with the type used to write the note and damage the photos, was found outside of the victim's bathroom window. A cut was found in the shade of one of the windows.

Given these facts, it [has been argued that it is] likely that the offender exited though the front window, climbed up to the roof, then walked over the area near or above Blimpies and made his exit from the rooftop.

It is also likely that he exited the same way he entered. It is further possible, though not established, given the dropped pen and the cut shade, that the offender waited for the victim to arrive home and surreptitiously viewed her reaction to his activities before finally leaving.

The offender allegedly broke into the victim's home, cut up or otherwise defaced many of her personal photographs with pen marks through her neck, left a number of pornographic videos behind, and wrote a death threat that was left on her pillow.

After being called in to the case and examining the evidence, Turvey, with the assistance of police investigators, established the following:

The window could not be removed from the outside of the building.

Even if the window could be removed from the outside, it would have to be dropped into the apartment and likely would have broken; it was unbroken.

Even if the window could be removed from the outside and then could have been dropped into the apartment without breaking, the act of stepping on it would have caused breakage.

The victim's dog hated strangers, yet the offender moved it from the front door area to the bedroom and shut it inside without incident.

Shortly, this information led to other inconsistencies in both the evidence and the alleged victim's timeline, as well as that of Det. No. 2. Ultimately, it was learned that the alleged victim and her handler, Det. No. 2, who was married, were involved in a personal relationship and that she had staged the scene to get his attention. The detective came to her aid as requested, and they spent 2 or 3 days in her apartment reviewing the evidence (the aforementioned tapes) before contacting anyone else and filing a police report.

Weapons at or Removed from the Scene

Of every weapon found at a crime scene, ask at least the following: Is the weapon found with the victim the one that caused the injury; if not, what was its purpose at the scene? Was there another weapon found at the scene? Does it have a known purpose?

EXAMPLE

A rifle was found beside an apparent suicide. Dr. John Thornton (personal communication, 1988) brought a class of students to the scene as part of an educational exercise. After the police had "finished with the scene," one of the students looked at the rifle and noted spider webs in the barrel.

The suicide theory was abandoned and the investigation was reopened as a possible homicide.

In this example, the suicide theory hinged on the rifle being used by the victim to inflict the fatal injury. Because the victim had died of a gunshot wound, and the rifle was the only weapon found at the scene, disproving its involvement in the victim's death was the only step necessary to cast doubt on the theory of suicide and suggest that the scene had been altered.

Sometimes there is evidence of weapons use at a crime scene but no weapon can be found there. For each crime scene it must be asked whether evidence exists that a weapon has been

removed and, if so, what purpose could its removal have served? If the answer to the first part of the question is no, answering the second part of the question becomes unnecessary.

Firearms

A firearm of some kind is the most likely weapon of choice in a staged crime scene (Turvey, 2008). It follows that the reconstructionist must be prepared to ask certain basic questions of each firearm in order to determine its involvement in the crime.

First, are the wounds consistent with the story presented? In suicides, could the victim have shot himself or herself? (See Figure 9.1.)

Then we must ask whether the firearm is loaded correctly, in a manner consistent with the evidence and the statements of witnesses.

EXAMPLE

A man claimed to have been sleeping in the bedroom when his wife shot herself with a shotgun using a bent coat hanger. The shotgun was found to be loaded to capacity with a live round in the chamber (Tulare County, W. Jerry Chisum and David Burd, 1969).

Next, is the hammer down on an empty casing? And is it the right casing? Furthermore, is the rotation of the cylinder consistent with the way the shots were fired?

EXAMPLE

The perpetrator in a particular case fired two shots into the head of the victim. He then reloaded the chamber and fired one more to “put gunshot residue” on her hand in an attempt to stage the scene as a suicide.



FIGURE 9.1 In this case, a young male's deceased body was found in his vehicle, engine on, in an open field, with a single fatal gunshot wound to the head. A 20-gauge shotgun was found across his lap, pointing toward a broken window with a round hole in it. However, an expended shotgun shell was found outside the broken window on the ground along with several cigarette butts. Furthermore, there was no brain, blood, or hair material inside or outside the shotgun barrel or on the victim's hands and wrists. Also, there was brain and bone material on the stock of the shotgun in such a manner as to suggest that it was delivered to that surface in situ. Add to this the fact that the victim's truck had suffered new damage to the front end, as though it had struck something, and was still leaking radiator fluid when discovered by authorities. The inescapable conclusion is that the decedent could not have fired the shotgun without some resulting transfer nor could he leave behind a spent shell to be discovered outside of the vehicle. This case was closed as a suicide, the cigarettes were not collected, and the body was cremated without autopsy.

Apparently, the perpetrator became confused when reloading at the scene and put one of the empty casings in the wrong chamber. Note that the pen tip in [Figure 9.2](#) indicates where the hammer was resting, and the arrow indicates the direction of rotation. The firing pin impression is wrong on one casing (Tehama County, Joe Rynearson, 1994).

Another question to consider is whether the firearm found at the scene is defective or not? Is it capable of chambering rounds and firing them?

EXAMPLE

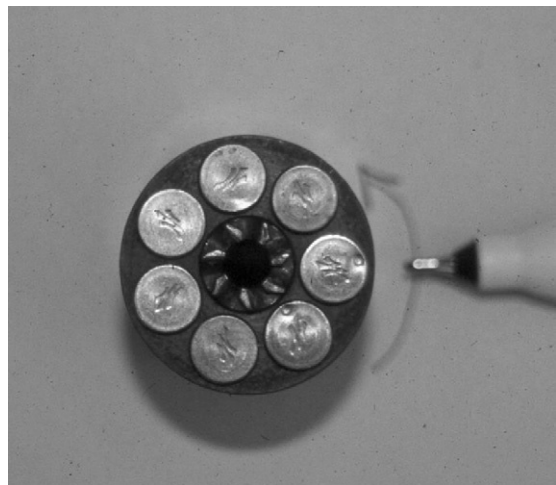
A man claimed that his 25 ACP could not have been used to shoot his wife as it was actually defective. He had taken it to a gunsmith a few days before the shooting because it would not work. The gunsmith testified that it would take at least 4 hours for him to correct the problem. The reconstructionist removed a screwdriver from his pocket, moved a screw, and showed that the gun was fully functional (Imperial County, W. Jerry Chisum and Ted Elzerman, 1968; Ted testified).

These questions are designed to establish a firearm's involvement in a particular case and should be answered in every reconstruction in which firearms are involved—not just those concerned with staging.

Gunpowder Deposits

Gunpowder deposits are composed of carbon, soot, unburned gunpowder, and the components of gunshot residue (GSR). Burning powder comes out of a gun barrel (and elsewhere, depending on the firearm design) and will, upon contact with skin, cause powder burns. These deposits must be consistent with the supposed act.

FIGURE 9.2 This cylinder was reloaded incorrectly by the perpetrator when he was staging a suicide. The pen marks the casing under the hammer, and the direction of rotation is indicated by the arrow. In this case, the cylinder was marked with an indelible marker prior to picking up the gun.



Most suicides are contact or near-contact shots. The powder distribution must be something that can be caused by the person holding the gun. A lack of powder indicates that there is a greater distance or that there was an intervening target.

EXAMPLE

A woman shot her sleeping husband on the couch. She used a throw pillow to muffle the sound. Then she placed the gun in his hand and placed the pillow under his head. There was no powder on his head, but it was present on the bottom of the pillow under the exit wound (Tuolumne County, W. Jerry Chisum, 1978).

Powder can be carried for as much as 3 feet from a person into the wound. A forensic pathologist must examine the bullet track to determine if powder particles are present. A single particle is insufficient proof of close range because fired bullets can have a particle stuck in the lubricating grease that will remain on the bullet for some distance.

To get GSR on the hand of the victim, the gun may be held close to the hand and fired. If it is close enough, gunpowder deposits will result and there may even be powder burns. The resulting pattern may not be consistent with the manner in which the gun can be held. In other words, the presence of a gun in the hand creates a void in gunpowder deposits that must be evident. If these patterns are different, it may indicate staging.

Movement of the Body

It is not at all common for staged crime scenes to involve movement of the victim's body to a secondary scene or "dumpsite" (Turvey, 2008). Typically, the scene is staged at the location where the body has fallen, perhaps even because of where the body has fallen, out of convenience. This may include the inability to move the body or the inability to sufficiently clean the scene before the body may be discovered. To determine whether this is the case, care must be taken to examine the conditions and circumstances that best address this issue. In each scene, this will depend on the interaction between the victim and the victim's environment, and the expected transfer evidence. This can include consideration of (but is certainly not limited to):

Evidence of drag trails and drag stains on the ground and against environmental surfaces (i.e., bunched carpet, heels dragged across mud, bloodstains leading in from another room)

(Figure 9.3)

Bunched or rolled-up clothing on the victim's body

Livor mortis inconsistent with the final resting position of the body (blood pooling against gravity)

Rigor mortis inconsistent with the final resting position of the body (joints stiffened against gravity)

Blood evidence in places where there should not be any

Trace evidence on the body from locations unassociated with the crime scene

FIGURE 9.3 Female victim's nude body found on a steep riverbank. Law enforcement crime scene investigators and detectives insisted that the victim was rolled down the hill from the road above. Note the drag trail in the vegetation leading up from the water below and the victim's outstretched arms. Upon close analysis, duckweed from the river was identified on the victim's body.



Clothing

Is the clothing pulled or rolled in a particular direction? A person being pulled by the feet will have their shirt pulled up, with the most deviation being on the side that was in contact with the surface. A person pulled by the hands will have the pants pulled down and the shirt stretched tight, and the legs will be extended. The hands may be placed in a “normal” position.

Consider also the following:

Has the clothing been removed from the victim or the scene? What purpose may this have served?

Have the pockets been searched? Are they pulled out even partway?

Has the body been rolled, causing the clothing to be distributed unevenly?

Are there smears of something on the clothes that indicate the body was dragged through something (soil, vegetation, water, etc.)?

Is there anything unusual about the clothing? Is anything inside out or backward?

Does it appear as though the victim may have been redressed after being attacked? If so, why were the clothes off in the first place and why would the offender bother to redress the victim—what purpose would that serve?

The reconstructionist may need to conduct experiments in order to determine how the clothing got the way that it did.

Shoes

In traffic accidents, the bottoms of shoes will have parallel scratches indicating the direction and location of the injuries to the body and the foot on which the victim was standing. If these scratches are missing, either the accident was at very low speed or the body was dumped at this location.

Consider the following:

Are the shoes on the correct feet?

Do the shoes have any transfer evidence inconsistent with the scene?

Was the victim wearing them during the commission of the crime or do the bottoms of the victim's feet indicate that the shoes may have been off (blood, injury, or scene transfer such as mud or gravel)?

Where are the knots in the strings?

A person tying his own shoes will bend over and tie them in the middle or lift the leg, cross it over the other, and tie the shoe so the knot is on the inside. A mother tying a child's shoe may tie it so that the knot is on the outside. When putting the shoes on a dead person, this mistake is easy to make.

Bloodstains

Bloodstains are a record of actions that occurred when blood was shed. The one rule that is always in effect with blood is that gravity works. Blood runs down, only going in a different direction if acted upon by another force. Again, blood runs down, never horizontal.

First, is the blood going in the direction it should, given the position of the body and gravity?

EXAMPLE

A man shot his wife while she was sitting on the bed. He lowered her to the bed and drove to a distant city. He called the police because she was not answering the telephone. He was sure a burglar had killed his wife in her sleep. The blood from the chest wound ran toward her feet, showing she was upright at the time of the shooting (Figure 9.4; Tulare County, CA 1998).



FIGURE 9.4 This woman was shot “by a burglar while she slept” claimed the husband. Note that the blood is running toward her feet, not the bed. The husband was convicted of homicide.

Next, are the bloodstains consistent with the purported actions of the victim and the suspect?

EXAMPLE

A woman was found by her husband with her head almost completely exploded from a 12-gauge shotgun contact blast. Most of the brains and tissue only went to the side out about 5 feet; however, two pieces of brain with scalp attached went out the door and struck the wall. The brains were responsible for two of the bloodstain patterns. The other originated approximately a foot from the corner of the opposite wall. Examination of the blood spatters on this wall showed that there were three separate acts that produced these stains. Two large stains were from the brains striking the wall, and the other was a castoff stain that did not originate from the area of the gunshot. There was a prior act that killed or seriously injured the victim, who then “committed suicide” (Tulare County, 1984).

Hair

The position of the hair is a frequently overlooked clue. Decedent hair can frequently show how the person came to the position in which she was found. This is particularly true with longer hair but not exclusively, because shorter hair may also show movement (Figures 9.5–9.10).

When a person is dragged, her hair will extend in the direction from which she came. If the head is raised and then lowered, the hair will be in a “pompadour” style; in fact, it may be on just one side if only one arm was used to pull with. A person with long hair who falls backward to the ground will have her hair flare out away from the head in a halo-like array. If falling to the front, the hair will also flare out from the head. It should not be under the face.

Hair also obeys the law of gravity. It will hang down unless something is acting on it. An injury that occurs sometime before death can cause hair to stick to the side of the head in drying blood. Drying blood can also capture hair movement on flat surfaces. Hair makes a pattern of very fine streaks.

In discussing all of these clues, one must know how the body can bend and move, and one must accept that gravity works.

A STUDY OF 25 STAGED CRIME SCENES

Materials and Method

The author selected cases from a national database of published and unpublished U.S. criminal and civil court decisions using a keyword search for the terms crime scene staging, scene staging, staging, staged crime, and simulated crime where crime scene staging was confessed to, witnessed, or established with the physical evidence. For the purposes of this study, crime scene staging refers to the alteration or simulation of physical evidence at a location where a crime has occurred or where a crime is alleged to have occurred in order to mislead authorities or redirect their investigation by attempting to simulate an offense or event that did not actually take place. Cases were reviewed manually and included or excluded based on whether the



FIGURE 9.5 Small person falling face down; note the hair. [Thanks to Julia and Kyra Chisum (the author's granddaughters) for assisting in illustrating the manner in which hair can be used to reconstruct activities.]

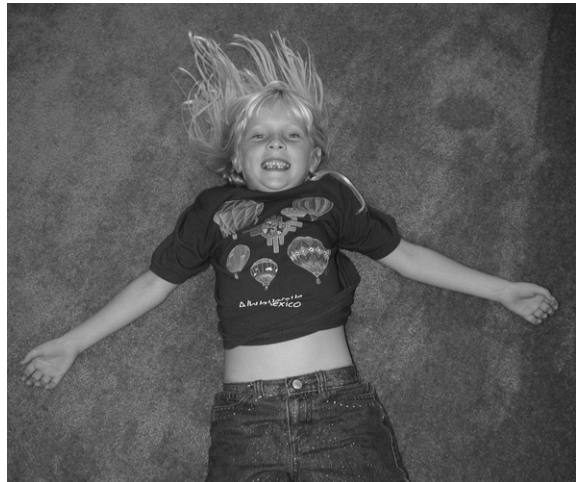


FIGURE 9.6 Note how the hair flairs out when a person with long hair falls to the ground.

FIGURE 9.7 The hair does not flair out as much on a small child.



FIGURE 9.8 When a person is dragged by the feet, her hair will trail pointing back to where she started. Note how the shirt has been pulled up due to friction.



preceding definition and conditions were evident. Using these parameters, a total of 25 usable cases involving crime scene staging, with 33 offenders and 31 victims, were identified from decisions rendered between the years 1980 and 2000.

Given the finding that 100% (25) of the cases studied involved at least one offender and at least one victim with a prior family/intimate relationship and that 84% (21) of the cases studied occurred inside or outside of the victim's home, the comparison of these data with published data from prior studies on intimate violence is appropriate (Bureau of Justice Statistics, 1998; Mukherjee et al., 1983).

This study did not include the consideration of cases where alleged victims of crime engaged only in self-injury to support false reports of rape, assault, kidnapping, and other similar fraudulent claims. While self-injury cases should be included under the umbrella of staging, as the

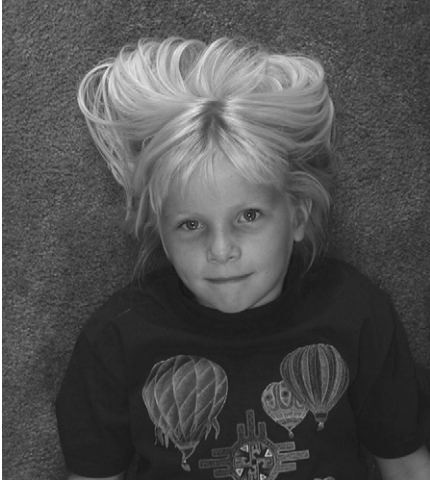


FIGURE 9.9 The person was dragged by her arms and then was laid down and her arms put by her sides. Note the puffed up hair that was trapped by the head. The pants (not shown) will be pulled down at the waist due to friction.



FIGURE 9.10 The hair shows that the person was rolled from her side or stomach onto her back over her right (the side with the hair) side.

victim's body is certainly an extension of the crime scene, the focus here is on the alteration of physical evidence at the alleged location of the crime. Literature specific to the study of cases involving self-injury is a bit more advanced and includes the following works: [Achache et al. \(1999\)](#), [Baedeker et al. \(1987\)](#), [Harms et al. \(1998\)](#), and [Pedal \(1994\)](#).

Results

Total cases: 25

Total offenders: 33

Total victims: 31

Discussion

Offender Characteristics

Table 9.1 provides an account of basic offender characteristics. At least one male offender was involved in the commission of the crime in 21 cases (84%), with a total of 25 male offenders, who constituted 75.76% of the total offenders. In 17 (68%) of the cases, only male offenders were involved. At least one female offender was involved in 4 cases (16%), with a total of 8 female offenders, who constituted 24.24% of the total offenders. In 4 (16%) of the cases, only female offenders were involved. In 4 (16%) of the cases, both male and female offenders were involved.

This is a contrast to data published in Mukherjee and colleagues (1983), who studied 151 homicide cases reported to the Chicago police during 1981 involving a victim and an offender (or suspected offender) of the opposite sex. In that study, 70 (46.36%) of the offenders were male and 81 (53.64%) were female. There the cases seem to divide somewhat evenly between male and female offenders, while in the current study of staged offenses males comprise a clear majority. Bureau of Justice Statistics (BJS) (1998), a more recent longitudinal study on "Violence by Intimates," declined to address the specific issue of sex differences among offenders across different types of cases.

An interesting finding of the current study, presented in Table 9.1, was that 4 (16%) of the cases studied involved the hiring of a hit man by one spouse to kill the other. This data split evenly, with the husband doing the hiring in half of the cases and the wife doing the hiring in the other half.

Of investigative relevance is the finding in the current study that 11 (44%) of the cases involved a confession by the offender and 6 (24%) of the cases involved a confession by a coconspirator or confidante of an offender. Only 3 (12%) of the cases studied involved a confession by both. This means that a total of 14 (56%) cases involved some form of confession. In almost every

TABLE 9.1 Offender Characteristics

	Cases/offenders	% Total cases	% Total offenders
Male offenders	21/25	84.00	75.76
Female offenders	4/8	16.00	24.24
Male only	17	68.00	
Female only	4	16.00	
Both	4	16.00	
Hired hit men	4/5	16.00	15.15
Hired by husband	2/3	8.00	9.09
Hired by wife	2/2	8.00	6.06
Offender confession	11	44.00	
Coconspirator confession	6	24.00	
Both	3	12.00	

case, the confession was achieved in no small part through confrontation of the offender or coconspirator with the inconsistencies of the coconspirator's statement in relation to the physical evidence at the scene. That is to say, crime reconstruction played a major role in identifying the factual inconsistencies and "defects of the scene" and subsequently assisted greatly in achieving a reliable confession of some sort. This also means that 11 (44%) of the cases studied did not involve a reliable confession. In those cases, crime reconstruction was ultimately used to prove, through the testimony of police officers and forensic experts, that staging had occurred, again demonstrating its importance in such cases.

Victim Characteristics

Table 9.2 provides an account of victim sex and relationship characteristics. At least one female was the victim of a homicide in 17 (68%) of the cases studied, for a total of 17 (54.84%) female victims. None of the cases studied involved multiple female victims. At least one male was the victim of a homicide in 11 (44%) of the cases studied, for a total of 14 (45.16%) male victims. Only 2 of the cases studied involved multiple male victims: a triple homicide with 2 male victims and a triple homicide with 3 male victims.

TABLE 9.2 Victim Characteristics

	Cases/victims	% Total cases	% Total victims
Female victims	17/17	68.00	54.84
Male victims	11/14	44.00	45.16
Male only	8	32.00	
Female only	14	56.00	
Both	3	12.00	
Family/intimate relationship with one or more offender	25/29	100.00	93.55
Wife	13/13	52.00	41.94
Husband	4/4	16.00	12.90
Son	3/4	12.00	12.90
Friend	2/2	8.00	6.45
Father	1/1	4.00	3.23
Mother	1/1	4.00	3.23
Boyfriend	1/1	4.00	3.23
Mistress	1/1	4.00	3.23
Girlfriend's daughter	1/1	4.00	3.23
No family/intimate relationship with one or more offender	2/3	8.00	9.68
Witness	1/2	4.00	6.45
Business partner	1/1	4.00	3.23

Also shown in [Table 9.2](#) is the finding that 25 (100%) of the cases studied involved 29 (93.55%) victims who had a current or prior family or intimate relationship with the offender. The 3 remaining victims include 2 collateral victims and 1 business partner (from the same case, *California v. Bolin*).

Of those victims who had a current or prior family or intimate relationship with the offender, the most striking finding is that 13 (54.12%) of the cases and 13 (46.43%) of the victims studied were wives (including one ex-wife) killed by or at the direction of their husbands. Husbands ranked second, comprising only 4 (16.67%) of the cases and 4 (14.29%) of the victims studied. Sons ranked third, comprising 3 (12.5%) of the cases and 4 (14.29%) of the victims studied. In those cases, the son was never the primary victim and was killed subsequent to the killing of his mother.

As shown in [Table 9.3](#), six (24%) of the cases studied involved multiple offenders and four (16%) involved multiple victims. Of these offenses, two were double homicides and two of them were triple homicides. It is interesting to note that both double homicides in the current study, as well as one of the two triple homicides, involved a mother and her son(s) being killed by a husband (in one of the double homicide cases, they were actually killed by two hired hit men).

These current findings contrast with those presented in [BJS \(1998\)](#), where victim/offender relationship data from 446,370 victims of murder and nonnegligent manslaughter from 1976 to 1996 are provided. In that study, 340,687 (76.3%) of the victims were male and 105,175 (23.7%) of the victims were female.

These current findings also contrast with those presented in [Mukherjee and colleagues \(1983\)](#), where it is stated "half of all intersexual killings involved prior intimate or familial relationship."

The findings of the current study in this area are of investigative significance, as they provide preliminary support for the hypothesis that crime scene staging is used most commonly to conceal an offender's close relationship with the victim(s). It would be a mistake to conclude from this that every case of staging is the result of an offender trying to conceal a close relationship with the victim based on data presented here. However, viewed as an investigative tool, this finding can be used to place that possibility at the top of the list of investigative possibilities and to thereby narrow the initial suspect pool.

Offense Characteristics

[Table 9.3](#) provides an account of the various offense characteristics examined in this study. Of the cases studied, staging was used in 25 (100%) of them to conceal the crime of homicide. This is certainly not the only type of criminal act or event that staging may be used to conceal, as shown by [Gross \(1924\)](#) and more recently by [Adair and Doberson \(1999\)](#). However, it may be the one that investigators are most familiar with and subsequently the most prepared to recognize.

[Table 9.3](#) goes on to show that, by a wide margin, the most popular form of staged offense is stranger burglary, involving 13 (52%) of the total cases. Suicide was a distant second, involving 14 (16%) of the total cases. Most commonly, the staging would occur with the body found in the bedroom [17 (68%) of the total cases]. It is difficult to refrain from speculating that this is a functional effect as opposed to something deliberately planned in advance. That is to say, the type of staging seen most commonly may be born of convenience in association with a domestic homicide. As stated in the first line of [Mukherjee and colleagues \(1983\)](#): "It is criminological cliché that a person is safer in Central Park at three o'clock in the morning than in his or her own bedroom."

TABLE 9.3 Offense Characteristics

	Cases	% Total cases
Staging intended to conceal homicide	25	100.00
Multiple offenders	6	24.00
Multiple victims	4	16.00
Staged offense		
Burglary	13	52.00
Suicide	4	16.00
Roadside robbery	2	8.00
Accidental drowning	1	4.00
Burglary/execution	1	4.00
Drug deal	1	4.00
Execution	1	4.00
Motor vehicle accident	1	4.00
Sexual homicide	1	4.00
Location of staged scene		
Bedroom	17	68.00
Vehicle on roadside	4	16.00
Living room	2	8.00
Outside of home	1	4.00
Swimming pool	1	4.00
Weapons		
Handgun	12	48
Rifle	4	16
Knife	3	12
Car seat	1	4
Fire extinguisher	1	4
Lead weight	1	4
Manual strangulation	1	4
Pantyhose	1	4
Unknown	1	4
Wooden dowel	1	4

TABLE 9.3 Offense Characteristics—Cont'd

	Cases	% Total cases
Multiple weapons used (knife + handgun)	1	4
Available weapon(s) used	11	44.00
Staged elements		
Offender "discovered" victim	18	72.00
Window opened/damaged	12	48.00
Removed valuables	7	28.00 (43.75% of 16 total staged burglary and robbery cases)
Emptied drawers	6	24.00 (100.00% of 6 total staged suicide cases)
Weapon(s) arranged	6	24.00
Body transported	2	8.00
Fake note	2	8.00 (100.00% of 2 total staged execution cases)
Drugs planted	2	8.00
Self-inflicted wound	2	8.00
Blunt trauma	1	4.00
Gunshot to chest	1	4.00
Telephone disabled	2	8.00
Porch light disabled	1	4.00

These findings gain more perspective when considered alongside findings associated with offender weapon use. Most commonly, the offender used a handgun [12 (48%) of total cases] or a rifle [4(16%) of total cases]. This is consistent with the findings presented in [BJS \(1998\)](#), where it is stated that in 1996, 65% of all intimate murders were committed with a firearm.

Surprisingly, in the current study, the weapon used by the offender was in fact available material in 11 (44%) of the cases. This means that in 14 (56%) of the cases studied, the offender brought the weapon into the scene. This finding is a strong indicator of some level of offense planning and forethought in those 14 cases and a similar lack of offense planning and forethought in the other 11.

[Burgess and colleagues \(1992, pp. 76–85\)](#) make the unsupported statement that what they refer to as spontaneous domestic homicides are necessarily unstaged and triggered by recent stressful events or a cumulative buildup of stress. They go on to state, however, that what they refer to as staged domestic homicides necessarily involve planning and more controlled, orderly crime scenes where less evidence associated with the true offender may be expected. These unsupported statements leave readers with the impression that a spontaneous domestic homicide cannot involve staging, and that staging suggests a sophisticated, cunning, and even emotionally controlled offender. The findings of this current study do not support this, given the evidence of overkill, unsophisticated staging, and lack of offense planning demonstrated in

the 25 cases, a number of which resulted from circumstances consistent with spontaneous domestic homicides. Only the staging was subsequently planned, and often not very well.

Of note is the low incidence of strangulation deaths, involving only two (8%) of the total cases. The first case involved a 28-year-old male parolee who befriended, then eventually robbed and manually strangled, an arthritic 87-year-old woman. The offender strangled the woman in her bed, stole a total of \$5 from her purse, and then tried to make it appear that a burglar had broken in and committed the crime by damaging a window and emptying out drawers (*Massachusetts v. Hunter, 1998*). The second case involved a man who strangled his wife to death with pantyhose and then arranged her body in the bedroom to appear as though, again, a burglar had broken in and committed the crime by emptying out drawers and moving around items in the scene (*Virginia v. Evans-Smith, 1989*). This becomes of interest to the investigator when suggestions are made about either injury to the neck in general, or strangulation in specific, being associated with someone who knows the offender well. These findings do not support such claims. The need for research involving victim/offender relationships and injury is clearly indicated.

Table 9.3 also provides a detailed breakdown of the specific types of elements that offenders staged, or attempted to stage, in relation to the crime scene itself. Most surprising to this author was the finding that in 18 (72%) of the cases studied, the offender was the one who initially “discovered” the victim’s body. In more than a few of these cases, this involved elaborate presentations of shock and grief, and the enlistment of others to “discover” the body with them. This finding is in direct conflict with the common notion that offenders who commit such crimes wish to leave the body to be found by others and dissociate themselves from the scene entirely. However, given the overall lack of sophistication evident in the staging uncovered in these 25 cases, this finding does not support the notion that “discovering” the body is part of an elaborate attempt to contaminate or obliterate trace/transfer evidence. What this finding does begin to suggest is that, in a domestic case involving suspected staging, the failure of a suspect to be involved in the discovery of the victim, by itself, is not the red flag that some might think it is. Rather, what it begins to suggest is that, in a domestic case involving suspected staging, the person(s) who discovered the victim’s body should be a priority for elimination as a suspect.

Another surprising finding was the number of cases involving valuables removed from the scene [7 (28%) of total cases]. This becomes more significant when we consider that this accounts for only 43.73% of the 16 total staged burglaries and robberies. A reasonable person would imagine that to stage a crime effectively where the offender was interested in stealing valuables, offenders would think to remove valuables from the scene to help complete the illusion. Clearly this is not the case. This, in combination with the frequent use of available material, speaks to the lack of sophistication evident in overall offender efforts to stage crime scenes, as mentioned previously.

Of further relevance to investigators is the finding that only two (8%) of the cases studied involved transportation of the victim’s body to a secondary scene. The first case involved a man who killed his wife with a blunt force object and then staged her death to look like an automobile accident (*Mississippi v. Whittington, 1988*). The second case involved the killing of a man’s ex-wife by three coconspirators (one female) with a shotgun. The victim’s body was driven to a road out in the country and then staged to look like a sexual homicide (*Texas v. Bellah, 2000*). It would be a mistake to conclude from this finding that in every case involving a secondary scene, the possibility of crime scene staging should not be seriously considered. It is crucial to

be aware of the possibility that this finding may have occurred because as secondary crime scenes are involved, investigators are less able, or less willing, to recognize crime scene staging.

The last item that bears discussion from Table 9.3 is the absence of the use of fake notes in any of the six (24%) staged suicides that were studied. Fake notes were evident in two (8%) of the staged cases, however, and both of those were intended to look like retaliatory executions. One of those execution cases involved a husband staging the homicide of his wife, and the other involved a wife staging the homicide of her husband (*Minnesota v. Mills, 1997; Virginia v. Bailey, 2000*).

This finding fails to support the investigative notion that staged suicides will often or even generally involve suicide notes. In many of the suicide cases studied, an associated issue was perhaps one of time. That is to say, the offenders did not have or give themselves the time, often through lack of planning, to engage in that level of sophistication.

Offender Motivations

Table 9.4 presents findings related to offender motivations. Motive was determined by either the existence of a confession as to motive or the existence of unequivocal behavioral evidence supporting the motive. Not surprisingly, given that the sample is comprised exclusively (100%) of domestic homicides, the motives involved either anger or profit. This includes 15 (60%) of the cases involving anger motivation and 12 (48%) of the cases involving profit motivation. Of note is that 2 (8%) of the cases involved both motivations.

One unexpected finding was the absence of overkill in seven (46.67%) of the cases where anger was the motive. It is commonly believed that evidence of overkill is suggestive of an anger motivation, as it was in eight (53.33%) of the anger-motivated cases studied. These findings do not support the argument, however, that the absence of overkill indicates an absence of anger. These findings do reinforce the evidentiary axiom that absence of evidence is not evidence of absence. The need for research involving the rate at which evidence of overkill is associated with domestic homicides (or intimate homicides) is clearly indicated.

Law Enforcement (LE) Offenders

Table 9.5 presents findings related to law enforcement offenders. Perhaps one of the most disturbing findings of this study was that five (20%) of the cases did involve an offender who was currently, or had recently been, in law enforcement. Of those cases, the majority were male offenders, four (80%), and there was a greater proportional variety of offenses that homicides were staged to appear as, with no clear favorite evident.

TABLE 9.4 Offender Motivations

	Cases	% Total cases
Anger	15	60.00
Profit	12	48.00
Anger + profit	2	8.00
Neither	0	0.00
Overkill evident	8	32.00
Overkill + anger	7	28.00
Anger w/o overkill	8	32.00

TABLE 9.5 Law Enforcement (LE) Offenders

	Offenders	% Total LE cases
Law enforcement	5	100.00
Male	4	80.00
Female	1	20.00
Hired hit man + LE	1	4.00
Staged offense		
Burglary	2	40.00
Roadside robbery	1	20.00
Sexual homicide	1	20.00
Suicide	1	20.00
Location of staged scene		
Bedroom	2	40.00
Vehicle on roadside	2	40.00
Living room	1	20.00
Weapons used		
Handgun	3	60.00
Rifle	1	20.00
Fire extinguisher	1	20.00
Available weapon used	2	40.00
Staged elements		
Offender "discovered" victim	3	60.00
Window opened/damaged	2	40.00
Removed valuables	1	20.00
Emptied drawers	0	00.00
Weapon(s) arranged	1	20.00
Body transported	1	20.00
Fake note	0	00.00
Drugs planted	0	00.00
Self-inflicted wound	1	20.00
Gunshot to chest	1	20.00
Telephone disabled	0	00.00
Porch light disabled	0	00.00

Of significance is the overall lack of skill evident in these staging attempts, which was not expected. For example, only one (20%) of the LE offenders transported the victim to a secondary scene in order to disassociate themselves from the victim, and in turn the victim from the primary scene. Additionally, only one (33.33%) of the LE offenders staging burglaries or robberies thought to remove valuables from the scene. And three (60%) of the LE offenders actually “discovered” the victim, none of whom made legitimate attempts to contaminate or obliterate trace/transfer evidence.

Findings

The findings of this study, which should be considered preliminary, are not without investigative relevance. As discussed, they support the consideration of several red flags associated with staged crime scenes and do not support several of the common investigative notions argued by previous authors. Additionally, future areas of research were identified, including the need to compare current findings with similar data derived from nonstaged domestic homicides occurring since the 1980s to establish a more useful baseline.

The early work of Dr. Hans Gross has been supported, however, all of which resounds in the literature today without much citation: Examine the forensic evidence carefully, corroborate/compare victim and witness statements with the evidentiary findings, reconstruct the crime meticulously, and assume nothing. Given this, the need for investigator training in even basic forensic evidence and crime reconstruction, and the discipline to employ it in every case, is evident. Failing this, preconceived theories of crime may yet prevent us from investigating and recognizing more complex staged crime scenes in the future.

CONCLUSION

Any interpretation of the physical evidence that suggests an action, an event, or a series of events, such as staging, is a form of crime reconstruction. This is the domain of the forensic scientist, preferably the forensic generalist. Although it is important for investigators and profilers to theorize and speculate as to what happened and how a crime may have occurred, these theories must ultimately be tested against the physical evidence. Investigators and profilers who proceed with a confirmatory mind-set and seek to interpret the available evidence in a light most favorable to their theory will have no trouble convincing themselves that theirs is the correct and only explanation for events. As provided in previous chapters, we can easily prove any theory so long as we go back through the evidence and ignore everything that would tend to disprove it. This is a common habit among nonscientists and is one of the reasons that the forensic scientist exists—as a filter for unfounded, untested, and ultimately unproven theories.

The scientific method demands that all known evidence in a case must fit a reconstruction theory, not just some, or the theory must be discarded. As stated better by noted historian Peter Novick (1988, p. 46), “The value of an interpretation is judged by how well it accounts for the facts; if contradicted by the facts, it must be abandoned.” Consequently, none of the physical evidence may be excluded or ignored. This is especially true when witness statements and physical evidence differ. A witness’s statement, like an investigator’s theory, represents one person’s

view of the crime that may or may not be accurate. In other words, the witness statement is one more description of events to test against the physical evidence.

Staging is a possibility in every case. Therefore, in every case, it must be considered and excluded before entirely abandoned as an explanation. It cannot be proven, however, through mere observation, intuition, and surmise. The evidence must be established reliably, conclusions must be tested empirically and rendered logically, and alternative explanations must be eliminated. Only then may staging be considered as the most viable explanation for events.

For guidelines on using crime reconstruction to interpret elements of staging, the reader should refer to [Chisum and Turvey \(2006\)](#).

SUMMARY

Staged crime scenes have been discussed in the investigative and forensic literature for more than a hundred years, as they have value in both realms. This literature is generally consistent in terms of definitions and the use of reconstruction techniques providing the basis for any related scene interpretations. Unfortunately, staging has not been studied adequately, and investigators infrequently possess sufficient education training to recognize and interpret them.

Establishing whether a crime scene has been staged requires crime reconstruction, which is a forensic discipline. Unfortunately, the majority of staged crime scenes are being interpreted by nonforensic personnel such as law enforcement investigators, including criminal profilers. The result has been interpretations of related evidence based on individual experience and other highly subjective measures.

QUESTIONS

1. What is the purpose of staging a crime scene?
2. True or false: The nature of ransacking at a crime scene is universally accepted as a method for establishing whether or not a crime scene has been staged.
3. Determining whether or not a scene has been staged requires education and training in _____, which is a forensic discipline.
4. True or false: Evidence of victim injury is confirmation that the person is a victim and that staging is not a possibility.
5. According to Hans Gross, what are the “defects of the situation” as they relate to staged crime scenes?³

³ It bears noting that Mark Safarik’s education with respect to forensic science consists of a series of law enforcement-taught short courses. He is not a forensic scientist, does not possess actual forensic science credentials, and yet holds himself out as a reconstructionist. He holds a B.S. in human physiology, and in 2007 he had only just received an online master’s degree in criminal justice, with no thesis requirement, no class time, and no internship. Moreover, his experience of “involvement” with more than 3000 cases is intentionally vague, such that it is not necessarily specific to cases that he’s actually worked or consulted on directly—it’s therefore unclear what his actual case experience was. Safarik’s resume is on file with the author.

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10

Trace Evidence in Crime Reconstruction

Meagan B. Gallagher and John I. Thornton

Wherever he went, his stick left a trace. –*Chao-Hsiu Chen*

Etiam capillus unus habet umbram. *Even a single hair has a shadow.* –*Publius Syrus*

Key Terms

Associative evidence; Bidirectional contact transfer; Control sample; Evidence; Trace evidence; Transfer evidence; Transfer of form (pattern evidence); Unidirectional contact transfer

The task of reconstructing a crime is a complicated undertaking, which may proceed along several avenues. Some of these avenues consistently work better than others, whereas others are rather treacherous. A brief review is warranted.

WITNESSES

Living witnesses may provide an account of what took place at the time the crime occurred. However, human witnesses are subject to some greater or lesser measure of frailty with respect to perception, description, and even candor. Some witnesses may deliberately elect to be uncooperative because of some hostility toward police, or authority in general, whereas other witnesses attempt to cooperate, but do not perceive the observed activity correctly. As any investigator quickly learns, an abundance of people fall into this latter category.

Surveillance cameras may have captured the action on tape or digital media, but the images may be deficient in terms of resolution or, for that matter, may be disappointingly pointed in a direction that fails to capture the activity of interest.

But witnesses need not be verbal, human, or even living; rather, witnesses may take on countless inanimate forms. The fundamental premise here is that during a criminal act, the activity often generates a record of itself. That record, if recognized and interpreted properly, may lead to a reconstruction of the crime. Since nature follows clearly identifiable patterns, we may use that record to tell a story.

PHYSICAL EVIDENCE

There is truly no limitation on what constitutes physical evidence. Anything, tangible or intangible, may become the physical evidence that helps us tell the story of what happened at the time of the crime; it may be as large and obvious as a truck or it may be so small that a microscope is needed to see it. In another case it may be as offensive as the odor of a decaying body or as subtle as a faint whiff of gasoline lingering after a fire. Here, we discuss only those small bits of evidence, often the most inconspicuous, but which have the ability to contribute to the reconstruction of the crime.

TRACES: THE SMALL BITS

For several reasons the small bits of evidence may have significance beyond what might be expected on the basis of their size. First, their occurrence may arise from processes that reflect the activities that generated them. Fracture, the broadcasting of fine particles, and adhesion of foreign particles come to mind. Second, because their size makes them inconspicuous, the existence of these minute particles often goes unnoticed by the perpetrator(s) of the crime. Finally, even if the individual were aware, he or she would find it difficult or impossible to do anything about it.

These small bits, or traces, may provide information that helps determine the factual circumstances of what happened at the time that the crime occurred. We call these materials **trace evidence**—an extremely broad category of physical evidence, but one of remarkable value.

Trace evidence has the capability of associating a person with a crime or telling us what actions took place. Examples of the former are a chip of paint from the car of a suspect found on the victim of a hit and run or a victim's hair found in the trunk of a suspect's car. An example of the latter is a trail of blood from one location to the place where the victim collapsed. The evidence may certainly serve both functions, and it is prudent not to make too much of a distinction between the two. Some cases are of the "whodunit" variety, whereas others are more properly of the "howdunit" type. Both are the subject of the crime reconstruction.

How trace evidence is viewed by courts and juries is also of relevant consideration. Trace evidence appeals almost universally to juries because (1) they often have some conversancy with the material—fitting a fractured coffee cup back together and the difference between red paint and blue paint is grasped easily—and (2) trace evidence comparisons often have an appeal to common sense, of which juries (and everyone else) tend to pride themselves.

No one has stated the value of trace evidence better than Dr. Paul Kirk, one of the principal forensic scientists of the 20th century. Turvey, in his introductory chapter to this work, commented on Kirk's development of the significance of physical evidence, but some amplification of Kirk's statements is appropriate here. Kirk (1953, p. 4) wrote:

However careful a criminal may be to avoid being seen or heard, he will inevitably defeat his purpose unless he can also control his every act and movement so as to prevent mutual contamination with his environment, which may serve to identify him. The criminal's every act must be thoroughly reasoned in advance and every contact guarded. Such restraint demands complete mental control. The very fear of detection, which must almost always be present, will make such control next to impossible. Wherever he steps, whatever he touches, whatever he leaves—even unconsciously—will serve as silent evidence against him. Not only his fingerprints and his shoeprints, but also 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. Physical evidence cannot be wrong; it cannot perjure itself; it cannot be wholly absent. Only in its interpretation can there be error. Only human failure to find, study, and understand it can diminish its value.

Kirk's words hold as true today as they did when they were first written, more than a half-century ago. We might add, though, that it is not just the criminal that leaves traces; the evidence may tell us how victims, witnesses, medical personnel, firefighters and police officers have influenced the scene (See Chapter 7: Crime Scene Investigation).

The analysis of trace evidence, and its application to crime reconstruction, cannot be trivialized. It is not the substance of television or cinema drama. It is often difficult in the extreme, occasionally tedious, and always attended by the requirement of technical correctness. In this regard, nothing has changed since the comments in 1917 by E.R. Dovey, the Government Analyst of Hong Kong, who issued this jeremiad:

[Trace evidence] work demands the greatest skill and experience that can be brought to bear upon it, the best instrumental equipment that can be procured, the utmost patience, the most rigidly exact work, and, lastly, a sufficiency of time.

In the intervening time, some trace evidence has not changed significantly, hair and soil and glass being prominent examples, while some forms of trace evidence, such as glitter or nylon, have been introduced. But nearly a century later, Dovey's remark holds true as ever.

TRACE EVIDENCE DEFINED

It is easier to provide examples of trace evidence than to develop a comprehensive, overarching definition. But we are obligated to make the attempt. *Trace evidence* typically falls into the category of **associative evidence**, that is, evidence that links two or more specific entities, whether they are people or objects. Within the context of crime reconstruction, trace evidence is something that links a crime to a person or an object. **Evidence** is something that offers proof, by means of which a rational mind becomes convinced of a fact. That part of the definition is easy. It's the "trace" part that poses more of a problem.

The word "trace" may be nuanced and used in different contexts, sometimes as a noun and sometimes as a verb. As a verb, we may use it to indicate an activity, as in "we made an attempt to trace the telephone call," or to indicate the fabrication of a replica, as in "he forged the signature by tracing over it." As a noun, the word "trace" may signify a mark or a sign of something that has passed through, as in "she left town without a trace." In this sense, the word trace suggests something—anything—that is left behind. Again as a noun, we use the word to indicate a minute (but generally perceptible) amount of something, as in "the wine displays a subtle trace

of oak and currant," or to indicate minute (and virtually imperceptible) amounts of something dispersed in a larger quantity of another material. In this usage, "trace" is essentially a contaminant. It is the latter two uses of the word, differing fundamentally in simply the amount of material under consideration, that find their place in "trace evidence."

Here we suggest a way of cutting through all of this and adopting another definition. We define trace evidence as "evidence of evidence." No definitive parameters exist to define precisely what can and cannot be classified as trace evidence; there is simply no list that can be compiled and bounded. Certainly we may speak of hair, fibers, paint, and glass. But any array of which we speak must be open ended. Is a smear of lipstick on a coffee cup trace evidence? Yes, decidedly so. A bite mark on the breast of a victim of a sexual assault? Again, certainly yes. A feather? Again, yes. The possibilities of inclusion are virtually infinite. Trace evidence consists primarily, although not exclusively, of minute bits of matter. What type of matter? Practically anything. It is for this reason that dealing with trace evidence is more complex, and therefore more demanding, than is often recognized.

The multifaceted and complex nature of trace evidence examination requires such extensive training, time, and effort that it has fallen out of favor in many forensic laboratories. But at the same time, it is often particularly rewarding to those who are engaged in its rituals. And perhaps most importantly, it is one of the most readily accepted forms of evidence by juries and the lay public.

Before we pass on to other issues, we must discuss one more aspect to trace evidence. A great deal, although not all, of what we countenance as trace evidence is in the form of *transfer*. Indeed, the terms "trace evidence" and "transfer evidence" are often used synonymously when appropriate. **Transfer evidence** involves an exchange of materials, or the production of a pattern. As developed later in some detail, trace evidence encompasses transfer as well.

UTILIZATION OF TRACE EVIDENCE

Trace evidence has the potential of great utility in establishing associations that lead to a reconstruction, but only if we recognize and interpret that evidence properly. If it is not acknowledged and not recognized, it is lost just as surely as if it had never existed. And if it is recognized, but for whatever reason is not collected and analyzed, it again is lost just as surely as if it had never existed. And if it is not interpreted correctly, it won't just hinder efforts to reconstruct the crime, it will result in a corrupt reconstruction. One may argue that evidence that is misinterpreted is worse than no evidence at all.

Walter McCrone, perhaps the foremost particle analyst of the 20th century, once estimated that less than 1 percent of all the potential trace evidence in crimes is ever collected and analyzed (McCrone, 1979). If this is accurate, the situation is deplorable. But it would be deplorable if it was 2, 4, or 10 percent.

Although trace evidence may assist enormously in the reconstruction of crime, it may not provide answers that will result in a complete reconstruction. Any reconstruction, whether based on trace evidence or any other type of evidence, is much like looking at a tapestry from the back side. The essence of the scene may indeed be understood in general terms. In some instances, it may be understood in definitive terms. In other instances, the evidence may simply not provide the clarity that we would need for a full reconstruction. We may not be able to reconstruct

every nuance and movement from an event. In these instances, the reconstructionist must take pains to explain why isolated elements of the reconstruction cannot legitimately be bridged. If a reconstruction is overextended and cannot be supported when subjected to severe scrutiny, a miscarriage of justice may occur. At the very least, the trust and confidence placed in the reconstructionist will be diminished. In summary, the reconstructionist must recognize the limitations of the evidence and interpret his or her results with these limitations in mind.

It is possible to develop an array of common types of trace evidence, and we will do so eventually. But it cannot be stressed enough that any such list is, as stated previously, necessarily open ended. Exigencies of a given case may vault an exceedingly obscure type of evidence into a position of prominence. Indeed, the more obscure the evidence, the greater may be its probative value. The other side of this coin, however, is that a rarely encountered form of evidence may not be recognized for what it is and what it may signify, or the crime reconstructionist may not know how to deal with it or, worse, may misinterpret it. Ignorance, or the type of bias resulting from parochial beliefs, may be at play.

DIVERSITY AND UNIQUENESS, VALIDITY AND PROBATIVE VALUE

The characterization of trace evidence is inextricably tied to the concept of diversity, which in turn is tied to the concept of uniqueness. The antecedents are in fact identical for both concepts. The physical world is complex, and the greater the complexity, the greater the potential for uniqueness. This is scarcely a distinction without a difference, as forensic considerations are classically formulated in terms of individuality and uniqueness.

Understanding Uniqueness

As diversity increases, so does the prospect of individuality, and *individuality implies uniqueness*. The concept of uniqueness is a bit tricky, and the reconstructionist is well advised not to view it with absolute rigidity. The forensic science profession has struggled, off and on, with the concept. Cole (2009) provides an excellent argument against the use of a rigid definition of uniqueness and individualization. Has the evidence fingerprint been uniquely identified as having been made by the right ring of the suspect to the total exclusion of all other fingerprints in the world? Has the evidence bullet been uniquely identified as having been fired through the suspect's firearm to the total exclusion of all other firearms that have ever been made? Does the physical match of the fractured evidence represent a totally unique event? We have commented on this subject previously (Thornton and Peterson, 2007):

[The forensic science field has] struggled with the concept of uniqueness, but then so have others—philosophers, logicians, Boolean algebra mathematicians, and rare coin dealers. Each of these groups has made an uneasy peace with the concept.

In keeping with this uneasy peace, the concept of uniqueness may be operationally defined. A less-than-absolute rendering is entirely suitable for practical considerations, even the grave instances typical of crime reconstructions. With many physical evidence categories, we do not have rigorous, mathematical proofs of uniqueness and our perception of it is often

experience based rather than data based. We should not lose sight of the fact that in those instances where a working assumption of individuality and uniqueness has been tested, the tests, although susceptible of criticism on rigorous mathematical or statistical grounds, have supported the notion of uniqueness. A problem only arises when the reconstructionist uses the term unique in the "this is unique to the extent that we are able to determine" when another person is unprepared to accept empirical proof and expects a rigorous mathematical proof.

Physical Evidence: A Complex Mosaic

Physical evidence in general, and trace evidence in particular, does not simply spring into existence. Trace evidence comes into being by the action of a legion of complex considerations that act in a multitude of ways to create the final mosaic of the evidence. In many and perhaps most cases, the relative contribution of formative factors cannot be determined readily, that is, the precise reasons that a particular mix of evidence items has come into existence are not apparent. In addition, the pertinent formative factors often act over small distances, measured in centimeters rather than meters, and result in a "microenvironment" in which the evidence is expressed. A short distance away in the microenvironment, the milieu of the evidence is likely to be different, with its own particular uniqueness. Some formative factors are natural, that is, an expression of the physical world without the intervention of humans. Others track human activity. The overall evidence becomes a "niche," a mosaic of countless of these microenvironments, the size and number of which depend on the circumstances in each case. The factors that contribute to their expression may involve several distinct operational levels and numerous interacting processes. Some of these processes will be prosaic, whereas others will be stylized and highly distinctive. And a change in one of these factors may influence other factors to a greater or lesser extent. From similar considerations we readily acknowledge the range of human activity, the diversity of human cultures, and the uniqueness of each person. We should be prepared also to acknowledge the uniqueness of the settings in which we encounter trace evidence.

Let's develop this in greater detail. Take, for example, a sample of soil from a crime scene. At this stage of the investigation, there is nothing yet to compare. But an examination of the soil reveals a complex mixture with considerable character. Some particles would be considered as naturally occurring: a few bits of decaying grass, an exoskeleton of a dead ant, pine pollen, mica, montmorillonite clay, decayed or decaying leaf litter from higher plants, tentatively recognized as oak, microcline and plagioclase feldspars, green-brown mica, a few rodent hairs, and quartz. The specimen may also contain particles that indicate the intervention of humans: a few small flakes of paint, blebs of polyester fibers, some rubber tire wear particles, and bits of asphalt and polyurethane. The total sample then is a confluence of natural and man-made materials, which together impart both the history and the career of the evidence and determine its overall character. If the natural conditions had been altered, for instance the absence of pine pollen or different geological conditions resulting in a different mineral constituency, then the character of the evidence would be different. Likewise, if the human contribution had been different, the character of the evidence would have been different as well. Hence the diversity of the evidence is engendered, and the individuality then follows, as does the implied uniqueness.

TRACE EVIDENCE TRANSFER: LOCARD REVISITED

When crime reconstruction was in its infancy, the French forensic scientist Edmond Locard introduced a concept that has had a profound influence on trace evidence interpretation. Much of the history of Locard's exchange principle has been presented by Turvey in the introductory chapter to this text and will not be repeated here. But a perhaps too casual translation of Locard's words has led to the generalization that "every contact leaves a trace."

That is not exactly what Locard said [what he actually said was that "*sometimes* (italics added) the criminal leaves traces at a scene by his actions. *Sometimes* (italics added), alternatively, he picked up upon on his clothes or his body traces of his location or presence"] but that is more or less how the doctrine has been passed down. Consider the following: "The basis of this reconstruction and of contact traces was laid down by Locard (1928)(sic) who stated that when two objects come into contact *there is always a transference of material from each object on to the other* [italics added]" (Nicholls, 1956, p. 39), or "The one statement that perhaps most clearly epitomizes the pursuits of the [crime reconstructionist] is that made by Edmond Locard who said 'every contact leaves a trace.' . . . Certainly every contact leaves a trace; *it is up to us to detect it* [italics added]" (James et al., 1980, p. xv).

However, we should recognize that Locard's doctrine is, and always has been, an assumption—plausible enough, but not an immutable law drawn after a systematic study or experimentation. Locard himself never postulated the principle, although in his writings he provided numerous practical examples in support of the concept. The Locard exchange principle is a useful operational doctrine, but it cannot be reasonably expected to stand the scrutiny of Daubert or any other rigorous evaluation. Current thought has crystallized to the point where the doctrine is viewed as a useful premise, but that any incorporation of the words "every" or "always" is inappropriate. Common sense tells us that whereas an angora sweater can be expected to be a rich and productive source of fibers, a nylon monofilament windbreaker will not. Contact with a dog may well deliver a profusion of dog hairs. Contact with a snake may not deliver snake scales. The Locard exchange principle does not take into consideration issues of persistence; it does not incorporate any clear understanding of the time frame over which it may operate. In short, the doctrine may be operative in some situations, but as a practical, realistic matter it may not be applicable to others. Exchange may or may not take place, it may occur in only one direction, it may have occurred but the exchange was not capable of being followed adequately, or evidence may have fallen off after transfer.

For these reasons, we propose to modify the phrase "every contact leaves a trace; it is up to us to detect it" to a more realistic and appropriate "*if a contact leaves a trace, it is up to us to detect it.*" This terminology places the responsibility where it belongs and underscores the presiding issue in trace evidence: recognition of the trace evidence is often more of a challenge than its subsequent processing. There can be no carping, however, that exchange often occurs across the contact boundary. Let us now examine the different possibilities of transfer.

VARIOUS FORMS OF TRACE EVIDENCE TRANSFER

When one surface comes into contact with another, there may be a transfer of material from one surface to another. As common sense would dictate, the more forceful the contact, the greater the amount of material transferred. Blood from a wound suffered by a victim may be transferred to the clothing of an assailant, for example.

Unidirectional Contact Transfer

Consider the following: A person is struck on the head with a metal bat. Hair and blood are found on the bat. This is a one-directional or **unidirectional contact transfer** from the donor to the recipient, commensurate with a certain level of association. Consider as well a blue automobile backing into a red fire hydrant, transferring blue paint onto the hydrant. A one-way or unidirectional contact transfer is the simplest type of transfer, and while it may offer significant evidence of association, it will not have the probative value of a two-way or bidirectional transfer.

Bidirectional Contact Transfer

The significance of contact transfer increases greatly when two-way or **bidirectional contact transfer** occurs, with material from Surface A being transferred to Surface B, and material from Surface B being transferred to Surface A concomitantly.

Consider now a person struck on the head with a wooden stick. Hair and blood transfer onto the stick, but the stick is fractured and a fragment of it embeds in the victim's scalp. This is a bidirectional transfer from two donors to two recipients, with a significantly augmented level of association. A bidirectional transfer of blood may well occur in an extended conflict between two persons.

Consider again a blue automobile backing into a red fire hydrant, transferring blue paint to the hydrant while at the same time transferring red paint to the vehicle. The probative value of the two-way transfer is much greater here than a transfer of only one paint.

Transfer without Contact

Transfer may occur without actual contact. The discharge of a firearm results in a profusion of products. When a firearm is discharged, there may be a cloud of soot, unburned gunpowder, and minute particles originating from the primer may be deposited on surfaces in close proximity to the firearm. In another example, when a window is broken, numerous minute particles are projected in the direction of the application of force. These particles may attach to the clothing of the person responsible for breaking the window, even though that person never approached the window closer than 1 or 2 meters. Projected blood spatter would fall into this category as well. These are examples of *transfer without contact*.

Transfer of Form: Pattern Evidence

In some instances, the form or pattern of one material may be transferred to another. This may or may not occur with a transfer of material. If there is a transfer, the actual material transferred may or may not be the primary matter of interest. Examples of **transfer of form (pattern evidence)** with a transfer of material include a shoeprint in dust or a pattern of blood broadcast onto a surface by blunt impact or a gunshot. In such instances, the nature of the material being transferred—in these instances, the bare fact that the material is dust or blood—is of less interest than the actual pattern formed by the transfer. But in other instances in the reconstruction of a crime, there would be greater probative value in knowing that the evidence, for example a visible fingerprint, was in blood, paint, or grease. The pattern may be formed by contact, as with the

shoeprint in dust, or it may be formed without actual contact, as with the spatter of fine droplets of blood. In some instances it is the interception of material, blood, for example, that constitutes the pattern formed.

The form of an item may, in some instances, be recorded on another surface without the actual transfer of material. An example would be a compression mark made by a tool on a ductile material, for example, a mark made by a prying tool on wood. The form and dimensions of the responsible tool may be discerned, but there is no actual transfer of material. Another example would be an automobile leaving a tire impression in mud. No rubber is transferred, but the impression conveys the size and tread design of the tire. Very often such marks are three dimensional, the extent of deformation and relief commensurate with the force applied and the hardness or softness of the surface upon which the mark is registered. This may be construed as a special instance of pattern evidence, but we prefer to view it as a separate category, as the *transfer of form (pattern evidence) without the transfer of material*. With evidence of this type, particular care should be taken to ensure that unidirectional transfer is truly absent, and not just so limited or so inconspicuous that it is overlooked.

Intermediate Material

It is possible that *trace evidence may be transferred via an intermediate material*. Consider an assault where a garment receives a deposit of blood. The garment subsequently comes into contact with a wall, with some blood being smeared onto the wall. Another object brushing against the wall may then receive some blood, despite having never come into direct contact with the garment. A dog owner may have dog hairs on his clothing that are incidentally transferred to a chair. Another person may sit in the chair and pick up dog hairs in the process. The clothing of the second person will then show dog hairs even if that person loathes all domestic animals. A crime reconstruction could go distinctly amiss if it was concluded that the second person had a history of contact with dogs. As with any aspect of crime reconstruction, a weather eye must be kept for plausible alternative explanations, and these must be evaluated in light of the experience of the reconstructionist and the particular details of the case under consideration.

ISOLATION AND PRELIMINARY EXAMINATION OF EVIDENCE

Trace evidence may be collected at the scene, or in the laboratory, in a variety of ways. *Pickoff*, the handpicking of minute bits of evidence, is effective when the evidence is readily recognizable. It has the advantage of isolating the evidence from extraneous material, in essence, separating the wheat from the chaff. Forceps or other tools will facilitate the recovery and isolation of the trace evidence, which may be packaged by itself. In some instances, a straightforward and relatively uncomplicated pickoff is not possible, and the material in question must be removed by scraping or similar mechanical action.

Tape lifting is another efficient recovery technique that is efficient, but use of this technique may result in the recovery of materials unrelated to the evidence of interest. Tape lifting simply entails applying an adhesive tape to a surface of interest so that when the tape is removed,

minute bits of evidence adhere to the adhesive. Subsequent microscopic examination of the tape reveals any possible evidence of interest, which may thereby be subsequently isolated.

In some instances, *solvent recovery* may be appropriate. A swab moistened with water is generally an effective means of recovering a very small bloodstain, more effective than attempting to scrape the suspected blood from the surface. Collection of an oil or grease sample may require use of an organic solvent.

Preliminary examination of the evidence is typically a sorting operation to segregate evidence from extraneous material on the basis of type substance type, size, form, color, texture, or other optical or physical properties (e.g., translucency or magnetism). Frequently, low-power magnification with a stereoscopic binocular microscope is adequate for preliminary examination. In some cases, examination may be extended to include such properties as density and the behavior of the material as observed under a compound microscope with polarized light.

Control Samples

As a general rule, it is essential to collect a control sample along with evidence collection. A **control sample** consists of a sample of known composition and history that may be compared with the trace evidence to evaluate the significance of the evidence or to assess the validity of the analysis conducted. Control samples are a vital part of the scientific method, as they may eliminate or minimize coincidental influences that might otherwise confuse a crime reconstruction. In short, controls will tend to eliminate alternative explanations of analytical results and the interpretations made as a consequence.

Control samples are frequently collected from areas adjacent to the location where the evidence was collected, but from an area unaffected by the conditions or activities having generated the evidence. Cuttings or swabbings of unstained surfaces near a bloodstain would be an obvious example. This control sample would ensure that the substrate or surface material does not interfere with testing. This is an example of a *negative control*. Negative controls confirm that the analysis and interpretation are not observing an effect that is unrelated to the reconstruction. *Positive controls*, however, ensure that whatever tests are applied and whatever conclusions are reached are competent. If, in a microscopic examination of trace evidence, an analyst concluded that a hair was likely a dog hair, a direct comparison of the evidence with a library standard of a dog hair would be appropriate. In trace evidence examinations, referral to a standard—a positive control—is accomplished very frequently.

One more example. In an arson investigation, gas chromatographic analysis of a sample of burned wood might suggest the presence of gasoline. A negative control would be a sample of the unburned wood. A positive control would be a sample of known gasoline.

Physical Match of Fractured Surfaces

When an object separates into two or more pieces with resulting irregular margins of the separated surfaces, in many instances they may be fitted back together. When this is accomplished, it is said that there is a *physical match* between the items, that is, a palpable complement of the separated items. This applies to fractures, tears and rips, or breakage in general and may be observed in metals, glass, polymers in general, wood, fabrics, automobile tail or turn indicator

lights, paper or plastic bags, or practically any other solid item. Other physical matches may occur without irregular margins if texture, pattern, or other features indicate continuity of the component pieces. Thin materials, such as paper, typically show a physical match in two dimensions, whereas other materials of greater thickness may show a match in three dimensions. Universally, a physical match proves convincingly that the separated item had at one time been joined. Physical matches are commonly considered to be the zenith of all forensic identifications, surpassing even DNA matches.

With few exceptions, the assumption of a common parent has not been subjected to rigorous scientific testing, as the necessity for doing so has never been recognized. Physical matches of surface contours have such an established basis in common sense and everyday experience that formal testing has always been considered needless, and perhaps even silly. One cracks a cracker and puts it back together. Restoration of the whole is entirely satisfying to the senses, and acceptance of the uniqueness of the fracture or tear margins proceeds directly. We are unaware of any serious challenge to physical matches by Frye or by Daubert.

Even if we desired to test tear uniqueness, it is unclear how legitimate experiments could be conducted in such a manner as to develop an overarching canon to explain all physical matches. Certainly one could break glass, for example, and compare the fracture margins. An empirical study such as this would provide some information, but after several hundred, or even several thousand experiments, it is unlikely that one more experiment would show something different. It is nevertheless reasonable to ask “how” unlikely. Roughly two millennia of human experience would support an answer of “very unlikely, verging on the impossible.” But no formal probability model exists that may be applied here.

There have been a few well-designed and well-executed experiments that would seem to have validity for a specific type of evidence—the tearing of duct tape, for example. But we can expect that courts may not accept a study of the tearing or fracture of one material as altogether relevant to the tearing or fracturing of another. An ASTM standard exists (ASTM E2288-09) for the physical match of tears in paper, and the subject of physical matches of fractures in general has been commented upon by [Tsach and colleagues \(2007\)](#). This work has shown that for materials of homogeneous properties, tearing even under closely repetitive conditions results in unique fracture margins.

Still, some physical principles are relevant. Consider first the breakage of a brittle solid such as glass. (Metals could be substituted here as an example of separation resulting from the rupture of atomic bonds). Glass, an amorphous, noncrystalline material, has no definite structure and no preferred cleavage. Atoms in the glass are arranged in no particular order, and in the separation process bonds break between atoms that are uniquely positioned in the glass. With any brittle solid, electrons in the outermost orbitals of a particular atom are held rather loosely, and at one instant in time may be associated with one atom, but an instant later may be associated with another nucleus. Therefore an electron cloud essentially meanders through the solid, with areas of relative strength and areas of relative weakness constantly in flux. This phenomenon makes it essentially impossible for fracture patterns to be replicated at different times. No realistic probability model has ever been proposed to describe this phenomenon. While a physical match is typically in conformity with intuition and common sense, it should be remembered that neither intuition nor common sense are science.

It has been suggested that in the fracture propagation process of a solid material, the fracture front progresses (1) directly forward with no deflection, (2) to the right or (3) to the left, (4) up,

(5) down, or a combination of (6) up and right, (7) down and right, (8) up and left, or (9) down and left. With this model, there are nine possibilities of direction for each iteration of a fracture.

If the process is random, which this model assumes, the probability of the fracture taking one of these paths is $1/9$. If, for example, a fracture moves ahead to the right and up, and then right and down, and then left and down, and then directly forward, the probability of this series would be $1/9 \times 1/9 \times 1/9 \times 1/9$, or $1/6561$. For a fracture involving hundreds of random iterations, the probability of the replication of the fracture becomes vanishingly small.

It would be difficult to defend the assumptions made in connection with this model and then to defend it mathematically. For that reason alone we do not embrace it. However, this model may have some utility in terms of conceptualizing the vagaries of the fracture propagation process and in explaining physical matches to investigators. We do not suggest that it be employed in court.

Some crystalline materials have preferred cleavage planes. Fractures of these materials proceed in accordance with highly stylized, repetitive atomic arrangements and are decidedly not random. Crystalline quartz, for example, does not behave in the same manner as glass, which is amorphous with respect to atomic arrangement.

We cannot establish physical matches if the surfaces are so minute that the character of the fracture surfaces cannot be discerned or if the fracture surfaces are actually featureless. An example of the former might be a minute fragment of glass—perhaps just a few millimeters—with a fracture surface that is totally planar. While both specimens would be essentially featureless, they might arise from different conditions.

An example of the latter would be two pieces of glass that had been scored with a glass cutter and then fractured. (In this instance, however, we can establish the commonality of the pieces by means of interferometry with a laser or an alternative light source.) In the case of cut wood with straight edges, an examination of the texture and grain, and perhaps any surface coating present, may establish that the pieces had at one time been joined.

Polymers and other materials that deform incidental to the separation process often pose a problem. Before the pieces separate, the material stretches to the point of failure, thus a discrete separation margin does not exist. It is not uncommon to encounter an item with an apparent area of fracture that complements an area on another item, but a physical match is impeded by a damaged and corrupt separation margin. In short, the areas that might match cannot reach one another. In cases such as this, photographing or casting the evidence may be of benefit. The deformed areas can be trimmed from the cast or the photographs in order to line up the areas that are not deformed to facilitate a match. Trimming the actual evidence should be a last resort, and then only after thorough documentation of the evidence.

Physical matches may be established in other materials, with fabrics being a conspicuous example. A large piece of fabric representing a missing piece of a garment is generally a straightforward, nearly trivial, exercise. The presence of a print or pattern to the cloth assists greatly in this regard, but is not obligatory. A close examination of the tear margins in plain cloth may confirm a physical match, as not all threads in the warp and weft of the fabric will separate at the exact same point. Plain cloth, with no print or pattern, may not be matched if the fabric has been cut, unless the cut is uneven. For example, margin irregularity occasionally occurs when scissors used to cut the fabric take another bite of the cloth.

With wood, a palpable match may not be feasible in some instances due to splintering and deformation of the wood in the separation process, but a comparison of dimensions and grain

(and of course the wood species) may allow an opinion to be reached as to whether separated pieces had at one time been joined.

The presence of paint or other surface coatings on any item may contribute greatly to physical match comparisons, as will the weathering of the surface, the presence of printed or handwritten text, or adhering debris of practically any sort.

We should recognize that, in some instances, a physical match may simply not be possible. Damage to a surface, following separation, but before the item is collected as evidence is not uncommon. In other instances, items may not match up because an intervening piece that would "piece together" the whole was not collected; much like a missing piece of a jigsaw puzzle in the center of the picture. And one should never lose sight of the fact that in constructing an array of reasons why a physical match cannot be established, the possibility that the items had never been joined must occupy a prominent position.

Microscopic Examination

For the trace evidence analyst, the microscope (from the Greek, μικρός—*micrós*, "small," and σκοπεῖν, *skopeîn*—"to look") is the most fundamentally important tool to his or her analysis. If the analyst is not actually looking through a microscope, then one will be no more than a meter or two away. Microscopic examination may characterize a material on the basis of form, color, and any peculiarities that might indicate its provenance. Certain quantitative measurements, such as refractive index and dispersion, and optical properties related to these features, may be determined on many samples (Houck and Bowen, 2005).

The preliminary examination of evidence typically employs a stereoscopic binocular microscope. This is actually two microscopes, joined optically so that each eye has its own. This enables a stereoscopic or three-dimensional image of the evidence to be visualized. With experience, a great many things may be recognized, manipulated and sorted, and compared. This form of microscopy, although limited to fairly low magnification, typically no greater than about 30 \times , is often adequate for a preliminary examination, and not infrequently for a definitive determination as well. This examination requires no sample preparation and may be accomplished with reflected light. In this form of microscopy, opaque or densely colored materials may be examined.

Higher power examinations, in the range of 100 to 450 \times , require use of a compound microscope. A compound microscope will not generate a three-dimension image (even if the microscope has one eyepiece or ocular lens for each eye). A compound microscope generally operates with transmitted light, requiring some sample preparation. And unlike a stereomicroscope with reflected light, the compound microscope is unsuited for thick or opaque specimens. The theoretical limit of optical microscopy is about 1500 \times with a resolution of about 0.2 μm —a micrometer is a millionth of a meter, or approximately 0.000039 inches—but the practical limit for most trace evidence types is about 450 \times . At magnification in excess of about 450 \times , the depth of field, that is, the portion of the specimen that will be in sharp focus, will be so slight as to make most observations difficult or unmanageable.

A great number of materials of potential significance as trace evidence may be directly recognized under the microscope. Many substances will be ubiquitous in the environment and therefore of little probative value for crime reconstruction, white cotton and quartz sand being

conspicuous examples. But other materials may be of very limited provenance and hence will be more valuable in the evidence interpretation. Table 10.1 provides common environmental samples that trace evidence analysts will generally be able to recognize quickly, although some of these particles show a greater prevalence in particular geographical locations.

The presence of coal, for example, would be greater in the eastern part of the United States than in the west. Common sense will tell us that pine pollen would be encountered more frequently in mountainous regions than in arid and desert locations. In some instances, these materials themselves will constitute the trace evidence; in other instances, the evidence may be superimposed on a suite of natural or manmade materials unrelated to any crime.

Light of wavelengths beyond the range of visible observations—ultraviolet and infrared—may be used with optical microscopy for some forms of trace evidence, with the image of the specimen captured by means of photography. Many wavelengths of visible light may be used to excite fluorescence emission from samples with viewing either by eye or with photographic film.

Some types of trace evidence, such as gunshot residue, for example, will be so minute that they require magnification beyond the capability of a compound microscope. For micrometer-sized samples, a scanning electron microscope (SEM) will be required. The SEM scans a surface with a sharply focused high-energy electron beam in a raster scan pattern (as in television). In the most common modality, the electron beam promotes secondary electrons from the sample, which are then detected and used to create an image of the surface topography.

The SEM can easily resolve surface detail down to about 1 to 5 nm—a nanometer is a billionth of a meter. A wide range of magnifications is possible, from a low of about 10× to more than 500,000×, although few trace evidence types would be graced by this very high magnification. Images formed by the SEM have a large depth of field and a pseudo-three-dimensional appearance, which facilitates recognition and interpretation of detail.

The electron beam of a SEM must operate in a high vacuum, which generally imposes some constraints on maximum size that can be accommodated in the instrument. Some sample preparation may be necessary, as the method requires the sample to be electrically conductive. Metal objects generally require no preliminary treatment, but nonconductive samples must be given a thin film of some conductive material if a decent image is to be captured. The conductive material is often a very thin layer of vacuum-deposited gold.

Microchemical Testing

Although many materials may be identified and evaluated by means of microscopy, chemical analysis will also be applicable in many evidence situations. As trace evidence is often limited in the amount available for testing, analysis on a “micro” scale—performed on milligram or microgram quantities—may be required. Chemical analysis on a large, bulk specimen is not microchemistry. An analysis of a sample of mineral ore, for example, would typically involve many grams, whereas trace evidence analysis of soil or minerals will often involve a few milligrams.

Many instrumental techniques are available for dealing with very small quantities of material. The instrumental approach of choice will be determined by the nature of the evidence, but conspicuous in any array of instruments applicable to trace evidence would be absorption

TABLE 10.1 Common Environmental Materials Recognizable under a Microscope

Diatoms	Moth scales	Seed hairs (trichomes)
Insect parts	Ragweed pollen	Pine pollen
Straw	Chemical coniferous fibers	Cotton
Flax	Mechanical nonconiferous fibers	Straw
Nylon	Polyester	Viscose
Wool	Fiber glass	Mineral wool
Asbestos	Quartz sand	Calcite
Gypsum	Talc	Pumice
Fluorite	Molding sand (zircon)	Kaolin
Bituminous coal	Cement	Cornstarch
Potato starch	Coal dust	Tea dust
Feces	Detergent soap powder	Ground glass
Silicon carbide	Smokeless gunpowder	Enamel dust
Catalyst dust	Metal shavings	Metal shot
Trash ash	Open hearth furnace particles	Incinerator particles
Oil soot	Domestic furnace coal	Pulverized coal
Engraving dust	Marijuana	Leather
Rubber	Bakelite	Teflon
Corundum	Abrasive cleaner	Jeweler's rouge
Silk	Open hearth steel slag	Rabbit hair
Rat hair	Arnel	Dynel
Table salt	Granular sugar	Powdered sugar
Cereal grain dust	Rice starch	Wheat starch
Tapioca starch	Pencil sharpener dust	Cigarette ash
Pencil eraser	Ink eraser	Tobacco dust
Paint spray dust	Sawdust	Asphalt
Apatite	Cryolite	Orthoclase feldspar
Geothite iron rust	Lepidolite mica	Dandruff
Caucasian human hair	Rutile titanium dioxide pigment	Black human hair
Asian human hair	Sponge spicules	Radiolaria
<i>Lycopodium</i> spores	Fern spores	Wheat smut spores
Timothy grass pollen	Lamb's quarter pollen	Pigweed pollen
Oak pollen	Sugar maple pollen	Cottonwood pollen
Acrylic plastic		

spectroscopy and gas chromatography for organic compounds, emission spectroscopy for inorganic compounds, energy and wavelength dispersive X-ray analysis for inorganic compounds, and X-ray diffraction for both organic and inorganic materials.

In a like fashion, many “wet chemistry” tests are available for both organic and inorganic materials. These are often scaled-down versions of tests that are applied to bulk samples. Color tests, known universally as “spot tests,” exist for most functional groups of organic materials and for inorganic elements. These are very sensitive tests, typically applicable to microgram quantities, and display high, although generally not total, specificity.

Microchemical testing may be obligatory in those instances where the evidence has no observable structure. Examples would include arson accelerants, bank robbery explosive dye packs, and lacrymators (tear gas). Paints and polymers will often fall within this category.

Microchemical testing will deliver composition. If a sample has a discernible structure, however, the trace analyst should not rush to microchemical testing. Knowledge developed of composition should not be subordinated to knowledge of structure. For example, instrumental analysis might indicate that an evidence compound is silicon dioxide, SiO_2 . While the analysis may be entirely valid and the composition is useful information, this alone will not tell us whether the sample is quartz, vitreous silica, agate, amethyst, carnelian, chalcedony, flint, jasper, onyx, prase, rose quartz, or tiger’s-eye. Optical properties of the type that can be determined by microscopy will distinguish among these various forms, however.

Not infrequently, the principal problem with microchemical testing of trace evidence is not in the actual testing, but in preparing the sample for testing. Many microchemical or instrumental techniques require the sample to be placed in solution. Chemical considerations may arise in which the process of getting the sample into solution is anything but trivial. The sample may not dissolve easily, and draconian measures necessary for dissolution may change the nature of the evidence. Such situations may challenge the analytical acumen of the analyst.

Destructive Testing

Some analytical approaches, while perhaps particularly suited to the analysis of a particular type of evidence, result in destruction of the sample. Conspicuous examples are mass spectrometry, emission spectrography, and pyrolysis, followed by gas chromatography.

Destruction of any evidence presents a difficult problem in forensic work, not from the standpoint of the science, but from the standpoint of the law. Evidence that might otherwise be available in a judicial proceeding has been destroyed, which poses a formidable potential 6th Amendment confrontation issue.

The manner in which this is generally dealt with is to proceed with the destructive analysis, but only after the evidence is documented thoroughly. (An additional consideration is that in anticipation of an adversary legal proceeding, the opposing side is informed of the plan to conduct a destructive test in order to allow the opposing side to witness the analysis or interpose a legal objection, at which point a court will resolve the issue.)

While the evidence, or a portion of it, may have been destroyed, what is left in its place are data. In a sense, the evidence has not actually been destroyed, but transformed. Just as the law of conservation of matter will allow matter to be destroyed while energy is produced, we propose here a *law of conservation of evidence*, which allows data to be substituted for tangible evidence.

Contamination

The very nature of trace evidence, where a single fiber or fragment of glass may constitute strong evidence of association, the possibility of contamination is ever present. This possibility must be measured and must be managed. Constant vigilance must be exercised in the collection of trace evidence and in its subsequent handling. The trace analyst must recognize the possibility that the evidence has been compromised by poor collection or handling by others, prior to its submission for examination.

UNIQUE FORMS OF TRACE EVIDENCE

It is not practical to discuss here the unique, once-in-a-lifetime presentations of rare forms of trace evidence, other than to say that they do exist and the reconstructionist must be prepared to deal with them. This requires constant vigilance and the willingness to accept and process an unfamiliar form of evidence. The reconstructionist must be willing to adapt.

Examples? Certainly. Two will suffice, both from actual cases.

EXAMPLE #1

In the first case, the crime scene was a “dumpsite.” A body was found in a remote location, with no indication that the victim was killed there. Rather, it seemed much more likely that the victim was killed elsewhere and transported to the scene. A few dry pine needles were discovered on the body, but pine trees and pine needles were not otherwise present at the scene.

Investigators developed a suspect, and a number of dry pine needles were found in the trunk of his car. Examination under a stereoscopic microscope established an actual physical match between the fracture edges of portions of needles from the body and from the vehicle trunk. The significance of this to the case is patent. The effort that this must have required on the part of the analyst is staggering, but it paid off.

EXAMPLE #2

In another case, a roof-top burglary of a supermarket occurred. To avoid breaking a window or door and thereby tripping an alarm, the burglars chopped a hole in the roof and lowered themselves down on a rope. In the process, they broke a jar of peanut butter, and one of the burglars stepped in the peanut butter. The crime scene investigator knew this because of a poorly defined shoe impression in the remaining peanut butter. Later that night, several suspects were stopped. One of them had some brown material smeared on the bottom of his shoe. Peanut butter? Well, maybe. If it were peanut butter, this would be an excellent form of associative evidence.

Both the investigator and the analyst were understandably averse to tasting the brown material on the bottom of a shoe. At this point, the case became a research project. What, besides peanuts, makes something peanut butter? What are the appropriate protocols for the analysis of peanut butter? The analyst must now go to the library and learn about peanut butter—its composition and profitable avenues of analysis. The point here is that many trace evidence cases may devolve into a full-blown research project. Neither the investigator in the field nor the analyst in the laboratory can be expected to know much about the actual nature of peanut butter, and looking under “p” for peanut butter in the

index of a textbook on physical evidence is not going to help, either. In instances such as this, the analyst and the reconstructionist must be prepared to embark on a campaign to understand the evidence. The effort may appear daunting, and it may well be formidable, but that is in fact what the evidence cries out for, and what it deserves.

Other examples of how trace evidence may provide essential information in crime reconstruction may be found in [Petrao \(1986\)](#), and trace evidence in general has been reviewed by [DeForest \(2001\)](#). In many instances, trace evidence, rather than dramatic DNA analysis or noble firearms evidence, brings coherency to the reconstruction and allows the case to be fully understood. In the broad landscape of physical evidence, trace evidence provides the poetry.

PROSAIC FORMS OF TRACE EVIDENCE

A number of physical evidence types represent the bulk of trace evidence and consequently will be discussed here. Because virtually any “type” of evidence may be present in only trace amounts, literally anything may be lumped into the category of trace evidence—from hairs and fibers to biological fluids, shoe and tire impressions, drugs, or even fingerprints. However, for the sake of limiting our discussion to trace evidence, rather than general criminalistics, we confine our attention to those forms of evidence that are categorized as “trace” in a typical forensic laboratory.

It is essential, however, that any person engaged in any aspect of crime reconstruction appreciates what trace evidence can contribute to the reconstruction process and what associations can be made.

Commonly encountered forms of trace evidence include

- Hair
- Fibers
- Paint
- Glass
- Soil
- Minerals
- Metals
- Dust
- Pollens, diatoms, and radiolaria
- Wood
- Paper
- Arson accelerants
- Explosive residue
- Gunshot residue
- Miscellaneous forms of trace evidence

Evidence types that may be categorized as trace evidence under certain conditions:

- Bloodstain pattern interpretation
- Footwear and tire-tread evidence

- Firearms evidence
- Fingerprint evidence

Conventional Trace Evidence vs Other Categories

Crime reconstructionists should understand that although any enumeration of trace evidence categories is bound to be arbitrary, a convention of sorts does exist. Following the general convention within the forensic sciences, these evidence categories do not typically fall within the purview of trace evidence. These areas are generally elevated to a realm of their own, and the editors of the present work have devoted chapters specifically to wound patterns (see Chapter 11: Wound Pattern Analysis), bloodstain pattern interpretation (see Chapter 12: Reconstruction Using Bloodstain Evidence), and firearms evidence (see Chapters 13 and 14: Shooting Incident Reconstruction, Parts 1 and 2).

It is important for us to recognize, however, that the demarcation between trace evidence and these other evidence categories is not absolute. Good professional practice will often call for a blurring of the margins. A bullet from a homicide victim is an aspect of firearms evidence, but a minute quantity of drywall gypsum embedded in the bullet, or a skuff of paint on the bullet, is a trace issue. Bloodstain pattern interpretation is practically a science unto itself and is definitely viewed as such by its practitioners, with justification. But a fine pattern of blood droplets on a pair of broken eyeglasses separated from the body of a homicide victim by several hundred feet would legitimately be construed as a trace evidence issue. A shoeprint in mud at a crime scene will typically be considered a footwear issue and not a trace evidence matter, but a few milligrams of soil on the sole of the candidate shoe would shift the emphasis toward a trace issue. Moreover, some laboratories will categorize pattern interpretation type evidence as trace evidence simply for the sake of assigning it to a particular department within the lab.

While these other categories represent cohesive and orderly bodies of information, their relationship to trace evidence must be seen as permeable. The converse may hold true as well. Physical evidence examinations and crime reconstructions must be a dynamic, vibrant endeavor. In any given case, the evidence may tilt toward trace or toward one of these categories, but the obligation persists in providing the evidence with the approach that it deserves instead of emphasizing one parochial approach to the detriment of another.

Holding to the general convention that these other categories do not fall within the penumbra of trace evidence, they are not discussed in this chapter, although a few selected references are included at the chapter end for the benefit of a reader who wishes direction for further study and consideration.

For anyone attempting crime reconstruction, the common trace evidence categories listed earlier should only represent a portion of the vast array of types of trace evidence that can be considered valuable.

Human Hair

Hair, a commonly encountered form of trace evidence, is shed easily and persists for an indefinite amount of time. Hair analysis can provide useful information, connecting a suspect to a victim or a crime scene or providing details that help shape the story of what happened.

For example, a hair, with tissue attached at the root, is found on a suspect's clothes. Because of the tissue attached, we can infer that some type of forceful contact occurred. Additionally, the tissue may be characterized by highly discriminating nuclear DNA to compare to the victim. In this example, we have a "best case scenario," as the piece of tissue could be used for nuclear DNA analysis, the same type of analysis used for blood or semen.

A microscopic examination will determine the basic characteristics of the hair. A microscopic analysis can provide investigative leads, as well as associative evidence. Is it animal or human hair? If not human, what species is it? Was the hair removed forcefully, cut, or did it fall out naturally? Macroscopic and microscopic characteristics of evidence hair, such as color, length, diameter, medulla types, pigment features, and noted hair disease conditions, can be compared to reference hairs from the suspect and victim (Robertson, 1999). Although these features cannot unequivocally identify the person that the hair originated from, they can certainly eliminate potential sources.

If features of the evidence hair "match" features of the reference hair, the most that can be said is that the evidence hair is "consistent with" having originated from a particular person, followed by a qualifier statement, which stresses that the hair would be consistent with having originated from many other people as well. Certain features of the hair, such as cross section, pigmentation patterns, and overall appearance may indicate the race of the hair's donor (Houck and Bisbing, 2005; Houck and Budowle, 2002) and/or body area. Making these distinctions, however, is somewhat treacherous, and most analysts approach this with considerable diffidence.

Hair may be subjected to the type of genetic analysis referred to as mitochondrial DNA (mtDNA) analysis. Because a single cell may contain over 5000 copies of mtDNA and only 2 copies of nuclear DNA, mtDNA analysis is much more suitable for hair (Dizzino et al., 1999). The high copy number of mtDNA makes it possible to reliably sequence a single hair shaft, just 1–2 cm in length (Houck and Budowle, 2002). Because the mitochondrial genome is passed down by the mother only, maternally related individuals share the same mtDNA sequence. Also, the mitochondrial genome is much smaller than that displayed by nuclear DNA; consequently, the number of polymorphisms available for discrimination between individuals is much smaller. For these reasons, mtDNA cannot uniquely identify the donor of the hair. While it does not provide the awesome statistics given by nuclear DNA analysis, mtDNA sequencing certainly provides useful information. In combination with results of a microscopic analysis, mtDNA analysis can provide strong associative evidence.

Animal Hair

In addition to human hair, animal hairs often appear in forensic casework. Determination of species, with the exception of some closely related species such as wolf and dog, is fairly straightforward with simple examination under a microscope. However, a more discriminating test may be valuable in some cases. As mentioned previously, witnesses come in every form, including household pets. An infamous case involving "Snowball the cat" demonstrates the utility of animal hairs. In this Canadian case, DNA analysis of cat hairs found at the crime scene linked a murder suspect to the scene. Specialty labs, such as the U.C. Davis Veterinary Genetics Lab, have successfully performed nuclear DNA analysis and mtDNA sequencing from various animal

sources including hair, saliva, blood, and feces. Multiplex DNA testing kits, similar to human DNA testing kits, exist for domestic cats (Butler et al., 2002), as well as dogs (Halverson and Basten, 2005). In some cases, DNA databases are even available for many domestic breeds so that population genetics can be applied to determine random match probabilities.

Fibers

Fibers are an archetypical form of trace evidence. They are ubiquitous, they typically have characteristic form and properties, they are prone to separation from their parent material, and they are persistent in their adherence to other evidence items. Those that originated from dyed garments are particularly conspicuous and are therefore easily recognized and collected. An important point is that a single fiber may be identified and factored into the crime reconstruction.

Whenever an object or individual comes into contact with textiles, fiber transfer may occur. Because fibers detach from the parent garment so easily, we expect that we may find fibers on an individual from his or her clothing, furniture, car upholstery, or carpet. Similarly, when a crime occurs, the perpetrator may carry away fibers from the victim's clothing or the crime scene, while the victim carries away fibers from the perpetrator's clothing, home, or car.

Special attention and care must be taken to collect any incongruous fibers, particularly in a case such as a kidnapping or a body dump, where fiber transfers cannot be explained by typical day-to-day contact. Although these fibers cannot be individualized, direct comparison may provide associative circumstantial evidence. By identifying the evidence fiber type and, if applicable, characterizing the dye properties, it is possible to assess the significance of the comparison if something is known about the distribution of the identified fiber in the textile industry (Table 10.2).

Identification of fiber type, and fiber comparison, typically requires both microscopic and instrumental techniques. Many natural fibers can be identified by their morphology, whereas manufactured fibers typically require microscopy plus instrumental analysis. Microscopic examination will establish whether the fiber is natural (vegetable fibers, e.g., cotton, linen or hemp, or an animal fiber, e.g., wool or silk) or a manufactured fiber (e.g., nylon, polyester, or acrylic). Natural fibers may also be identified by staining reactions. Polarized light microscopy will establish the optical properties of the fiber, which is useful for classifying synthetic fibers into broad categories, or even distinguishing between some natural fibers of similar morphology. Side-by-side comparison of evidentiary and suspect fibers under a comparison microscope will illustrate similarities and differences in fiber features, such as diameter, shape (cross section), surface characteristics, and color.

Fourier transform infrared spectrometry (FTIR) is the instrument of choice for fiber analysis. Infrared light passes through a substance, in this case a preparation of the fiber, and certain frequencies of light are absorbed while others are transmitted. (Which frequencies are selectively absorbed or transmitted depends on the chemical constitution of the sample.) A spectrum, or plot, of the frequencies of light transmitted, generated by the instrument, is a type of chemical fingerprint and can be compared to standards to determine the identity of the fiber type. In addition to fiber identification, the spectrum will distinguish between fibers, of the same class, with different copolymer compositions (Robertson and Grieve, 1999), providing a great deal of

TABLE 10.2 Natural and Manufactured Fibers

Acetate	Nylon
Acrylic	Nytril
Anidex	Olefin
Aramid	Polycarbonate
Asbestos	Polyester
Cotton	Ramie
Flax	Rayon
Fluorocarbon	Saran
Glass	Silk
Hemp	Spandex
Jute	Triacetate
Modacrylic	Vinal
Novoloid	Vinyon
	Wool

information when comparing evidentiary and suspect fibers. Instruments are available that are designed specifically for small sample analysis. For example, micro-FTIR, which is essentially an FTIR with infrared microscope attachments, allows for the examination of samples as small as 1–2 mm. With this technology, virtually any fiber substantial enough to be collected and handled may be analyzed.

For comparison purposes, colored fibers provide the most information. Instrumental methods exist that will discern differences in color far beyond the capability of the human eye. A typical forensic lab will be able to characterize fiber color using a microspectrophotometer. However, even more sensitive methods have been developed that utilize a combination of liquid chromatography and mass spectrometry to analyze dyes extracted from a single fiber (Petrick et al., 2006).

So a fiber has been taken from a crime scene, compared to a fiber from the suspect's clothes, and found to be of the same type, same copolymer composition, and same color properties. What does this mean? We once had a colleague ask what the point of fiber analysis was. He said "So you find a fiber and determine it is a synthetic fiber made in China . . . so what? It doesn't mean anything." We feel this is the product of unhappy and shortsighted thinking.

If it is a gray acrylic fiber similar to fabric in the victim's car it probably doesn't mean anything. But if it is a variety of relatively rare fibers similar to those found on suspect, a positive association may mean something to a jury. Short of a physical match between the edges of swaths of cloth, a positive association of fiber evidence certainly does not represent individualization. The significance of the association will depend on the facts of the case, including the number of fibers found, whether there is a cross-transfer of several types and colors of fibers, where they were found, and other relevant considerations. Except for blue denim, white, or

gray/black cotton, no fibers should be construed as entirely common (Roux and Margot, 1997). Houck (2003) intercompared 2083 fibers from 20 unrelated crimes—a total of 2,168,403 comparisons and found that no two fibers displayed precisely the same microscopic characteristics and analytical properties.

Paint

Traces of paint may assist in establishing if contact occurred between two sources, at least one of which is painted. If both surfaces are painted, the possibility of cross-transfer in both directions exists, which may provide even more information for an interpretation of lab results. Only a physical match between a paint fragment and the location on the object where the fragment was lost will unequivocally identify the paint source. Otherwise, the paint chip(s) can be characterized based on the number of layers of paint, as well as color, thickness, organic, and inorganic composition of each layer.

Comparison of the physical characteristics of reference and evidentiary paint samples (color, thickness, number of layers) requires only a stereomicroscope and may eliminate nonmatching samples with minimal time and effort. If the samples match, instrumental analysis will then provide more information, either by eliminating the “match” or strengthening the likelihood that the evidentiary sample originated from the source of the reference sample. Micro-FTIR or attenuated total reflectance (ATR-FTIR) will establish the organic composition of each layer of paint to characterize chemical type (e.g., acrylic or alkyd) and specific polymer composition. Inorganic (elemental) composition of each layer is typically determined using a SEM energy-dispersive X-ray spectrometer (EDS).

In the case of unknown paint chips, analysis may be useful for investigative purposes. The composition may indicate the source type (e.g., automotive or architectural), and databases exist for automobile paints, making it possible in some cases to determine the year, make, and model of the source vehicle. In 1985, paint analysis was used in this way to identify and later convict a serial rapist in England. Yellow paint scrapings found on a tree at one of the crime scenes were analyzed and identified as “harvest gold,” an automobile paint used on a single model, the Austin Allegro, from 1973 to 1975. One of the potential suspects was found washing an Allegro, painted harvest gold, when police went to question him. Scratches in the car’s paint matched the height of the paint scrapings found on the tree. Although not all paint cases will be as ideal as this one, this case demonstrates the utility of paint evidence and why it should not be overlooked.

Glass

Glass occurs at crime scenes with moderate frequencies because it is represented so abundantly in structures and materials (from windows, to beverage bottles, to car headlamps) and is so easily breakable. Typically, any individual who comes into contact with broken glass will carry minute particles of it away on his or her clothing, hair, or shoes. For this reason, glass evidence becomes particularly useful in crimes involving breaking and entering (e.g. burglary) or hit-and-run accidents.

The most useful information we can learn from glass is whether fragments collected on (or in association with) a suspect originated from the source of glass at the crime scene. The only way to establish this conclusively is from a physical match between glass fragments. Typically, fracture matches are only established with larger fragments, but with the aid of a stereomicroscope (and a lot of time, effort, and a little luck) it may be possible to establish physical matches between small particles. Without a physical match, it may not be possible to conclusively associate glass evidence, but it can be determined whether the glass originated from ordinary soda–lime–silica window glass, tempered glass from commercial business establishments, tempered glass from automobile side or rear windows, beverage bottles, or automobile headlights.

Characterization of glass fragments on the basis of color, thickness, density, refractive index and related dispersion, and elemental composition also provides a great deal of useful information. Density and refractive index determination are both simple and nondestructive tests, but because these properties share a very strong correlation (Thornton et al., 1984), most laboratories do not perform both. Refractive index is the principal optical property examined in glass evidence. The measurement provides high discriminating power and can be determined accurately using a glass refractive index measurement (GRIM) instrument, which many labs have available. Even without the GRIM instrument, refractive index determination can be accomplished with a standard polarized light microscope and a set of refractive index immersion liquids.

Analysis of minor and trace element composition can provide further discrimination of glass samples indistinguishable by color, thickness, refractive index, and density (Montero et al., 2003). Inductively coupled plasma–atomic emission spectrometry (ICP–AES) and ICP–mass spectrometry (ICP–MS) are two of the most sensitive techniques available for this type of analysis. The ICP instrument is essentially an extremely hot torch (reaching temperatures up to 10,000 Kelvin), which excites or ionizes atoms in the sample before they enter the AES or MS detector (Skoog et al., 2003). Although these instruments are capable of the highest degree of differentiation, many labs do not have them available due to budget limitations. However, more universal X-ray methods, such as SEM–EDS or X-ray fluorescence, also measure elemental composition, but with slightly less sensitivity. Elemental analysis provides a sensitive means of discriminating glass fragments from one another; although conclusions regarding an association between glass fragments may not be drawn conclusively, it may be stated with moderately high probability that glass fragments with statistically indistinguishable elemental profiles originated from the same manufacturing source (Smith et al., 2006).

Soil

Soil is most assuredly an important type of physical evidence and has, on a number of occasions, provided invaluable information by means of which crime reconstruction has been based. Establishing that the soil on the shoes or clothing of a suspect matches that from a crime scene will lend support to the notion that the suspect did, in fact, visit the scene of the crime. Likewise, the comparison of soil from the tires or the undercarriage of an automobile with soil from a particular location may establish with greater or lesser certainty that the automobile was at one time present at the location.

While the number of soil evidence cases currently processed by forensic laboratories is not large, this may in part reflect a regrettable attitude of negligence on the part of police investigators

and an even more shameful attitude of disinterest on the part of forensic scientists. Unfortunately, techniques for the forensic comparison of soil do not provide dichotomous answers nor possess the probative value of DNA evidence, of fingerprints, or of firearms and tool mark evidence. This is not due to an inherent lack of uniqueness among soils, but rather to a lack of developed methodology to adequately demonstrate the inherent uniqueness of soils.

Soil is not just a mixture of minerals. Soil is the superficial, weathered surface of the earth. In addition to parent minerals from which it has been formed, it typically contains greatly degraded plant material (humic acid and fulvic acid) where no plant structural elements may be recognized and partly degraded plant material where the plant material still has some recognizable structure (leaf litter), pollen, and a living biota. A typical soil will have a billion bacteria per gram of soil. Characterization and identification of evidence soil samples are not restricted to an identification of the minerals of which it is comprised.

Soil from a crime scene may be compared with soil from a suspect's shoes or clothing, soil from the undercarriage of a vehicle, or soil on a tool. Alternatively, if the origin of a soil sample is in question, it may be possible to determine the source location. Analysis of only a few milligrams of soil can establish color, texture, mineral composition, and density gradient distribution (Murray and Tedrow, 1975).

Using polarized light microscopy, an experienced analyst can identify the primary minerals in soil, based on their optical properties. SEM-EDS can also aid in identification. Clay minerals, which are too small for optical analysis, require instrumental analysis, such as X-ray diffraction.

Examination of organic matter can further discriminate between soil samples that share similar inorganic properties. Humic substances, or degraded biomolecules, make up the bulk of organic matter in soil. Due to the complexity of this type of material, it is not typically analyzed in most trace laboratories, although a successful method of instrumental analysis by FTIR does exist (Cox et al., 2000). Identification of botanicals, pollen species, or diatoms found in a soil sample may indicate the location of the soil source.

Minerals

Minerals are the parent, soil is the progeny. Soil is the weathered surface of the earth and is developed from parent minerals over geological epochs. (Dirt, however, is soil where it is unwanted.) Because minerals comprise much of the surface of the earth, they may from time to time represent an exceedingly important form of physical evidence. In addition to the identification of minerals in evidence rocks and evidence soils, mineral identification is applicable to the identification of some manufactured products as well.

For example, the identification of small particles or even a smear of drywall (i.e., sheetrock) gypsum in the clothing of a burglary suspect is in fact a mineral issue, as is the identification of rutile titanium dioxide pigment in a paint sample.

Gem identification is undeniably a type of mineral characterization, but this subject is sufficiently unique to justify a separate discussion and is encountered so infrequently in crime reconstruction as to be excluded from the present work.

With respect to crime reconstruction, it is likely that "mineral" identification will be invoked more often than "rock" identification. Certainly there will be exceptions. While bulk structure should never be neglected in the haste to determine composition, if a granite rock is used to bash

TABLE 10.3 Common Minerals

Augite	Fluorite	Muscovite
Apatite	Gypsum	Microcline
Barite	Glauconite	Orthoclase
Beryl	Hornblendes	Pennine
Calcite	Hematite	Plagioclase
Clinochlore	Hypersthene	Phlogopite
Corundum	Ilmenite	Quartz
Dolomite	Limonite	Rutile
Diopside	Magnetite	Sphene
Epidote	Marcasite	Talc
Enstatite	Monazite	Tourmaline
		Zircon

out someone's brains, it would be identified as "granite rock" rather than as a "crystalline mass of quartz and feldspar."

Minerals may be identified on the basis of color, refractive index, and other related optical properties, density, hardness, cleavage propensity, magnetism, opacity, particle size, and particle shape. These features have been compiled and tabulated for thousands of minerals.

About 3500 minerals have been described, many so rare that a mineralogist may endure his or her entire career without ever encountering a specimen. But of these thousands, fewer than 200 are common, and a forensic worker can accomplish considerable casework by being able to identify as few as two dozen of the most commonly encountered minerals (Table 10.3). And in acquiring the skills needed to recognize the two dozen common minerals, an analyst will acquire the skills needed to identify or at least characterize the hundreds of other minerals that may occasionally be encountered. With a modest investment of time, an analyst can learn to recognize quartz and calcite in an evidence specimen in a moment. The identification of a rare mineral, however, might take hours or even days, but it would be possible. It would not call for skills beyond the ability of the person with fundamental training in optical microscopy. (An analogy can be made to the identification of illicit drugs. Most forensic laboratories find that almost all illicit drugs submitted are restricted to a few chemical compounds, e.g., methamphetamine, cocaine, and heroin. But a person trained to recognize and identify these common illicit drugs could, given time and motivation, identify an obscure piperidylbenzilate as well.)

Metals

Small metal fragments may be encountered, primarily in scenes involving crimes against property. Metal shavings from drilling operations may be found in the clothing or shoes of a suspect. With burning operations with an acetylene torch or a burning bar, dispersed fragments

of molten metal propelled through the air will freeze into spherical globules, which may be found in the clothing of a suspect, often in conjunction with a tiny scorched area on the garment fabric. Several instrumental approaches are suitable for trace metal samples. These include emission spectrography (ES), ICP-ES, and SEM-EDS. In the characterization of metals, the major element of composition (e.g., iron, copper, aluminum) is first determined, followed by the adventitious trace elements. The trace elements can be about anything, reflecting the processes utilized in the production of the metal, as well as materials coextracted from the parent mineral ore. As an example, traces of silver are encountered frequently in lead, and manganese, phosphorous, chromium, and nickel are encountered frequently in steel. As another example, the aluminum alloy designated 2014 contains both titanium and chromium, whereas the 3003 aluminum alloy has neither. Quantitative, as opposed to qualitative, analysis may be required to discriminate among samples of a generic type, for example, alloys of iron, copper, brass, bronze, and aluminum.

In the characterization of evidence metal samples, both quantitative and qualitative analysis may work in concert. Quantitative analysis will distinguish between, for example, 10 carat gold (42%) and 18 carat gold (75%), but in this example qualitative aspects may be of assistance as well, in that 10 carat gold typically is alloyed with silver but not copper, whereas 18 carat gold is typically alloyed with copper but not silver.

Small metal fragments may be isolated and collected by picking them off in an examination of evidence under a stereoscopic binocular microscope. Fragments of ferrous metals, such as steel, may be recovered conveniently by virtue of their magnetism. Copper, lead, and aluminum may not be recovered with a magnet, and many stainless steel alloys are not magnetic as well.

Dust

In a discussion of the forensic significance of trace evidence, [Palenik \(1988\)](#) has reminded us that:

We live in a continuously crumbling world. Through the action of man and nature, almost any substance is eventually reduced to dust and may therefore conceivably turn up as a microtrace. Although it is impossible to prepare oneself to recognize every substance in its powdered form, it is possible, with a little effort, to learn to recognize the more commonly occurring particles.

Dust is a representation of the conditions in which we live, a miniature representation of our environment. It is typically composed principally of very finely divided mineral particles, along with biological and vegetable material, although dust may involve literally anything in specific instances. In an early discussion of dust as trace evidence, [Locard \(1930\)](#) stated broadly that "All chemical substances may be met with." In other words, one may expect to encounter anything when examining the minute particles that comprise dust. The uniqueness of parent materials from which dust is derived defines the uniqueness of dust itself, and hence its probative value as evidence. Apart from minerals and vegetable and fabric fibers, frequently encountered materials include micrometer-sized particles of epithelial cell fragments, fragments of insect exoskeletons, fly ash from industrial applications, scales of butterflies, eggs of lower animals and insects, rubber, polymers, cosmetics, feathers, asphalt, tobacco, pollens, diatoms, and various food and spice products. [Hess \(1996\)](#) provides a useful reference on the subject.

Shed human epithelial cells represent a significant component, as much as 75–80%, of many dusts. The human body sheds dead and dying cells, called “raft,” at a rate of up to 40,000 per minute—about 6 grams a week—and are preyed upon by the house dust mites that exist on all indoor surfaces. A typical worn mattress may have 100,000 to 10 million mites, each producing 10 to 20 waste pellets a day. Dead mites contribute significantly to the typical dust environment.

Identifying the composition of dust may point investigators to a particular location. For example, dust from kindergarten sites often tilts toward the inorganic (sand, loam, clay), whereas dust from the houses of animal owners will tilt toward organic materials. The abundance of dust, even in locations not considered to be “dusty,” is greater than we generally appreciate. Nearly 1000 dust particles per square centimeter settle on surfaces in domestic households and accumulate at a rate of approximately 6 mg per square meter per day.

Not everything that constitutes dust has significance. Cotton fibers, for example, are so ubiquitous that they are typically intentionally ignored. White and blue fibers, for example, tend to be found everywhere, but less common colors, such as purple and red, generate interest more readily. In many instances, dust may be only partly characterized as to be fundamental composition, but even a partial characterization of the dust under a microscope may establish a valuable association.

Household dust may contain some human DNA from shed epithelial cells. Tens of micrograms of DNA per gram of dust may be expected. Studying 36 samples, the work of [Toothman and colleagues \(2008\)](#) showed the DNA to range from 9 to 28 ng/cm² of surface area, but of this, only 0.2 to 1.2 pg/cm² was human DNA. At the present time, DNA analysts would like to have 1.5 ng of DNA to work with, although they can work with as little as 0.2 ng. Human DNA was detected in 35 of the 36 samples tested, and 22 of the 36 samples showed allele distributions of varying degrees of complexity. The implications of this study are twofold: (1) dust may, in some instances, provide evidence by means of which people could be identified within a defined environment, but (2) the presence of a not inconsiderable amount of dust in other evidence may be a significant contamination source in forensic investigations.

Pollen, Diatoms, and Radiolaria

Pollen, diatoms, and radiolaria are of a size, distribution, and character as to be of particular value as trace evidence. The presence of these materials may provide strong evidence of their provenance, therefore contributing greatly to a crime reconstruction.

Pollen may be found in soil or in the clothing of a suspect and may assist in linking a suspect with a particular geographical location. Although some pollens are quite large and even visible to the unaided eye, most are so small that a casual observer without a microscope would be unaware of their very existence. Additionally, pollen grains of different species are quite distinctive, and a determination of the suite of pollen in a given evidence sample will be of great value in characterizing the particular history of that item.

A pollen grain possesses three concentric layers. The central part typically possesses two nuclei. The surrounding layer is called the *intine*, and the outer layer is called the *exine*. The exine is stable, at least relative to the inner structures, and preserves an identifiable shell long after the inside dies and disappears. The layers of the exine may be distinguished under a microscope by

staining reactions. Pollens are not identified on the basis of the exine alone, however. The grain shape and the presence and arrangement of apertures in the pollen grain are also noted. Phase-contrast microscopy and dark-field microscopy are well suited for the examination of fine structure of pollen grains, and staining with safranin is commonly employed for detailed examination.

Diatoms [from the Greek *διά* (*dia*) “through” + *τεμνειν* (*temnein*) “to cut”] are microscopic algae with hard parts. They are aquatic, and both fresh- and saltwater forms exist. Most are unicellular in the size range of 10 to 150 μm , roughly of the same size as pollen. They are encased by a cell wall of silica, called a frustule. These frustules show a wide diversity in form, usually consisting of two asymmetrical sides with a division between them, hence the “cut through” appellation given by the Greek. It is estimated that there are approximately 100,000 species.

As the cell wall of diatoms is composed of silica, they are resistant to decomposition and persist in the environment for long periods of time. Fossil records of diatoms date back to the early Jurassic age, about 185 million years ago. They are often ornate and complex, and display a great detail of character. Different species may be distinguished easily under a microscope, even if the trace analyst cannot specifically identify the species by name.

Radiolaria are also distinguished easily and show even more complex structures than diatoms. Radiolaria are amoeboid protozoa with incredibly intricate mineral skeletons. They are oceanic, but may be found in any location that was ocean in prehistoric times. They are generally microscopic, on the order of 30 μm , although some may be as large as 2 mm. In some soil samples they may be abundant. As with pollens and diatoms, their ornate structure permits them to be recognized easily under a microscope, if not identified as to species.

Wood

While wood may be identified readily by inspection of color and grain when large areas are available, such as the identification of furniture or wall coverings, the trace analyst is often faced with the identification of very small pieces. In some instances, the identification of macerated fibers will be required, as in the identification of paper components.

Typically, small sliver-sized fragments of wood may be segregated into softwoods and hardwoods. This designation actually does not refer to the hardness of wood as the term “hard” is generally understood. Balsa wood is a hardwood, and pine is a softwood. What makes a wood a hardwood is the presence of “vessels,” which can be appreciated with a microscopic examination. Wood will typically show different microscopic features in three orientations with respect to the axis of a sample of wood. The three orientations are a cross or transverse section, a section along the axis radiating from the interior toward the exterior (radial section), and a section tangential to the growth rings (tangential section). Vessels are best seen in a cross or transverse section. Softwoods do not possess vessels, but the arrangement of fibers will generally permit their identification on the basis of their appearance in the three sections.

With very small pieces of evidence wood, it may not be possible to establish an orientation by means of which three sections may be viewed under a microscope. In this instance, the wood may be identified by macerating the wood and identifying the fiber components under the microscope. Staining reactions will aid in this process.

Paper

The trace analyst may be called upon to examine a sample of paper to establish the origin of the paper or to establish the extent of similarity between two samples. An example of the first problem would be where the analyst is asked to assist in a kidnapping case by providing the investigators with information concerning the manufactured and type of paper, the intended use of the paper, and any other information that would be of value in tracing the paper through its normal distribution channels. An example of the second would be a comparison of a holdup note with paper found in the possession of a suspect.

Paper is such a common commodity in our everyday life that we tend not to think about it to any great extent or to contemplate how it is made and how it may vary. Modern papermaking uses pulped wood fibers primarily, but recycled rag of both cellulosic and noncellulosic fibers may be used. In addition, synthetic fibers may be introduced into papers as a result of use of recycled rags.

Paper may be characterized on the basis of its color, weight, opacity, reflectivity, the presence of any filler or coatings, the presence of dyes or pigments, and the type of fibers employed in its manufacture. Processes used in the manufacture (soda, sulfate, sulfite processes) may be determined by staining reactions. The type of wood pulp fiber may be determined by microscopic examination and staining reactions.

Arson Accelerants

While trace evidence is generally tangible, it need not be. Following a fire that was deliberately set and in which a petroleum accelerant was used, residues of the flammable material may be recovered and identified. Despite being weathered, contaminated, and present in only trace amounts, petroleum materials may, in many instances, be identified after a fire. This holds even when only vapors of the accelerant and no liquid material remains. A gas chromatograph (GC) is particularly well suited to this task.

While any flammable petroleum material could be used as an accelerant, as a practical matter nearly all arson cases involve gasoline. It is an effective accelerant, is readily available, and can be acquired without the purchaser becoming conspicuous.

The initial examination of arson debris is for traces of volatile liquids, together with a general search for other items of significance, for example, "triggers," such as fuses, matches, chemical incendiaries, and cigarettes. Due to alteration and contamination of volatile liquids, class characterization is often the practical limit of characterization. In those cases where two liquid samples are compared directly, further characterization may be possible. At first consideration, it may be surprising that arson accelerant residues survive a fire. Survival and persistence are favored by incomplete combustion and migration of accelerant residues away from heat. Initially, liquids flow to the lowest surface, seeping into carpeting, flooring, or soil. These absorbent materials are often effective retainers of flammable liquids. Surface burning causes the accelerant to migrate toward the interior. If burning is not complete, the accelerant is protected from evaporation by the air space at the material surface. Water may also fill this space when the fire is being extinguished, preserving a pocket of residue within the absorbent material.

By far the most common arson accelerant, gasoline is not just one material, but a mixture of dozens and dozens of hydrocarbon entities. The more volatile of these are consumed

preferentially during a fire, and the remaining residue is consequently depleted of certain components. Consequently, the gas chromatographic analysis of residue after a fire will not match a sample of the liquid material that was used. In recognition of this, the ASTM (2010) standard for the identification of gasoline in fire residues is quite explicit. It requires gas chromatographic identification of a specific methyl-naphthalene doublet, two specific alkylbenzene doublets, and a specific five peak group of ethyltoluenes.

Explosive Residue

When explosive materials are detonated, much of the explosive chemical is converted to energy and consumed in the explosion. However, small amounts of the parent material will survive. These residues are broadcast widely and may be recovered from objects at the scene. Although the amounts of material are small, typically they are sufficiently great to permit their identification by chemical and instrumental means.

In the past, the bulk of explosive cases have involved a very small number of explosive materials, typically smokeless gunpowder (nitrocellulose and nitroglycerine) or "black powder" mixtures of carbon, sulfur, and a strong oxidizer such as chlorate or nitrate, perhaps with aluminum "flash powder" incorporated into the mixture. With the increased incidence of state-supported terrorism, other more powerful explosives, such as dynamite, TNT, RDX, or Semtex, may be encountered with greater frequency. Analytical techniques are available for the detection of commercial and military explosives down to the microgram level.

Gas chromatography, mass spectrometry, infrared spectrophotometry, and X-ray diffraction predominate in the identification of residues. Chemical microscopy, color tests, solubility tests, and thin-layer chromatography may be applicable in some instances.

A somewhat peculiar situation exists with respect to the literature on explosive residue analysis. The references on explosives at the end of this chapter are those appearing in the open and accessible literature. Certainly much has appeared in the open literature. However, much of the published work, while perhaps open, is not particularly accessible. A voluminous literature exists in the category of symposia, for example, *Proceedings of the 5th International Symposium on the Analysis and Detection of Explosives*, hosted by the U.S. Department of Treasury Bureau of Alcohol, Tobacco, Firearms, and Explosives.

Gunshot Residue

We classify gunshot residue (GSR) into two categories, *uprange* and *downrange*; both of which qualify as trace evidence. Downrange residues consist of soot (at very close range) and fragments of unburned gunpowder (at close range). At a greater distance, but still limited to just a few feet from the muzzle of the firearm, chemical tests may detect traces of lead, copper, and barium on target materials or nitrite from the combustion of smokeless gunpowder.

The size and shape of the patterns made by soot, unburned gunpowder, and lead and barium distributions may establish the location of the firearm, with respect to the target, at the instant of discharge. Chemical and instrumental tests exist for confirmation of fragments of unburned gunpowder, and chemical tests exist for the demonstration of very fine particles of lead and barium. The sodium rhodizonate test is a color test for lead and barium, the lead originating from a

lead bullet; vaporized lead from the core of a jacketed bullet exposed to high temperature before the bullet leaves the barrel; lead azide or lead styphnate from the cartridge primer; or a combination of these sources. The sodium rhodizonate test will not deliver a precise muzzle-to-target distance, but it may give an approximation of distance and will clearly determine the maximum distance to which these materials will be deposited on a target for a particular combination of target material, firearm, and ammunition.

The *Greiss test* is a color test for nitrites, formed as a result of combustion smokeless gunpowder. The density and distribution of a pattern of nitrites may indicate the distance between the muzzle of the firearm and the target material. The sodium rhodizonate test and the Greiss test may be run in tandem, with the sodium rhodizonate test run subsequently to the Greiss test, to develop the different sorts of information. Both tests may be run on garments that have been bloodstained extensively.

Uprange GSR consists of very small particles (about 1 μm) of lead, barium, and antimony derived from the primer mixture of the ammunition. At the instant of discharge, these particles disperse around the firearm in a sphere roughly the diameter of a beach ball. Anything within that domain will likely be contaminated by these particles. The particles are so small that a scanning electron microscope is needed to visualize them. The SEM used for this purpose is equipped with an energy-dispersive X-ray spectrometer to analyze candidate particles for the elements lead, barium, and antimony.

In theory, finding GSR on the hands of a suspect is a crime reconstructionist's dream. Many people, including many police investigators, are under the impression that this information would definitively prove who the shooter was. Consequently, those laboratories that do gunshot residue analysis are often deluged with samples to analyze, and as this type of analysis is costly, agencies may expend a great deal of money on these analyses. The reality of gunshot residue analysis, however, is that the interpretation is often not clear-cut. If the hands of a subject are tested and show these particles, it is consistent with the following: The person (1) has discharged a firearm recently, (2) has been in close proximity (i.e., within the "beach ball" domain, although this is a conservative estimate) to a firearm when it was discharged, (3) has handled a firearm or other object contaminated with GSR particles from a previous or subsequent gunshot discharge, or (4) touched the hands (or possibly the clothing) of another individual who has discharged a firearm or handled a recently discharge firearm, or (5) was in an area (e.g., a room or a car) in which a firearm had been discharged recently.

As with many other types of trace evidence, the analysis of gunshot residue is relatively straightforward. The interpretation, however, is greatly dependent on the nature of the possible shooting scenario, as well as the nature of the results. In some cases, the significance of the presence of GSR is tenuous, as it is dispersed easily and contamination may occur easily. For example, if a suspected shooter is handcuffed by a police officer who handles firearms consistently and whose holster and duty belt are loaded up with residue from routine range practice, the possibility of contamination is clearly present. In other situations, however, gunshot residue analysis may lend great support to the crime reconstruction (e.g., if two suspects exist and each claims that the other was the actual shooter, the quantity of gunshot residue on their hands can certainly be telling).

The lack of gunshot residue on the hands of a suspect may also be insignificant, as the residue is washed off skin surfaces easily and does not persist on the skin of an active subject for more than a few hours. However, on the hands of a dead subject, such as a suspected suicide victim,

gunshot residue will persist for an extended time. On other surfaces, such as clothing, and in the absence of strong movement that would dislodge them, residues may persist indefinitely. It would be prudent for investigators to keep these facts in mind in their handling of suspects or evidence related to a shooting and to understand the limitations of this type of evidence.

Miscellaneous Forms of Trace Evidence

As has been stressed previously, there is no limitation as to what may represent trace evidence in particular cases. Nearly anything in the physical world can become evidence when a crime occurs. Some types of evidence occupy a very narrow niche and are encountered rarely, but when they do arise may have a profound impact on the crime reconstruction. A few of these are discussed here as examples. No effort is made here to exhaust, or even to begin to confer, the possibilities of less commonly encountered forms of trace evidence; such an effort would require volumes and would still be derisory; that is the nature of trace evidence. The examples presented here are a mixed salad of trace evidence types, included here to simply draw attention to the diverse landscape of trace evidence in general.

Automobile Light “On or Off”

Determination of vehicular light “on or off” falls into the category of narrow niche evidence. In reconstruction of a vehicular collision, we may need to determine whether or not a vehicle’s headlights, taillights, or turn signals were operating at the time of collision. A microscopic examination of the tungsten filaments, whether fractured or intact, may answer this question.

If the light is on when the glass envelope is broken at the time of a collision, the heated tungsten filament will then be exposed to atmospheric oxygen and will fail within a second or two. The separated ends of the filament will show a bulb-shaped globule of tungsten on the ends. If this is contemporaneous with the collision, there may be minute fragments of glass from the broken envelope fused onto the filament, which at the moment of the collision may be at a temperature of 2800°C. The melting point of borosilicate glass of the glass envelope, however, is only about 1100°C. If the tungsten filament is exposed to oxygen when hot, a residue of tungsten oxide may be seen on the filament or at its base. Tungsten oxide is yellowish-white in a thick film, but because of interference of light may exhibit other colors in thin films. A color test with stannous chloride is available as a confirmatory test, or instrumental analyses may be performed.

If the collision occurs with the light off, the filament is cold. While it may be fractured, in this case the ends of the filament will be blunt. If a lamp has burned out by age, that is, a normal burnout not resulting from a collision, the ends will exhibit distinct tapering, clearly distinguishable from the abrupt terminus associated with cold fracture or the globule of tungsten or fused glass associated with a hot fracture. The coiled tungsten helix of a lamp filament puts one in mind of a spring, and because of our greater familiarity with springs than with tungsten filaments, we assume that a filament would have some resiliency. This is not the case. Tungsten filaments are rigid and inflexible. When they are strained, they fracture.

Projectile Wipes and Projectile Trajectory

Metal wipe tests can verify bullet penetration of walls, doors, and other more or less-fixed objects at a crime scene. Sensitive chemical tests, such as the dithizone (diphenylthiocarbazone) test for lead and the rubeanic acid (dithioxamide) test for copper, will confirm the presence of lead from lead bullets; copper from jacketed bullets; or, in the case of lead-nosed, copper-jacketed bullets, both lead and copper. Because of the potential toxicity of lead, commercial test strips for lead exist for environmental testing, which may be utilized for forensic purposes. Copper test strips are also available commercially, but are more difficult to apply at crime scenes because the copper comprising the jackets of projectiles is so much harder than the soft and ductile lead. Consequently, less copper can be expected to be wiped onto the surface being penetrated, providing less copper to enter into the chemical reaction. In short, chemical tests for copper wipes are more challenging in both application and interpretation than the relatively unambiguous tests for lead. When copper-jacketed projectiles are suspected, it is preferable to excise the putative bullet hole and submit the entire excised item for examination in the laboratory.

Bullet trajectories and ricochet are discussed in detail in other chapters in this text (see Chapters 13 and 14: Shooting Incident Reconstruction, Parts 1 and 2). Very often the angle of approach of a bullet to a surface may be discerned. A bullet approaching perpendicular to a surface is likely to result in a circular hole, a commonsense interpretation. A bullet approaching at an angle, however, will result in an elliptical hole. The elliptical hole will not be entirely symmetrical and will show beveling of the side of approach. A probe of the same diameter as the bullet placed in the hole may document the approach angle for purposes of measurement and photography.

If the bullet has struck an intermediate object, or has ricocheted, the trajectory of the bullet may, however, have been destabilized, resulting in the bullet tumbling in flight. In such an instance, the bullet may strike the final surface with a side on presentation, typically referred to as a “keyhole” impact. Any reconstruction must take into account the possibility that the bullet has not been destabilized before striking the surface in question.

Bank Robbery Exploding Dye Packs

Money given to a bank robber may include a package that soon will explode, contaminating both the money and the robber with a visible red dye. The trace analyst may be required to verify the dye on money, clothing, and anything in close proximity at the moment the pack explodes. The expected dye is 1-methylaminoanthraquinone. The lachrymator *o*-chlorobenzylidene malonitrile may be present as well; this is discussed next. The dye, which is soluble in methanol, may be analyzed by FTIR and GC-MS.

Lachrymators (*o*-Chlorobenzylidene Malonitrile and 2-Chloroacetophenone) and Pepper Spray

o-Chlorobenzylidene malonitrile and 2-chloroacetophenone are generally referred to as “tear gas,” although both are volatile solids. Confirmatory analysis may proceed by means of GC-MS, although the chemical identity of these materials will generally manifest themselves before and during the analysis by the discomfort caused the analyst. We can say the same for pepper spray

(*Capsicum*), an alcoholic extract of chili peppers. GC alone, GC-MS, or thin-layer chromatography are all suitable methods for the analysis of capsicum.

Paper Matches

In some instances, we can identify the particular matchbook from which an isolated paper match, for example, a match found at a suspected arson scene, was torn. Paper matchbooks are typically made from recycled newspapers. Layers of newspapers are pressed together, with the outside layers bleached to the beige-gray cardboard color generally seen. Interior layers of the paper match will show the original printing of the newspaper. Soaking the match and teasing apart the layers will reveal cleaved letters, which may line up to adjoining matches in the respective layer in the parent matchbook.

Feathers

Feathers are not a common form of evidence, but when encountered may constitute strong association. They may be processed by conventional microscopy or by scanning electron microscopy and keyed out to indicate species.

Glitter

Glitter is more prevalent in the environment than might be expected, principally as a result of its durability. It can be found in cosmetic products, in textiles, and in arts and crafts and embedded in plastics. Glitter, which consists of thin pieces of foil or plastic, cut into tiny particles, can be easily identified and subsequently isolated because of its light-reflective properties. Glitter can be characterized on the basis of size, shape, color, thickness, number of layers, specific gravity, and distance between apparent colored diffraction lines. Additionally, shape anomalies from the machine used to cut the glitter parties may offer further individualization. Instrumental analysis using ATR-FTIR or Raman microspectrometry will provide information on the particle's chemical properties.

Cosmetics

Cosmetic products, such as lipstick or foundation, for example, are transferred easily onto cigarette butts, glassware, clothing, and other surfaces. These products are highly persistent and encountered rather frequently at crime scenes with moderate frequency. If cosmetic smears are significant, it may be possible to characterize these types of products based on color by employing microspectrometry, or to identify the chemical composition using FTIR, gas chromatography with flame ionization detection, or SEM-EDS. Combining two or more of these techniques will provide a high degree of discriminating power, which is particularly useful if a known or suspect sample is available for comparison.

SWGMAT GUIDELINES

Under the aegis of the Federal Bureau of Investigation, scientific working groups have been established to develop procedures and practices that apply to various evidence types. These groups, all with the prefix SWG, pronounced “swig,” encompass a considerable number of evidence types, including questioned documents (SWGDOC), firearms and tool marks (SWGGUN), DNA methods (SWGDM), fingerprints (SWGFAST—for Friction Ridge, Analysis, Study, Technology), bloodstain pattern analysis (SWGSTAIN), shoe print and tire tread evidence (SWGTREAD), and even for dog scent identification (SWGDOG).

The working group for trace evidence materials is SWGMAT (Scientific Working Group on Materials Analysis—“swig-mat”). SWGMAT has promulgated guidelines for trace evidence recovery (SWGMAT, 1999a), on quality assurance in trace evidence examinations (SWGMAT, 2000a), on human hair examination (SWGMAT 2005a), the initial examination of glass (SWGMAT, 2005b), elemental analysis of glass (SWGMAT, 2006a), the collection, handling, and identification of glass (SWGMAT, 2005c), glass examination in general (SWGMAT, 2005d), glass fractures (SWGMAT, 2005e), glass density determination (SWGMAT, 2005f), glass refractive index determination (SWGMAT, 2005g), general fiber examination (SWGMAT, 1999b), microscopy of fibers (SWGMAT, 1999c), visible spectroscopy of fibers (SWGMAT, 1999d), thin-layer chromatography of fiber dyes (SWGMAT, 1999e), infrared analysis of fibers (SWGMAT, 1999f), pyrolysis gas chromatography of textile fibers (SWGMAT, 1999g), fibers and cordage (SWGMAT, 1999h), and paint analysis and comparison (SWGMAT, 1999i).

We should recognize, however, that the SWGMAT guidelines suggest how certain evidence types should be analyzed, and they are valuable in that regard. But they do not address interpretation. They do not clarify what is meant when we say that something is the “same,” that something “matches,” or that something is “consistent with” something else. It is possible, through ignorance, inattention, or inexperience, to be in total compliance with SWGMAT guidelines yet fail to interpret the evidence properly. We do not intend for our comments to be construed as criticism of SWGMAT or any other scientific working group, but rather as a gentle admonition or caveat. SWGMAT in particular has made a conscious decision that each method will require its own approach to interpretation, with interpretation to follow after methods of analysis and training.

STANDARDS AND DATABASES FOR TRACE EVIDENCE IDENTIFICATION

Although a trace evidence analyst working frequently with a particular type of evidence will accumulate a mental store of information over a period of time, it is not possible to retain in one’s memory the thousands of bits of information associated with even the most common types of trace evidence. Access to compendia of analytical information is essential to the work of a trace analyst.

A database may contain reference samples—known standards—against which an evidence sample may be compared. Known standards are, in fact, a type of database, but in general practice they are referred to simply as “standards.” This database will consist of tangible samples—

glass, animal hairs, or flammable liquids for comparison against a possible arson accelerant or synthetic fibers mounted on microscope slides, for example.

Another type of database may consist of analytical information, for example, the solubility characteristics of synthetic fibers in various organic liquids or the refractive indices of minerals. Information of the latter sort lends itself to computer retrieval, and because these types of data are universal, they may be shared by many examiners and many forensic laboratories. Databases of this sort must be kept current, however. If the database is not current, or if the purpose of the database is diminished, it will lose its relevance. At one time, INTERPOL maintained an extensive file of typeface strikeups of typewriters from around the world, but the senescence of typewriting in developed countries has resulted in this database losing much of its importance.

A different arrangement of data may serve another function. Data demonstrating the attributes of evidence samples over time may permit a determination of how common or how rare an evidence sample may be. For example, a collection of the refractive indices of glass specimens compiled as a result of previous case will allow an analyst to project data from an instant case against the frequency of occurrence of those particular values, thereby assisting in interpretation of the significance of the evidence.

Commercial databases and sources of standards exist for many evidence categories. GC-MS libraries are available both in hardcopy and in electronic form, as are FTIR libraries. Certified standards are available for fibers, paints, glass, and flammable liquids.

For microscopic examinations of trace evidence, access to a compendium of data is essential. An extensive atlas of images and other identifying information—the so-called *Particle Atlas* published by McCrone Associates on an electronic subscription basis and by Microdata Ware on a CD—is available for a host of trace evidence types, and specialized atlases are available for animal hair, fibers, minerals, pollens, and other materials.

POTENTIAL SOURCES OF ERROR IN TRACE EVIDENCE ANALYSIS

In trace evidence analysis, as with all types of physical evidence, we must be concerned with error. It is an error in itself to assert that errors are not made in the reconstruction of crime. Misinterpretations and incorrect crime reconstructions are made, and there is a professional obligation to manage it. Clearly there are aspects of crime reconstruction that carry high risk, where an error could potentially result in severe untoward consequences. And the risk will inevitably be greater in those instances in which the examinations are unusual and rarely attempted. Many trace evidence types will fall within this category. With commonplace types of evidence that are being dealt with constantly, we consequently have methods developed and tested, we have safeguards in place, and we have accumulated experience. An example would be bloodstain pattern interpretation, which occurs with sufficient frequency that the reconstructionist is likely to have a significance amount of conversancy.

The type of case we need to be particularly attentive to is a particular case where the analysis is entirely novel or which is seldom conducted. Particular care must be taken in connection with trace evidence analysis, as rarely encountered evidence is by no means uncommon. With a low frequency of submission, the reconstructionist is denied the ability to develop a long history of trustworthy experience. Relevant experience may be accrued at a very slow rate, is not recalled precisely, or previous experience may have led to conflicting results. In the worst case, the

reconstructionist may have no experience at all upon which to call. A feather adhering to the clothing of a homicide suspect may be from a parakeet at a crime scene. If, in fact, the feather is a parakeet feather, it would constitute a very strong association between the suspect and the scene. The analyst may go years between feather cases, but is suddenly called upon to make a critical decision concerning the provenance of the evidence. While much hinges on the analysis, the low frequency of this evidence should cry out for particular caution.

If experience cannot enter this arena, we must fall back on education and training. For the crime reconstructionist, every day should be a training day. Every day a deposit should be made into an account of core critical values, because someday we may be forced to make a withdrawal. What are “core critical values?” They are specific to each and every type of evidence being examined. The reconstructionist will need to know what they are. If anyone concerned with a case cannot identify the core critical values pertaining to that case, they should stop and think about the evidence some more.

Formal education and training in crime reconstruction, provided by others who are presumably more experienced in dealing with the particular evidence genre, are but a part of the equation. Casual training of on-the-job type is again valuable, but is not sufficient to provide the level of protection that you need, and deserve. There is an imperative that, in addition to every other type of training, the crime reconstructionist trains himself or herself in core critical values and their application to the case at hand.

QUALITY ASSURANCE PRACTICES FOR TRACE EVIDENCE ANALYSIS

Several avenues present themselves for the assurance of technical correctness in the analysis of trace evidence. These include accreditation of laboratories, certification of individual analysis, peer review, and periodic proficiency tests.

Laboratories are accredited; individuals are certified. Accreditation is defined in the forensic profession as the formal assessment and recognition that a forensic laboratory is capable of meeting and maintaining defined standards of performance, competence, and professionalism. This assessment is done by an outside, impartial authority. Accreditation is a status earned by a laboratory. Certification is earned by a person.

An adjunct of the American Society of Crime Laboratory Directors—the ASCLD Laboratory Accreditation Board, or ASCLD/LAB—offered a voluntary accreditation program from 1981 to 2009, in which statements of principles describing acceptable levels of performance and enunciating criteria for evaluation. This accreditation was by no means limited to trace evidence analysis and typically countenanced the full spectrum of evidence types for which a laboratory was responsible.

In March of 2009 the ASCLD/LAB accreditation program, known as ASCLD/LAB Legacy, was terminated. Another program, known as ASCLD/LAB–International, was instituted, in which laboratories are expected to conform to ISO 17025 requirements, specifically the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 17025:2005–*General Requirements for the Competence of Testing and Calibration Laboratories* and the ASCLD/LAB–*International Supplemental Requirements for the Accreditation of Forensic Science Laboratories* (2006). Once a laboratory has successfully achieved accreditation status under ISO/IEC 17025, the ASCLD Accreditation Board then monitors continued conformance with

accreditation criteria. One aspect of this monitoring is the participation and performance of the laboratory in external proficiency tests. Proficiency tests are discussed in more detail later.

The American Board of Criminalistics offers certification of individuals in a number of areas—drug testing, molecular biology and DNA, fire debris and explosives, firearms and tool marks, trace evidence, and crime scene reconstruction. Several levels of certification are available. For trace evidence analysis, the most rigorous level requires 2 years of experience in performing trace analysis and is focused on hair and fibers and on paint and polymers. An annual proficiency test is required.

Many laboratories have a detailed quality assurance manual program. The Virginia Department of Forensic Science, for example, has placed their quality assurance manual (113 pages) on the Internet (at www.dfs.virginia.gov), along with their trace evidence procedures manual (155 pages) and their trace evidence training manual (154 pages). Standard protocols of analysis are suitable for many cases, but the very nature of trace evidence is such that instances will present themselves where a promulgated protocol or guideline will not address an uncommon or unique item of evidence. At that point, the training, experience, and professional acumen of the analyst are at a great premium.

Most forensic laboratories use peer review to assure the technical correctness of the work of an analyst. In this, prior to issuance of a formal report, a supervisor with experience in the area in question reviews the evidence, the work that has been done, and the conclusions drawn from it. Many laboratories have instituted peer review of both a technical and an administrative nature as an obligatory part of the work of the laboratory.

Proficiency tests present a peculiar state of affairs, not only for the trace analyst, but for the forensic sciences at large. Proficiency tests, where the analyst is informed of the correct answer only after completion of the test, is certainly a valid means of assuring the competency of the analyst and of the methods that he or she has employed. The results of proficiency tests are generally made public or become public as part of discovery proceedings. Forensic analysts of whatever ilk view proficiency tests with considerable angst, not so much because they are unwilling to prove their competency, but because of the onerous and perhaps perpetual stigma attached to a failed test. This is an area where science and the law are in tension. Under an adversary system of law, an analyst may be asked on the witness stand if he or she has ever failed a proficiency test. The question, when posed, will stress the “ever.” A certain measure of shame will inevitably be attached to a failed proficiency test, but it is manifestly unfair to have that shame ascribed in perpetuity. This is the law, but from the viewpoint of science may be of dubious relevance. The analyst who has since performed unerringly for years will understandably, and with justification, resent having a failed proficiency test hung around his or her neck as an undying and eternal albatross.

We do not set our hand against proficiency testing. It is an aspect of quality assurance that is the price of doing business, and is of definite benefit. But it should be recognized that proficiency tests may be constructed that are so facile that anyone would get them correct—even the most inept analyst using questionable procedures—or they may be so difficult that virtually no one would get them entirely correct. The distinction between an easy test and a difficult one is rarely if ever appreciated if and when an analyst is asked about his or her performance.

Proficiency tests may be administered by an outside agency, as with accreditation and certification procedures. However, some laboratories deal with the issue of the everlasting stigma of a failed proficiency test by *internal* proficiency tests, additional tests that are so complex and

difficult that a totally correct answer will rarely, if ever, be achieved. These are referred to as “stinker tests.” They serve as a learning exercise for the analyst, which is of course one of the ostensible purposes of a proficiency test. But they also serve the purpose of enabling the analyst, in response to the question “Have you ever failed a proficiency test?”, to say “Yes, it happens all the time. We have internal proficiency tests that are extremely complex and difficult, and we aren’t expected to get them correct in all of their aspects.” This takes the sting out of admitting performance that is short of some hypothetical ideal, as no shame is attendant to this process.

TRAINING OF TRACE EVIDENCE ANALYSTS

Most established forensic laboratories have formalized training regimens for trace evidence analysts. These typically involve background reading, review of data and reports generated in cases analyzed previously, and shadowing and being mentored by an experienced analyst.

In the closing days of the 20th century, forensic science was delivered a gift. The introduction of DNA analysis suddenly provided enormously more discrimination than conventional serology in the analysis of blood and semen, the two materials of greatest significance in the investigation of violent crimes. The investigations of homicide and assaults, sexual or otherwise, received a profound benefit.

The emphasis placed on DNA analysis, while not unjustified, has resulted in fewer resources being allocated to trace evidence. It takes several years of devoted study to become truly adept at mineral, wood, or pollen identification. A forensic laboratory may find it difficult to justify training a person to conduct examination of material that arise only rarely in casework. The identification of feather species would be a good example.

This presents a problem that quickly becomes circular. The laboratory is unable to deal with a particular type of evidence. Faced with the realization that the evidence will not be graded by a laboratory examination, field investigators may cease to collect that particular form of evidence. The laboratory then has fewer submissions of that type of evidence, which compromises the efforts of the laboratory to train personnel in that type of analysis. Some laboratory directors maintain that trace cases are seldom submitted to the laboratory, but at the same time admit that efforts to find trace evidence at crime scenes are often desultory.

This problem is compounded to an even greater extent by the movement toward laboratory accreditation. While laboratory accreditation is a desirable thing in its own right, many laboratories have deliberately curtailed their acceptance of less common forms of trace evidence, pleading that the rarity of the evidence does not justify the development of a protocol for that type of evidence and that appropriate proficiency test samples—an accepted corollary to accreditation—are not feasible. The forensic science community has not yet come to grips with this dilemma.

TRACE EVIDENCE INTERPRETATION IN CRIME RECONSTRUCTION

In the interpretation of trace evidence as it applies to crime reconstruction, the principal issue is the presence of a type of evidence where it is not to be expected. An uncommon material, wherever situated, often is of immense significance. But also, common environmental materials,

such as those in [Table 10.1](#), found in a place that cannot be explained on the basis of ordinary activity may also be of particular significance.

While there are general standards for trace evidence analysis, SWGMAT guidelines, for example, there are no codified and universally accepted standards for trace evidence interpretation. The interpretation of trace evidence in crime reconstruction is a confluence of science, common sense, personal experience, folk wisdom, and ideology. We are not, however, enemies of any of these other things being piled on top of science, but only if they can be clearly enunciated and justified.

Let's start with something simple and straightforward. Consider the following example: In a hit-and-run case, blue paint over a red primer is found on the victim's green car, and green paint over a black primer is found on the suspect's car. In both instances, good accord is seen in the number of layers, the color of the layers, the sequence of the layers, the relative thickness of the layers, and the chemical type of paint. This is a bidirectional transfer with a great deal of developed information, resulting in a very strong level of association, and it should be reported that there is very strong evidence of contact between the vehicles. This example illustrates that when there is contact, and an exchange of evidence, the nature of that exchange is dependent on the materials and circumstances involved. It is the responsibility of the reconstructionist to account for this in his or her interpretations.

It is important to understand that reconstruction does not proceed immediately from trace evidence. First there must be detection of the evidence, followed by its isolation, identification, comparison when appropriate, evaluation, and association. Then, and only then, may we proceed to a reconstruction. *Interpretation is involved at each step.* This process may take only an instant, as might occur in the recognition and interpretation of a blood trail from one location to the place where the victim was found, or it may take many days, as in the complex analysis of overlapping blood spatters. If the evidence is not interpreted properly, then any perceived associations will be faulty. If the associations are faulty, then the resultant reconstruction will be fallacious. As developed elsewhere in this text, there is a moral and professional responsibility on the part of the reconstructionist to interpret the evidence correctly. Subsequently, the consideration of evidence association must be tended with the utmost concern.

Crime reconstruction, it must be remembered, is not a simple or trivial endeavor. For any person wishing to pursue crime reconstruction, a useful (and humbling) exercise is to go into one's own kitchen and attempt to dispassionately reconstruct recent activities that have taken place there in the past day or two. This is not even a realistic reconstruction because the expected activities are familiar and to some extent known. A more challenging exercise would be to go into a neighbor's house and attempt the same thing. If these attempts at reconstruction are murky or incomplete, then how much reliance can be placed on reconstruction in a totally unfamiliar milieu? It is a question that needs to be asked often, but rarely is.

Associations, and by extension reconstructions, may be commonsensical and entirely valid. The problem arises from employing common sense, but labeling it as the product of a scientific determination. In assessing the associations that may present themselves in the examination of trace evidence, whether it be in a kitchen, a crime scene, or both, the work of [Cwiklik \(1999\)](#) stands out conspicuously with regard to placing trace transfers in clear perspective. It represents one of the few new approaches to trace evidence in the present millennium. It will be outlined here, but those involved in crime reconstruction, particularly in the interpretation of trace evidence, would be well advised to consult and become familiar with her work.

Cwiklik melds science, in the form of statistics, with many of our beliefs that we would typically label as “common sense.” And Cwiklik does ratify, in a fundamental form, the Locard exchange principle. Using set theory as a guide, Cwiklik has proposed rational criteria for making decisions concerning the significance of trace evidence. Criteria proposed, which have been accepted by most people working in the area of trace evidence, assist in establishing contact based on corresponding sets of trace particles, for excluding contact in the absence of corresponding sets of particles, and for the recognition of instances in which prudence argues for refraining from making either an association or an exclusion. Unique in discussions in the forensic science literature of trace evidence transfer is Cwiklik’s treatment of the extended array of conditional possibilities that may apply to a given situation. These include situations in which trace evidence may have been lost since the initial contact or the possibility of secondary transfer of evidence to an object, which then transfers a portion of that evidence to yet another object. Cwiklik is also the first to suggest that multiple criteria be applied simultaneously to the assessment of association, as opposed to one or two criteria applied separately or sequentially.

Cwiklik’s work is particularly relevant to considerations of association and their liaison with reconstruction conclusions. She points out the nuances that are at play. With respect to validity, isolated associations may themselves be of various strengths. When compounded or when combined with investigative and other facts of a case, a rational mind may find them relevant and convincing. Reconstruction, as the next step, involves a manipulation of those associations, with each association accompanied by its own level of certainty or uncertainty. Often, the emphasis in reconstruction is not on the strength of the conclusion as expressed by the reconstructionist but, rather, its validity.

TRACE EVIDENCE AND THE FUTURE

Unfortunately, and to the detriment of the forensic sciences and despite its elegance and utility, trace evidence is experiencing a period of decline. Many of the techniques originally developed to deal with trace evidence analysis came into being in connection with the investigation of burglary and other crimes against property—offenses that are not currently investigated as aggressively as in the past. Many investigative agencies have channeled nearly all of their investigative efforts into crimes against a person, with homicide and sexual assault cases dominating their investigative tapestry. When blood and semen evidence exists, trace evidence is often given a subordinate role in the investigation. Although this is understandable, given the capability of DNA to discriminate among individuals, the skill inventories required for trace evidence analysis are forced into senescence. Some trace evidence categories will be encountered only rarely, whereas at the same time full competency in the identification of, for example, woods, pollen, or soil minerals, requires years of study.

All too often, individual forensic scientists are uninterested or unwilling to engage in the time and effort to train in these often highly technical, and certainly specialized, types of analyses, knowing that they will have the opportunity to practice these skills on actual casework much less frequently than, for example, a DNA analyst will on an evidence blood sample. For the same reason, laboratories often do not want to devote the resources to keep their trace equipment and analyst training up to date or even keep their trace section accredited. Overall, training in trace evidence analysis has lost momentum, particularly with young forensic scientists hearing the

siren song of DNA analysis. Cases that rely solely on trace evidence may suffer as a consequence. Using trace evidence to make a possible association, or a probable exclusion, may not provide the instant gratification that a cold hit on a DNA sample does, but it is often the trace evidence that brings coherency to the physical evidence in a particular case or provides invaluable investigative information to point investigators in a particular direction.

A number of years ago the Marine Corps had a recruiting pitch appearing on billboards. It said, "No one wants to fight a war, but someone needs to know how." We believe that similar consideration can be made here with respect to trace evidence. Trace evidence analysis may not be the current forensic vogue, but someone needs to know how to do it, and laboratories should be capable of providing it. The trace analyst may not examine feather evidence on a routine basis or an obscure trace of lip gloss, but someone needs to know how to do it. The crime reconstruction may have a dire need of it.

It is hoped that the eclipsing of trace evidence by DNA typing is a short-term adjustment. We believe trace evidence will continue to have a future, but only if the forensic science community, the police, and the judiciary give it the respect, and support, that it legitimately deserves. This is a challenge to up-and-coming reconstructionists, those who would rely on them, and those who seek to educate them.

SUMMARY

There is truly no limitation on what constitutes physical evidence. Anything, tangible or intangible, may become the physical evidence that helps us tell the story of what happened at the time of the crime; it may be as large and obvious as a truck or it may be so small that a microscope is needed to see it. Small bits of evidence may have significance beyond what might be expected on the basis of their size. These small bits, or traces, may provide information that helps determine the factual circumstances of what happened at the time that the crime occurred. We call these materials *trace evidence*—an extremely broad category of physical evidence, but one of remarkable value.

Trace evidence has the capability of associating a person with a crime or telling us what actions took place. Examples of the former are a chip of paint from the car of a suspect found on the victim of a hit and run or a victim's hair found in the trunk of a suspect's car. Trace evidence typically falls into the category of associative evidence, that is, evidence that links two or more specific entities, whether they are people or objects. Within the context of crime reconstruction, trace evidence is something that links, or unlinks, a person with a crime.

Commonly encountered forms of trace evidence include hair, fibers, paint, glass, soil, minerals, metals, dust, pollens, wood, paper, arson accelerants, explosive residue, and gunshot residue.

When one surface comes into contact with another, there may be a transfer of trace material from one surface to another. The types of trace evidence transfer include unidirectional contact transfer, bidirectional contact transfer, transfer without contact, and transfer of form.

Trace evidence may be collected at the scene, or in the laboratory, in a variety of ways. Methods of collection include pickoff, tape lifting, and solvent recovery. As a general rule, it is essential to collect a control sample along with evidence collection. A control sample consists of a sample of known composition and history that may be compared with the trace evidence to

evaluate the significance of the evidence or to assess the validity of the analysis conducted. Control samples are a vital part of the scientific method, as they may eliminate or minimize coincidental influences that might otherwise confuse a crime reconstruction.

Trace evidence has the potential of great utility in establishing associations that lead to a reconstruction, but only if we recognize and interpret that evidence properly. The reconstructionist must recognize the limitations of the evidence and interpret his or her results with these limitations in mind.

SUGGESTED EXPERIMENTS FOR THE TRACE INSTRUCTOR

1. Vacuum sweepings

Have each student bring in a bag or at least a cupful of vacuum sweepings. Use a sieve and remove the dust. Put the sweepings in small bags with numbers. The number is a key to the person who brought the sample in.

Redistribute the samples. Ask the students to:

- a. identify as many things in the vacuum sweepings as they can
- b. try to describe the household the sweepings came from
- c. devise a questionnaire that would allow you to identify the classmate

(These must be general questions, such as do you have any pets?)

2. Lint filter

Have the students collect a sample of lint from the filter on their dryer.

Each person examines their own sample.

How many fibers can they identify?

Can they relate these fibers to any particular garments?

3. Soil samples

Have each student collect samples of soil from a particular location where they live. The point should be at the center of a 2-foot circle, and samples should also be taken on the edge of the circle at 0, 90, 180, and 270 degrees (N, E, S, W); there should be five baggies of soil.

Plot the locations on a map (Google maps).

Separate the vegetation.

Separate the rocks.

Dry and crush the soil.

Compare the soil to a Munson color chart, if available.

Have each person list the things they see in the soil.

Compare the lists. Are any two soils the same?

These experiments will give the students an appreciation for the uniqueness and value of various samples. It will also allow them to use their investigative skills in determining the source of vacuum sweepings.

QUESTIONS

1. Define trace evidence.
2. Which evidence types can be categorized as trace evidence?
3. Explain the difference between bidirectional contact transfer and unidirectional contact transfer.
4. What revision is suggested to Locard's exchange principle and why is it important?
5. List three examples of commonly encountered "transfer of form" evidence.

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Wound Pattern Analysis

Brent E. Turvey

The sword the body wounds, sharp words the mind. –*Menander, Greek playwright*
(342 BC–292 BC)

Key Terms

Abrasions; Administrative force; Antemortem; Brutal force; Burn; Control-oriented force; Contusions; Defense injuries; Defensive force; Environmental wound patterns; Experimental force; Fractures; Lacerations; Lethal force; Negative documentation; Offensive injuries; Overkill; Perimortem; Physical torture; Postmortem; Precautionary force; Restraint; Sharp force; Therapeutic or diagnostic wounds; Wound pattern analysis

Injury may be sustained by a victim or an offender and can be the result of intentional or accidental actions on the part of either. Wounds vary in severity, extent, and appearance relative to the amount of force delivered, the time over which force is delivered, the area of the body receiving force, and the characteristics of the object or weapon delivering force (DiMaio and DiMaio, 1993, p. 87). Some are intended to merely cause harm, whereas others are intended to kill. Because they are a physical manifestation of action and motive, they are a useful form of behavioral evidence.

Wound pattern analysis involves the recognition, preservation, documentation, examination, and reconstruction of the nature, origin, and intent of physical injuries. Whether a case involves homicide, sexual assault, abuse, or any other act of interpersonal violence, wound pattern analysis can play a crucial investigative and reconstructive role. The recognition, preservation, and documentation of wounds are found most commonly in reports and documentation made by crime scene investigators, medical personnel in cases of sexual assault and abuse, or the coroner or medical examiner in cases where a death has occurred. Because of the widely varying levels of training and expertise of those involved at this stage, an equivocal forensic analysis of all wound documentation is urged for missed, and misinterpreted, wound patterns—as well as any environmental sources.

As with any type of physical crime reconstruction, wound pattern analysis is partly science and partly art (Lee, 1994, p. 193). It requires not only rigorous methodology but

multidisciplinary expertise. Above all, however, it is firmly grounded in the scientific method and Locard's exchange principle, which asserts that anyone, or anything, entering a crime scene both takes something of the scene with them and leaves something of themselves behind when they leave (Saferstein, 1998, pp. 4-5). Any victim, and the injuries that he or she suffers (or does not suffer), is an extension of the crime scene.

Wounds are a common enough occurrence and, in fact, are a part of everyday life—from cuts, scrapes, and bruises to broken bones. For the purposes of this work, however, we focus primarily on wounds associated with violent interpersonal crime. This is done with the full awareness that other criminal and noncriminal events can result in a wide range of injuries beyond our intended scope.

TYPES OF WOUNDS

The first thing to establish when examining any wound, after it has been documented thoroughly (measured, photographed in context, photographed with and without a scale, etc.), is what type it is. For that we need to have the right language at our disposal. Descriptors for wounds are specific in their meaning, having a basis primarily in medical terminology. The following is a list of general wound types adapted from DiMaio and DiMaio (1993). It is not an all-inclusive or detailed list, but rather a cursory overview for readers to begin familiarizing themselves with the language of injury. For more complete information regarding the precise interpretation of wound patterns, readers are again admonished to reference the recommended texts earlier.

Blunt Force Trauma

Blunt trauma is caused by force (Figure 11.1). Adelson (1974, p. 378) describes the mechanisms of injury in blunt trauma as impacts delivered by weapons' forceful contact of part or the entire body against an unyielding surface and combinations of impact and forceful contact (Figure 11.2).



FIGURE 11.1 Teenage victim of a sexual homicide. Note abrasions on right forearm near the elbow. The offender's fingers digging into the victim's arms as she struggled caused these injuries. This is an example of control-oriented force applied to a living, unrestrained victim.

FIGURE 11.2 Teenage victim of a sexual homicide. Postmortem drag marks across the left abdomen resulting in a semi-irregular directional pattern abrasion and associated laceration. The victim was dragged up and across a grassy, gravelly hillside with metal objects in the environment, causing this array of wound patterns.



These are divided into the following categories.

- **Abrasions.** An excoriation or circumscribed removal of the superficial layers of skin indicates an abraded wound. Examples include ligature furrows where movement causes the skin to break and redden, as well as the long marks that can be left behind on a body from dragging it across a rough surface such as concrete.
- **Contusions.** These are injuries (usually caused by a blow of some kind) in which blood vessels are broken, but the skin is not. They can be patterned (imprinted, not directional) and nonpatterned. They include bruises and hemorrhages, which can often be aged based on color. Differentiating postmortem and antemortem contusions is also an important consideration in reconstruction ([Adelson, 1974, p. 382](#)).
- **Lacerations.** These torn or jagged wounds tend to have abraded and contused edges. They can be differentiated from sharp force injuries by the recognition of tissue bridging from one side of the laceration to the other (indicating shearing or crushing force). [Adelson \(1974, p. 387\)](#) warns examiners to beware that bullets striking the skin tangentially, without penetrating, can mimic lacerations and incise wounds.
- **Fractures** of the skeletal system. Focal fractures are the result of a limited amount of force applied to a localized area. Crush fractures are the result of a lot of force applied to a large area. Penetrating fractures are the result of a great deal of force concentrated on a small area.

Burns

Burn means to damage by heat, fire, or chemical. Burn injuries are caused by the following:

- Direct exposure to open flame
- Contact with hot objects
- Radiated heat waves
- Scalding hot liquids/steam
- Chemicals
- Microwaves

Sharp Force Injury

Pointed, bladed, or edged objects and weapons cause sharp force wounds. These may be divided into the following categories.

- Stab wounds. These injuries are the result of being pierced with a pointed instrument. The depth of the injury into the tissue is usually greater than its width in the skin.
- Incise wounds (cuts). These injuries are the result of sharp instruments being drawn across the surface of the skin, even into the tissue, and are longer than they are deep.
- Chop wounds. These injuries are the result of heavy instruments with a sharp edge. They go deep into the tissue, can be associated with bone fractures, and can have a combination of incised and lacerated characteristics. Examples include injuries inflicted by axes, hatchets, machetes, swords, and meat cleavers.

Gunshot Wounds

The purpose of a firearm (rifle, handgun, or shotgun) is to deliver force from a distance with a single projectile or multiple pellets. These will generally arrive at a target with enough force to be either penetrating (entrance wound only) or perforating (entrance wound and exit wound). They include entrance wounds, which are divided into the categories of contact, near contact, intermediate, and distant. They also include exit wounds and atypical entrance and exit wounds (e.g., ricochet) (DiMaio, 1993) (Figures 11.3–11.5).



FIGURE 11.3 This adult male victim was shot to death with a .40-caliber Glock semiautomatic pistol. He turned sideways to protect himself. These are all entrance wounds. Of note, none of these wounds to his upper body would have been fatal. The fatal injury was delivered to his leg, hitting the femoral artery and resulting in massive blood loss.

FIGURE 11.4 This adult male victim was shot to death with a single shot from a .357-magnum pistol to the face at close range. He hit the floor face first, causing the distinctive abraded contusions around his eye. This victim was killed when he encountered a female thief in an office while working after hours. The context is consistent with administrative force.



FIGURE 11.5 This adult male victim was shot to death with a single blast from a 12-gauge shotgun at close range. His body was found at an outdoor scene, in a field. The context is consistent with administrative force.

Therapeutic and Diagnostic Wounds

Therapeutic or diagnostic wounds are injuries inflicted by emergency medical service (EMS) personnel during treatment. They include things such as needle marks, various incisions and puncture marks, and even bruising caused by rough handling or transport. When interpreting wounds, it is important to get a complete record of the activities of EMS personnel so that those injury patterns unrelated to crime scene behavior between the victim and the offender can be separated out.

Postmortem Wounds versus Antemortem Wounds

An important, but often overlooked, behavioral consideration in wound pattern analysis is whether wounds were inflicted before, during, or after the onset of death. This is an involved and often imprecise process that may require more than just examining the wound. If an injury



FIGURE 11.6 This Asian female homicide victim was shot to death in a convenience store while working the cash register. She suffered a penetrating (entrance wound with no exit) gunshot wound to the chest from a .40-caliber Glock pistol, which can be seen just above her left breast (irregular entry). She suffered only one other gunshot wound: a perforating shot to the lower left thigh, with a shallow, subcutaneous course. EMS personnel opened up her chest to relieve pressure from fluid that was accumulating and hampering breathing, as well as to perform other life-saving procedures. Note the puncture and associated bruising in the right shoulder region, also from EMS. She died at the scene, and crime scene personnel bagged her hands to preserve evidence.

was inflicted just before or just after death, it may not be completely possible to determine—hence, the use of the imprecise term **perimortem** (Figure 11.6).

Antemortem wounds are those that occur during the period of time before death. They tend to be associated with injuries that result in a lot of bleeding either internally or externally. When large vessels are broken antemortem, as in gunshot wounds or deep stab wounds, this might result in what is referred to as arterial spray or arterial gushing. When smaller vessels are broken antemortem without perforation or penetration, as in wrist or ankle ligatures, there will be internal hemorrhaging into the surrounding cells.

Postmortem wounds are those that occur during the period after death. They are commonly associated with very little or almost no bleeding from broken arteries and veins. This is not a hard and fast rule, however, as every injury has its own peculiarities.

Given the difficulty of interpreting whether certain wounds were postmortem or antemortem, it is advised that multiple perspectives (medical examiner, reconstruction criminalist, arson investigator, etc.) be involved in any case of equivocal wound analysis (whenever the precise nature and timing of a wound are questioned).

PHYSICAL ORIGINS OF WOUNDS

As already discussed, wound patterns originate from a variety of intentional and accidental sources. In some cases, the source may be readily apparent or inferred by the distinctive pattern of the wound and the distinctive nature of the environment the wound was received in. In other cases, the source of wound patterns may not be so readily apparent. Injuries whose source is disputed or where there is more than one potential source may be referred to as **equivocal wound patterns**.

To approach the analysis of an equivocal wound (a wound of unknown origin), it is important to keep in mind all of the potential relationships in a crime scene. Crime reconstruction in general and wound pattern analysis and behavioral evidence analysis in particular involve the active understanding of those relationships by accounting for them. They rely on the process of seeking out and eliminating possibilities to understand the nature of a relationship in a given exchange of force. To that end, consider that wound patterns are most often the result of interaction between any combination of objects, weapons, individuals, and their respective environments.¹

Weapon to Victim/Offender

This refers to any item found in the crime scene (available materials) or brought to the crime scene by the victim or the offender used for the purpose of administering force (see the Motivational Origins of Wounds section presented later in the chapter). Examples include the following.

- A rock used to strike a victim in the head that leaves behind lacerations, abrasions, and contusions
- A gun used to shoot a victim that leaves behind a contact wound to the forehead
- A kitchen knife used to ward off an attacker that cuts the attacker's forearm
- A lamp cord used to bind a victim that leaves behind a flat, smooth ligature furrow around the wrists
- A shirt collar used to control a victim that leaves behind material compression abrasions

Restraint to Victim

A **restraint** is any item found in the crime scene or brought to the crime scene that is used to physically control, limit, contain, or restrict a victim. Among other things, restraints are used to make living victims more compliant and less of a threat to the offender. They are also used to make deceased victims less unwieldy and more compact for transport. When the victim is compliant, unconscious, or dead, a restraint is likely to leave only a smooth transfer impression

¹ Svensson and Wendel (1965) provide two important points of reconstructive concern. First, they discuss the matter of injuries to the clothes (p. 297):

Injuries to the clothes occur from tearing, crushing, cutting or penetration by edged weapons, axe blows, etc. The damage is measured, and the report should contain statements of the kind, position, size and manner of occurrence of the damage. In pertinent cases the damage to the clothes should, during autopsy, be compared with the position of corresponding wounds on the body. In this way important information can be obtained regarding a particular body position when the injury was inflicted.

Second, they offer, with illustrations, a rendering of characteristic injury patterns that may be indicative of "nowadays less common" trades (p. 415). These include marks, scars, wearing, and hardening related to the hands and other extremities of clerks, bakers, engravers, jewelers, tailors, shoemakers, upholsterers, glaziers, washermen, dyers, photographers, chemists, bricklayers, carpenters, painters, blacksmiths, coal workers, and stokers. This is a didactic example of profiling by wound pattern analysis.

or cause only minor reddening of the skin depending on how tight it is. A victim who is non-compliant, combative, or attempts to evade an attack will likely move around. This will cause movement of the restraint and subsequently abrading and contusing of the tissue beneath and around the restraint. It can also result in multiple restraint wound patterns, again, depending on how tight the restraint is and how much the victim moves around. Examples include the following.

- A shirt collar pulled up around a victim's neck to control his or her movement that leaves a material compression abrasion.
- Handcuffs on a victim's wrists to keep the arms together in front of or behind the victim's back, leaving a circular abraded and contused pattern.
- A victim's jeans pulled down around her ankles during a sexual assault to gain access to her sexual areas and also restrain her legs. Metal zippers or buttons can cause superficial lacerations on the thighs and calves; jean material can cause material compression abrasions on the ankles.
- A garrote placed around a victim's neck at the onset of a sexual assault that leaves an abraded and contused ligature furrow.

Environment to Victim/Offender

Environmental wound patterns can result from any item in the crime scene that comes into contact with the victim/offender in such a manner as to cause an injury. That is to say, these items are simply a part of the scene, and the fact that they caused wound patterns on a victim or an offender is an unintentional result of victim-offender behavior. In cases of homicide, this includes injuries and wound patterns created during transport as well as in the facility where the autopsy is performed. It also includes wounds inflicted by animals ([Figure 11.7](#)).

Keep in mind that crime scenes can be indoors, outdoors, or in a vehicle. The nature of any environments involved in a crime may be determinable by the nature of the wound patterns left



FIGURE 11.7 Female prostitute victim of a sexual homicide. This victim's body was disposed of at an outdoor location in the grass. Ant predation left behind these distinctive reddish-brown wound patterns.

behind. (Carpet patterns can suggest an indoor or vehicle scene somewhere; vegetative patterns can suggest an outdoor scene.) Examples include the following.

- Carpet in a trunk that transfers a material pattern onto the skin of a nude, deceased victim during transport
- Leaves in a field leaving imprints on a victim's body disposed of at that location
- Drag marks left behind on skin from pulling a body across a gravel road
- Lacerations and abrasions inflicted to the bottom of a victim's bare feet from running across rocks in an effort to escape captivity
- Mosquito bites received by an offender while disposing of a body in an outdoor scene
- Poison ivy received by an offender while attacking a victim in a wooded area
- Trade names from raised lettering on products that come into forceful contact with the victim or offender

Victim to Offender and Offender to Victim

Person-to-person wound patterns result when a victim or an offender causes direct injury to the other using a part of the body as a weapon. Body parts can leave distinctive wound patterns on another when used as a weapon during an attack. In addition, items worn on the body can be a defining part of the wound pattern and add not only to its recognizability but to its distinctiveness as well (Figure 11.8).

Of defense injuries, Adelson (1974, p. 490) remarks:

multiple contusions or abrasions on the extensor surfaces of the forearms and wrists and the dorsum of the hands furnish strong objective indications of attempts by the victim to protect himself from blows being rained down upon him. Accordingly, these injuries fall into the classification of "defense wounds." Fractured or avulsed fingernails may indicate injury produced by the assailant's blows, or attempts by the victim to protect herself by scratching.

FIGURE 11.8 Female victim of a rape. The offender forced her to her knees in the back of his utility van and penetrated her orally with his penis. During the course of this part of the rape, the victim suffered these abrasions from the wooden floor.



Of offensive manual injuries, [Adelson \(1974, pp. 490–492\)](#) remarks:

abrasions and contusions over the knuckles can be sustained as a result of offensive efforts by the victim as well as by his defensive maneuvers. Ragged knuckle lacerations may indicate that the victim's fist struck his opponent's anterior teeth when a blow landed on the latter's open mouth.

Examples include the following:

- A fist used to punch a victim in the face, causing a black eye
- An open hand used to slap a victim's face, causing a distinctive, hand-shaped welt
- Fingers around a victim's throat, which can leave distinctive abrasions and contusions in the skin from fingernails
- A victim's own necklace or scarf causing distinctive compression patterns on the victim's neck as the result of manual strangulation
- An offender punching a victim in the forehead while wearing a distinctively shaped ring, which leaves behind an equally distinctive wound pattern
- An offender stomping on a victim's back, leaving behind a compression abrasion representative of footwear treads
- A victim biting an offender on the arm during an attack, leaving behind a unique bite-mark impression
- An offender biting a victim on the shoulder to achieve compliance, leaving a unique bite-mark impression

A final note is required on the issues of timing, context, and association. Not every wound encountered on a victim's body is necessarily associated with the crime at hand, and this association must not be assumed. Some people bruise easily because of diet, medical conditions, or medications; athletes may have an assortment of injuries from their respective play; victims of domestic violence may have injuries of all manner and form; and people get drunk and fall down. All this to say that injury is a part of everyday life, for some more than others. The physical origins of wounds must be established in terms of both source and timing. Just because a wound is found is not reason enough to connect it to the crime under consideration. Its association must be made clear.

MOTIVATIONAL ORIGINS OF WOUNDS

Once the nature and physical origin of a wound pattern have been determined, it may be possible to make an assessment as to the general motivation for inflicting that wound (the intent). Remember the assertion of Dr. Wynne E. Baxter, from Chapter 1:

The object of the inquiry is not only to ascertain the cause of death, but the means by which it occurred. Any mutilation which took place afterwards may suggest the character of the man who did it.

Wounds are the result of behavior involving the use of force. As behavioral evidence, wounds can help suggest offender motive and intent, among other characteristics. The precise mechanisms for interpreting motive and intent, let alone physical reconstruction, tend to involve both

science and art. When any professional opines as to the motivation or intent of a victim or an offender's behavior, based on wound patterns inflicted, or anything else for that matter, that professional is engaging in no small part in the fuzzy process of criminal profiling.

As already mentioned, some wound patterns are caused by the unintentional or unconsidered application of force. They can be the result of accidental behavior or environmental elements. These are not grounded in, or reflective of, a functional (*modus operandi*) or psychological (signature aspect) need.

Other wound patterns can be caused by the intentional use of force. Planned or not, they are grounded in, and reflective of, functional or psychological needs. As [Adelson \(1974, p. 516\)](#) observes:

Overall consideration of the heterogeneous group of homicidal deaths which comprise the category of "fatal blunt assault" indicates that many do not start out as purposeful killings or even as attempts to inflict serious bodily harm. From this standpoint, these deaths are quite different from those wherein the victim died because a gun was fired at his head or a knife was plunged into his chest. In these latter instances, there can be little doubt that the assailant intended to kill or to wound seriously.

The types of intentional force found most commonly in criminal cases include the following.

Lethal Force

Lethal force is a term used to describe physically aggressive behavior that is sufficient to kill. It includes the intentional infliction of injuries to vital areas such as the heart, head, or neck. It may involve a weapon, a chemical, or bare hands. The defining element is that the force used results in death. Lethal force can be administrative, brutal, or involve overkill.

Administrative Force

Administrative force is a term used to describe behavior focused on the delivery of a specific, purposeful amount of injury in order to accomplish a particular goal. In such instances, the offender is focused and without distraction. The offender's subsequent delivery lacks evidence of emotion, passion, or other motivations. It is characterized by a short time interval, a single method of injury or killing focused on a specific or vital area or organ (head, neck, chest, etc.), and an absence of time spent on extraneous activity (looking for valuables, looking for personal items, eating or drinking at the scene, cleaning up or staging the scene, etc.). Examples would include a sniper killing a victim with a single shot, killing with a single lethal dose of poison, breaking someone's hands or legs for failure to pay a debt, striking a victim once to gain compliance, and so forth.

Brutal Force

Brutal force is a term used to describe physically aggressive behavior that involves the onset of one or more injuries that inflict tremendous damage, often until death results. However, brutal force does not always result in death, nor is it necessarily intended to kill. It is generally in the

service of anger. Examples can include multiple blows to the face with a blunt object such as a hammer, a shotgun blast to the face, and detonation of an explosive device that removes a limb.

Overkill

Overkill is injury beyond that needed to cause death. It involves the repeated infliction of injury subsequent to the application of lethal force. Overkill is generally in the service of cumulative rage—anger and frustration that have built up over time. Common examples involve multiple gunshots with reloading, a dozen or more stab wounds in the same general area, and multiple attacks to a victim's head and neck with multiple weapons. For examples, see [Figures 11.9–11.14](#).



FIGURE 11.9 Female victim of a sexual homicide. Her nude body was found in a field buried beneath the grass. She had been stabbed more than two dozen times in the back, chest, and throat, and subsequently her neck was cut. She died of massive blood loss and punctured organs. The victim was a known prostitute and drug addict who died at the hands of a serial killer. If the behavior could be associated with sexual activity, this might begin to suggest a sadistic intent. However, if the injuries were inflicted rapidly, it would preclude this possibility; sadistic behavior requires time for the offender to enjoy it.



FIGURE 11.10 Teenage victim of a sexual homicide. This victim was penetrated both anally and vaginally, resulting in a bruised vagina and a torn anus. She was then beaten with a hammer in the face at least 10 times, resulting in a crushed skull. She was also strangled manually. Note the distinctive round and crescent shaped injuries to her face and the fingertip-shaped contusions on her neck. The assailant was an older male whom she had dated.

FIGURE 11.11 Victim of a domestic homicide. Multiple stab wounds were inflicted to the back, neck, and arms while the victim was face down on the bed with her hands bound behind her back. Cause of death was ligature strangulation.



FIGURE 11.12 This elderly female victim was found strangled and beaten to death alongside her bed. She had several broken ribs, broken fingers, and suffered blunt force trauma to the head. Her eyes evidence petechial hemorrhaging consistent with the manual strangulation that killed her. Contributing to the finding of overkill in this case is the fact that this elderly victim was deaf and arthritic, meaning she could have been subdued easily. However, the offender went well beyond that.



Control-Oriented Force

Control-oriented force is a term used to describe physically aggressive behavior intended to restrict victim movements. This includes holding a victim manually, the use of restraints such as handcuffs and ligatures, locking a victim in a room, or disabling a victim by breaking a victim's legs or feet. For examples, see [Figures 11.1](#), [11.15](#), and [11.16](#).

Defensive Force

Defensive force is a term used to describe physically aggressive behavior intended to protect the individual administering it from attack, danger, or injury. The application of this term to a behavior does not imply, by its nature, that the behavior was justified legally or morally. Rather it is meant to describe behavioral intent. Examples of defensive behaviors that leave behind wound patterns could include the following:

- A victim kicking an attacker in the groin in order to facilitate a flight to safety
- A victim shooting an attacker out of fear for his or her own safety or the safety of another immediate victim
- A victim biting an offender on the penis during the course of a sexual attack
- An offender pushing a victim out of the way after kicking him or her in the groin



FIGURE 11.13 Female victim of a sexual domestic homicide. Victim was found in her home with golf balls in her mouth and vagina; golf tees inserted in a distinctive pattern beneath the skin in her face, torso, and thighs; a ball-point pen inserted beneath her chin; her nipples cut off; and a knife inserted into her vagina. Both the victim and her husband were alcoholics who worked at the same golf course. The couple had a volatile 2-year marriage, and the husband had become increasingly jealous over her relationship with another woman.

Precautionary Force

Precautionary force is a term used to describe physically aggressive offender behavior that results in wound patterns intended to hamper or prevent the recognition and collection of physical evidence and thwart investigative efforts. For an example, see [Figure 11.17](#). Examples of precautionary acts that leave behind wound patterns include the following:

- Burning a victim's pubic area to destroy evidence of sexual assault
- Chopping off a victim's hands and head to obscure future investigative efforts at identification

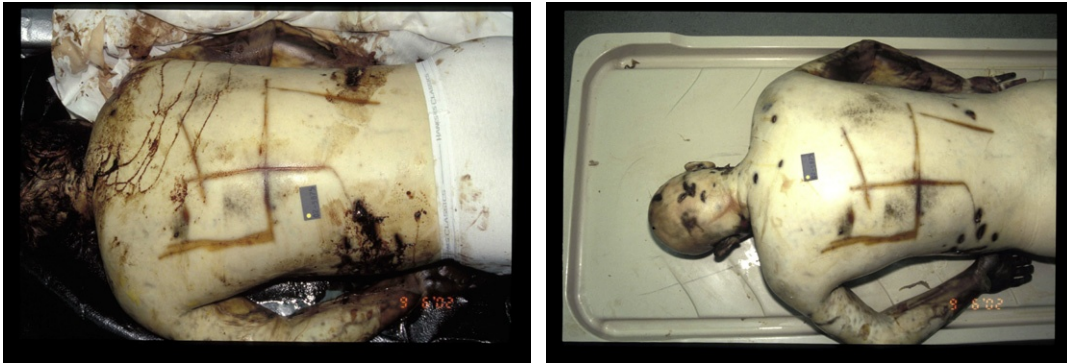


FIGURE 11.14 Middle-aged victim of a domestic homicide. This homosexual male was attacked in his bedroom by his younger roommate and one of the roommate's friends. He died after being beaten, stabbed, and kicked. Both were convicted of stabbing him, beating him with a hammer, and carving a swastika in his back after they had gone to a concert and used methamphetamine.

FIGURE 11.15 Victim of a domestic homicide with arms bound behind her back by an electrical extension cord. This available material is a common form of binding, consistent with control-oriented force.



- Inflicting misleading injuries to a victim, postmortem, to mislead investigators into believing that an accidental or punishment-oriented homicide by a family member was a sexual homicide committed by a stranger

Experimental Force

Aggression is defined as hostile behavior that is intended to distress or in some way emotionally afflict others. The requirement here is an object that one is being aggressive toward; in most cases, this would be a living and conscious victim. **Experimental force**, then, is a term that should be used to describe behaviors involving force that fulfill nonaggressive, often psychological, and fantasy-oriented needs. It does not require a conscious or living victim. Examples of experimental behaviors that leave behind wound patterns could include the following:



FIGURE 11.16 Elderly female victim of a sexual homicide with arms bound behind her back by telephone wire. This available material is a common form of binding, consistent with control-oriented force.



FIGURE 11.17 Torso of an African female homicide victim. All injuries are sharp force, cutting through skin and not bone. Disarticulation of the torso was complete, servicing the transport of the victim, the concealment of her identity, and the cause of death.

- Postmortem evisceration of a victim's entrails
- Postmortem biting of a victim's breasts
- Postmortem removal of a victim's breasts
- Perimortem stab wounds of repeated, symmetrical nature or of varying depths
- Postmortem or perimortem insertion of large foreign objects into a victim's orifices
- Violent antemortem sexual activity with a chemically (because of drugs or alcohol) unconscious victim

Physical Torture

Physical torture is the intentional and repeated infliction of nonlethal injury to a victim. To satisfy the requirements of torture, the victim must remain alive and conscious during the initial infliction of the injury so that he or she can experience the pain that follows. In most cases, there is a specific aim involved, such as getting information, obtaining a particular statement such as a confession or denouncement, sexual gratification (a.k.a. sadism), or revenge. For examples, see [Figures 11.18](#) and [11.19](#).

FIGURE 11.18 This male child victim of a sexual homicide suffered premortem sexual assault and torture. He was penetrated anally, resulting in rectal lacerations. Pictured is one area of sharp force injuries where the offender stabbed the victim multiple times, feeling around beneath the skin. This is evidence of torture and, in combination with the sexual activity, is consistent with sadistic motivation.



FIGURE 11.19 Adult male victim found asphyxiated in a hotel room with a ligature. The offender cut one of the victim's nipples off, bit the other one, and inflicted multiple nonlethal sharp force injuries, including a shallow stab to the chest. These injuries are most consistent with a sadistic motivation.



WOUND PATTERN ANALYSIS: GENERAL GUIDELINES

The following are some basic guidelines that this author has found useful when applied to actual casework.

1. Wound pattern analysis relies on competent, thorough documentation of injuries, as well as the same for the environments in which any injuries occurred. This should also include **negative documentation**, or a record of areas where no injuries exist on a subject, and of associated environments believed to contain none of the items responsible for injury.
2. It is useful to perform wound pattern analysis not only on victims, but also on offenders and suspected offenders.
3. It is important not to interpret wounds, or any behavior, in a fact vacuum. A wound should be examined and interpreted in the context of the event in which it occurred (as part of a particular history, as part of an environment, and as part of a sequence of events).
4. It is important to establish whether an injury was inflicted antemortem, perimortem, or postmortem.
5. It is important to establish the origin of an injury. What likely caused it and how and what behavior(s) that it may represent. Brainstorming and experimentation are useful to these ends.
6. It is important to determine whether and how the wound is associated with the crime at hand.
7. One person cannot be expected to recognize every form of wound pattern in existence, no matter how much training or experience one has. Multiple forensic disciplines should be involved in any analysis involving extensive, complex, or questioned injury patterns. This provides multiple perspectives and increases the experience base, reducing the possibility of overlooking or misinterpreting wound patterns.
8. It is important to establish the motivation and intent of an injury in its context, which means determining whether the injury was accidental or intentional. If it was caused intentionally, then we need to further examine it and try to understand what the person inflicting the injury believed he or she would accomplish by doing so. Again, this cannot be done reliably outside the context of the crime and in the absence of thorough histories.
9. Wound pattern analysis is reliant on physical evidence. Physical evidence may be concealed, poorly documented, undocumented, lost, or otherwise unavailable. Therefore, competent and certain conclusions regarding origin, intent, and motivation may not always be possible. The certainty of all conclusions regarding wound patterns should be commensurate with the known facts of the case.

For specific texts devoted in part or whole to the concepts and procedures involved in the major types of wound pattern analysis, the author strongly recommends that readers reference the following works:

- Adelson, L. (1974). *The Pathology of Homicide*. Springfield, IL: Charles C. Thomas.
- DiMaio, V. (1993). *Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques*. Boca Raton, FL: CRC Press.
- DiMaio, D., and DiMaio, V. (2001). *Forensic Pathology*, 2nd Ed. Boca Raton, FL: CRC Press.
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- Dolinak, D., Matshes, E., and Lew, E. (2005). *Forensic Pathology: Principles and Practice*. Boston: Elsevier Science.

Monteleone, J. (1996). *Recognition of Child Abuse for the Mandated Reporter*, 2nd Ed. St. Louis, MO: G.W. Medical Publishing.

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Symes, S., Chapman, E., Rainwater, C., Cabo, L., & Myster, S. (2010). *Report: Knife and Saw Toolmark Analysis in Bone: A Manual Designed for the Examination of Criminal Mutilation and Dismemberment*. National Institute of Justice, Contract Number #2005-IJ-CX-K016. Erie, PA: Mercyhurst College, Document No.: 232227, October.

Vanezis, P. (1989). *Pathology of Neck Injury*. Somerset, UK: Butler & Tanner.

Whelan, M. (1997). *Color Atlas of Sexual Assault*. New York: Mosby Medical.

SUMMARY

Injury may be sustained by a victim or an offender and can be the result of intentional or accidental actions on the part of either. Wounds vary in severity, extent, and appearance relative to the amount of force delivered, the time over which force is delivered, the area of the body receiving force, and the characteristics of the object or weapon delivering force. Some are intended to merely cause harm, whereas others are intended to kill. They are a physical manifestation of action and motive and therefore a useful form of behavioral evidence.

The first thing to establish when examining any wound, after it has been documented thoroughly (measured, photographed in context, photographed with and without a scale, etc.), is what type it is (blunt force, sharp force, gunshot, etc.). Next, an attempt must be made to determine its physical origin (a weapon, an object, the environment, etc.). Without knowing these details, it is not possible to infer the motivational origin of the wound.

QUESTIONS

1. What is one certain method used to distinguish between sharp force injuries and lacerations?
2. Give three examples of precautionary force.
3. What is the purpose of negative documentation?
4. True or false: A victim must be conscious to be tortured.
5. Burns are injuries caused by heat, fire, or _____.

References

Adelson, L. (1974). *The Pathology of Homicide*. Springfield, IL: Charles C. Thomas.

DiMaio, V. (1993). *Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques*. Boca Raton, FL: CRC Press.

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Lee, H. (1994). *Crime Scene Investigation*. Taoyuan, Taiwan: Central Police University Press.

Saferstein, R. (1998). *Criminalistics: An Introduction to Forensic Science* (6th ed.). Upper Saddle River, NJ: Prentice-Hall.

Svensson, A., & Wendel, O. (1965). *Techniques of Crime Scene Investigation*. New York: Elsevier.

12

Reconstruction Using Bloodstain Evidence

W. Jerry Chisum

Blood will tell, but often it tells too much. —*Don Marquis (1878–1937), A Roach of the Taverns*

Key Terms

Abrasion; Amputation; Avulsion; Bloodstain pattern analysis; Bloodstain patterns; Incision; Laceration; Langer's lines; Livor mortis; Penetrating wound; Perforating wound; Puncture

Bloodstain patterns are the visible record of the bloodshed at a crime scene. **Bloodstain pattern analysis** is the examination of the shapes, locations, and distribution patterns of bloodstains for the purpose of interpreting the physical events that caused them. It is premised on the theory that bloodstain patterns are characteristic of the forces that created them.

Bloodstains are among the most useful forms of physical evidence in the reconstruction of a crime. They are present in almost all cases involving violence where there is bloodshed. They may also be present in burglaries, hit and runs, and many other crimes. Most recognize their present value for the identification and comparison of the blood, often with DNA testing, which assists in determining whose blood is present and where. However, bloodstains can also provide information for reconstruction of the incident that is far more useful in investigations and court proceedings than that derived from other technologies. Bloodstain patterns—their existence, shape, volume, and location—are of tremendous reconstructive value. There may be no doubt as to who shed the blood, but the nature of the stains deposited at the scene may yield great information about what events took place and how they occurred.

HISTORICAL CONTEXT

The examination and use of bloodstain evidence in criminal investigations and court proceedings are not new, even to this past century. Neither is an appreciation of its multiplicity. As explained by Andrew Fleming, M.D. (1830–1896), who wrote about the importance of examining and identifying bloodstains at the time of the Civil War (1861, p. 1):

In the trial of criminal cases, especially where the evidence is of circumstantial character, it is frequently of the greatest importance to determine of what certain spots are composed, in order to fix the guilt or attest the innocence of the accused. . . .

The blood is an almost homogenous fluid, endowed, while under the catalytic influence of the vessels, with a property closely resembling vitality, and bearing the elements out of which the various structures are to be developed or sustained, and from which the glands elaborate their special secretions. The variety of its numerous attributes indicates the complexity of its nature. Owing to its complexity, and the absolute certainty required in a medicolegal investigation, arises the difficulty of the examination of suspicious stains.

Although Fleming was concerned primarily with the chemistry and composition of blood, he was ultimately interested in the purpose of our current work: crime reconstruction. As such, his worthy sentiments remain relevant.

BLOODSTAIN PREREQUISITES

This chapter is not written for the bloodstain pattern novice, although certain basic information is discussed. It is written for the reconstructionist with a general forensic science background, who has also attended basic crime scene investigation and, at least, basic bloodstain analysis courses, taught by qualified forensic scientists. The reconstructionist must be well versed in the scientific method, have studied forensic bloodstain literature, and have conducted his or her own experiments. This chapter is intended to provide additional tips and applied information about how to approach the problems of interpreting bloodstain patterns.

Consider the following prerequisites.

Recommended Reading

For the beginner, or those unfamiliar with the subject, several volumes have already been written about bloodstain pattern analysis. The author recommends reading at least the following texts:

James, S. (1998). *Scientific and Legal Applications of Bloodstain Pattern Interpretation*. Boca Raton, FL: CRC Press.

James, S., & Eckert, W. (1998). *Interpretation of Bloodstain Evidence at Crime Scenes* (2nd ed.). Boca Raton, FL: CRC Press.

Bevel, T., & Gardner, R. (2008). *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction* (3rd ed.). Boca Raton, FL: CRC Press.

This is not an unequivocal endorsement of the aforementioned efforts. Each is written for a particular audience, and each has strengths and weaknesses alike. However, they are as good a place to start as any.

Terminology

The Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN) is a group of scientists (not all forensic) gathered on a national level to develop the field of bloodstain analysis.¹ The recommended terminology of the SWGSTAIN is presented here as these terms may be used in the chapter.

- *Accompanying Drop*: A small drop produced as a by-product of drop formation.
- *Altered Stain*: A bloodstain with characteristics that indicate a physical change has occurred.
- *Angle of Impact*: The acute angle (alpha), relative to the plane of a target, at which a blood drop strikes the target.
- *Area of Convergence*: The area containing the intersections generated by lines drawn through the long axes of individual stains that indicates in two dimensions the location of the blood source.
- *Area of Origin*: The three-dimensional location from which spatter originated.
- *Backspatter Pattern*: A bloodstain pattern resulting from blood drops that traveled in the opposite direction of the external force applied; associated with an entrance wound created by a projectile.
- *Blood Clot*: A gelatinous mass formed by a complex mechanism involving red blood cells, fibrinogen, platelets, and other clotting factors.
- *Bloodstain*: A deposit of blood on a surface.
- *Bloodstain Pattern*: A grouping or distribution of bloodstains that indicates through regular or repetitive form, order, or arrangement the manner in which the pattern was deposited.
- *Bubble Ring*: An outline within a bloodstain resulting from air in the blood.
- *Cast-off Pattern*: A bloodstain pattern resulting from blood released from an object due to its motion.
- *Cessation Cast-off Pattern*: A bloodstain pattern resulting from blood drops released from an object due to its rapid deceleration.
- *Directionality*: The characteristic of a bloodstain that indicates the direction blood was moving at the time of deposition.
- *Directional Angle*: The angle (gamma) between the long axis of a spatter stain and a defined reference line on the target.
- *Drip Pattern*: A bloodstain pattern resulting from a liquid that dripped into another liquid, at least one of which was blood.
- *Drip Stain*: A bloodstain resulting from a falling drop that formed due to gravity.
- *Drip Trail*: A bloodstain pattern resulting from the movement of a source of drip stains between two points.

¹ Google the organization SWGSTAIN to view their charter and progress.

- *Edge Characteristics*: A physical feature of the periphery of a bloodstain.
- *Expiration Pattern*: A bloodstain pattern resulting from blood forced by airflow out of the nose, mouth, or a wound.
- *Flow Pattern*: A bloodstain pattern resulting from the movement of a volume of blood on a surface due to gravity or movement of the target.
- *Forward Spatter Pattern*: A bloodstain pattern resulting from blood drops that traveled in the same direction as the impact force.
- *Impact Pattern*: A bloodstain pattern resulting from an object striking liquid blood.
- *Insect Stain*: A bloodstain resulting from insect activity.
- *Mist Pattern*: A bloodstain pattern resulting from blood reduced to a spray of microdrops as a result of the force applied.
- *Parent Stain*: A bloodstain from which a satellite stain originated.
- *Perimeter Stain*: An altered stain that consists of the peripheral characteristics of the original stain.
- *Pool*: A bloodstain resulting from an accumulation of liquid blood on a surface.
- *Projected Pattern*: A bloodstain pattern resulting from the ejection of a volume of blood under pressure.
- *Satellite Stain*: A smaller bloodstain that originated during the formation of the parent stain as a result of blood impacting a surface.
- *Saturation Stain*: A bloodstain resulting from the accumulation of liquid blood in an absorbent material.
- *Serum Stain*: The stain resulting from the liquid portion of blood (serum) that separates during coagulation.
- *Spatter Stain*: A bloodstain resulting from a blood drop dispersed through the air due to an external force applied to a source of liquid blood.
- *Splash Pattern*: A bloodstain pattern resulting from a volume of liquid blood that falls or spills onto a surface.
- *Swipe Pattern*: A bloodstain pattern resulting from the transfer of blood from a blood-bearing surface onto another surface, with characteristics that indicate relative motion between the two surfaces.
- *Target*: A surface onto which blood has been deposited.
- *Transfer Stain*: A bloodstain resulting from contact between a blood-bearing surface and another surface.
- *Void*: An absence of blood in an otherwise continuous bloodstain or bloodstain pattern.
- *Wipe Pattern*: An altered bloodstain pattern resulting from an object moving through a preexisting wet bloodstain.

These terms will allow you to communicate with other bloodstain analysts and are important for that reason. However, mathematics and physics components are necessary for certain bloodstain analyses and interpretations. Many bloodstain “experts” are not scientists, but rather police technicians, taught by virtue of a short bloodstain course, lacking any real scientific education or training.

Short Course Pitfalls

It is recommended that anyone interested in crime reconstruction take a course in bloodstain analysis from a qualified forensic scientist.² Courses like this can be useful for providing certain basic overviews of fundamental concepts.³ However, depending on the scientific background of the instructor, they may be lacking in crucial areas.⁴ Most short courses have the student conduct experiments to establish what can be learned from a blood drop. However, they don't always follow or impart a scientific methodology nor do they always follow up with the science used to support findings.

A great deal of time in most basic classes has been spent on single drop analyses and the review of basic bloodstain types and terms. In actual casework, bloodstains are very seldom limited to a single drop. Consequently, the reconstructionist is not concerned with individual drops, but, rather, their overall pattern. The short courses that exist do cover, to some extent, general patterns, which is perhaps their greatest value. However, the approach to interpretation tends to be parochial as opposed to holistic, and it betrays a misunderstanding of the variation that can exist in real life. Analysts who are trained to look at and interpret single drops in a rote and technical fashion tend to miss the forest for concentrating on the individual trees with respect to their conclusions.

Of utmost importance, yet often forgotten by the technical bloodstain analyst, is that blood flow is controlled by forces acting upon the blood. One force that is always acting on blood flow is gravity. Therefore, unless there is another force acting on the blood, it will run down. It may fill a space, or it may pool, but even then it will follow contours like a river traveling along its bed, always flowing to a lower point, that is, toward the earth.

Short Course Recommendations

As part of any short course on bloodstain analysis, students should at the very least be shown drops of various shapes or diameters. Then they should be

1. Asked to propose various reasons for the differences
2. Asked to develop various experiments to test these various theories
3. Asked to conduct the experiments and explain how the experiments refute or support these various theories
4. Required to keep records of any measurements made and the results of any calculations

² National Crime Investigation and Training (NCIT) offers a "bloodshed evidence" course (www.ncit.com). The principal instructor is a multilaboratory manager with 40 years of experience working crime scenes and 35 years of teaching law enforcement and forensic scientist crime scene investigation and crime reconstruction.

³ As explained in [Edwards and Gatsonis \(2009, p. 178\)](#): "Workshops teach the fundamentals of basic pattern formation and are not a substitute for experience and experimentation when applying knowledge to crime reconstruction. Such workshops are more aptly applicable for the investigator who needs to recognize the importance of these patterns so that he or she may enlist the services of a qualified expert. These courses also are helpful for attorneys who encounter these patterns in the course of preparing a case or when preparing to present testimony in court."

⁴ SWGSTAIN is in the process of designating what will be covered in these courses. It is hoped that they will include our recommended subjects.

These records will be used to determine accuracy, precision, significant numbers, and error rates.

The first part is following the scientific method: observe, theorize, experiment, and reiterate. The second part, analysis of the results, is seldom taught. Appreciating these deficiencies is the difference between the technician's pedantic understanding of bloodstains and the forensic scientist's interpretive role in reconstruction of the crime.

Students should also be taught about the importance, and limitations, of measuring. Seldom does anyone but a scientist question the measuring devices used. That is because they well know that all measuring devices have limitations. Therefore, the accuracy of any instrument used should be determined and accounted for in all calculations and interpretations. For example, the reticle in a hand lens cannot be used to measure micrometer distances. If it has 0.1-mm divisions, then the measurements would be no better than ± 0.02 mm as that would be as close an estimate as one can make between the marks. Yet, there have been cases in which the third decimal place (1.325 mm) was claimed. This is not scientifically possible.

In some of the classes that the author taught, copies of blood drop patterns enlarged five times were used so that students could make measurements "more accurately" and with "more precision." The drop patterns used were at 10 degree intervals. The students were told to use the formula for the angle of incidence by taking the measurement of the width and length of the drop. Thirty students measured the drops using stereomicroscopes and reticles. The variation in the resulting angles was considerable, as much as ± 10 degrees; the average difference was ± 3 degrees. That was a class exercise with 30 measurements; in the field, measurements are made once and accepted as absolute. There is no variation in the measurements because they aren't repeated. However, there is a range associated with all measurements and accounting for it is a significant but seldom discussed interpretive limitation.

A fast "field method" for finding the *area of convergence* and the *area of origin* is to use a laser equipped with a circular holograph. First find the convergence by aligning the laser beam with the long axis of some of the drops from the pointed end. Where the beams cross is the area of convergence. Now you need to attach the circular hologram. It can be used to determine the angle of impact of several drops. The laser is held above the area of convergence and pointed at the drops. The circle becomes an ellipse as the laser beam strikes at an angle. When the laser ellipse matches the ellipse of the blood drop, the angle of impact is determined. The area of origin is determined from determination of the angle of impact of several drops.⁵

Another issue deals with significant numbers. When using the formula for calculating the angle, which involves taking the arc sine or arc cosine, a calculator will give the answer to six or more places. These numbers are not meaningful. The concept of significant figures is not normally taught in bloodstain classes. The result cannot have more figures (or places past the decimal) than the lowest number of figures. For example, if you measure one direction as 2.2 mm and the other direction as 0.5 mm, then the result may be expressed to one significant figure: $\alpha = \cos^{-1} 0.5/2.2 = 80 \pm 5^\circ$, not the calculator result of 79.863° . These mathematical

⁵ Classroom comparison of the measurements of angle of impact made with the laser and by the length vs width shows the laser to be more accurate and precise.

concepts need to be included so that the “error rate” can be stated. The analyst who testifies that there is an error rate of 0 is sadly in error. Using these two mathematical concepts gives the analyst a standard error to testify about. This error is inherent in the equipment used and is not the fault of the analyst.

BLOODSTAIN ANALYSIS AND THE NAS REPORT

The field of bloodstain analysis has been criticized by the National Academy of Science’s report on the forensic sciences (Edwards and Gatsonis, 2009; see the Preface to this second edition). In particular, they found it pedantic and lacking science. Several of the criticisms and concerns reported in the NAS report were actually expressed in the first edition version of this chapter.

The NAS report states that there needs to be more research in order to make this field more scientific. The author could not agree more. This will require the involvement of more actual scientists, and researchers, in a discipline that has suffered from their absence.

We made a high-speed video of bloodstains at the California Criminalistics Institute (part of the California Department of Justice) in the mid-1990s. The video was used to disprove the “suckback theory” that the International Association for Identification committee had approved in the late 1980s and early 1990s. This theory had been used ignorantly to explain blood in the barrel of a gun, even though it violated what we know about physics.

More videos of this nature must be made of gunshots into blood, of blood splashes, of blows to bloody objects, and other bloodstain phenomena. These must then be examined by properly educated and trained forensic scientists so that some of the questions, myths, and false impressions about bloodstain evidence can be resolved or eliminated. For example, can blood drops strike one another after leaving a blow? If so, do they combine? Why do we only get misting up close to a gunshot and large drops only at a distance? There are many questions and few answers.

BACKGROUND INFORMATION

Before interpreting bloodstains, reconstructionists should have some basic information about the case. They should understand the bloodstain patterns and their limitations; they should know the types of injuries sustained by the parties involved; they should know some basics about the victim; they should know something about the dimensions of the scene and the placement of any furniture; and they should know what type of instrument was used to cause the bloodshed. If the reconstructionist simply looks at the bloodstains without this background information, he or she can make serious errors.

Blood in the Body

Blood need not be shed to be of importance. The human body, living or dead, may hold blood patterns essential to a reconstruction of events. These include *bruising* and *livor mortis*.

Bruising

In a live person, the blood is being pumped through the arteries and into the capillaries, returning to the heart through the veins. Blows delivered to a body can break capillaries, veins, and even arteries. Blood will then leak under the skin and be exhibited as a bruise. This blood is no longer affected directly by the heart. It is now under the control of gravity and the firmness of the tissues. For example, a bruise will migrate down the body. In a young healthy person, this migration is very limited but can show that the person was lying down or standing up for a long period right after the incident. In an older person, when the skin is loose, the bruise can look much worse as the blood will flow under the skin, causing a much larger bruise than expected. This effect is intensified if the person is taking a blood thinner (Figure 12.1).

Livor Mortis

Livor mortis is the settling of blood by gravity to the lowest part of the body, provided there is no restriction to the area, such as pressure from a surface, binding, or material. Because gravity is always working, livor mortis starts immediately upon the heart stopping. The time it takes to become visible is dependent on how much it causes contrast with the normal skin color of the decedent. The darker the skin, the longer it takes to become visible. Over time, blood that has seeped through the walls of the capillaries or ruptured those capillaries will congeal. The blood cannot flow from that region if the body is now moved. This is when livor is said to be “fixed.” This phenomenon is useful in determining if the body was moved after death. Pressure will prevent the blood from settling in the area; therefore, there are areas where the body is pressing against a surface or the clothing is tight that do not show livor mortis (Figure 12.2).

Blood from the Body

Blood that is out of the body flows under the influence of gravity. It can be pumped from a vein or it can be spurted from an artery, but as soon as it leaves the body gravity is acting upon it. When the heart is no longer beating, the blood flow is dependent solely on gravity. The primary



FIGURE 12.1 This man was struck above the right eye. He had a small abrasion and bruise when he went to the hospital. However, he was on blood thinners and he continued to bleed from the injury. This blood ran under the surface of the skin. Two days later, when this photo was taken, he had a massive bruise extending from his right eyebrow to his right shoulder.

FIGURE 12.2 The red areas are lividity; the light band across this woman's back and on her hips is where the weight of the body was as she was lying on her back. The compression of the tissue kept the blood from draining into these areas.



FIGURE 12.3 This woman was supposedly sleeping when a "burglar" shot her. The blood on her side runs counter to gravity. This fact, combined with other evidence, was used to build a case against the husband for her murder.



rule to remember in examining bloodstains is, again, "gravity works!" Gravity always pulls the blood toward the earth. It may pool or flow around a high point due to the contour of the object it is on, but it always moves down. If the stain is not in a downward direction, then the object it is on was moved since the time the blood was deposited and before it dried (Figure 12.3).

Arterial Spurting

The signs of arterial spurting are not common phenomena at crime scenes. Spurting only occurs when the artery is close to the surface and is not covered with clothing. The aorta may be severed and the blood is pumping from the heart in great gushes; however, it is 2 to 5 inches inside the chest. With that much tissue to transverse, it will not escape the body unless the wound is the lowest point. The blood will fill the chest, collapse the lungs, and still the heart. However, a shot to the face may reach the major arteries in the neck (carotid). The hard tissue of the head (skull) keeps the hole open, through which the blood may pump (Figure 12.4).



FIGURE 12.4 This man shot himself in the face accidentally (he thought the chamber was empty). The blood pumped out of the hole for a distance of approximately 4 feet.

The arms, legs, neck, and head have arteries close to the surface. These arteries will spurt blood when cut. However, clothing will absorb the energy associated with these spurts; as the cloth interferes with the stream, less spurting will be exhibited. The scalp is covered with many small arteries. A blow to the head may cut one or more of these arteries. A very thin stream of blood can be spurted from the scalp for a distance up to 3 feet. The stream is similar to one squirted from a syringe with a large-bore needle (Figure 12.5).

Several reported instances of arterial spurting have turned out to be cast-off blood resulting from injuries sustained during a fight. It is important that the reconstructionist not assume that just because blood is in a trailing pattern it must be the result of arterial spurting. This is one of the reasons you need to know the types of injuries.

CASE EXAMPLE

I was asked to assist a police laboratory that was documenting a crime scene involving a great deal of arterial spurting. The criminalist said there was arterial spurting all over the house. When asked how he knew it was arterial spurting, he replied that he had taken a course in which arterial spurting was emphasized and he learned to recognize it. He had no doubt that he was right.

The criminalistics laboratory shared quarters with the coroner's office. I inquired about the autopsy that had been performed on the victim. We interviewed the doctor. When asked if there were any major arteries cut, he replied, "No, none of significant size." Then he was asked if there were major veins cut and he replied with the same answer.

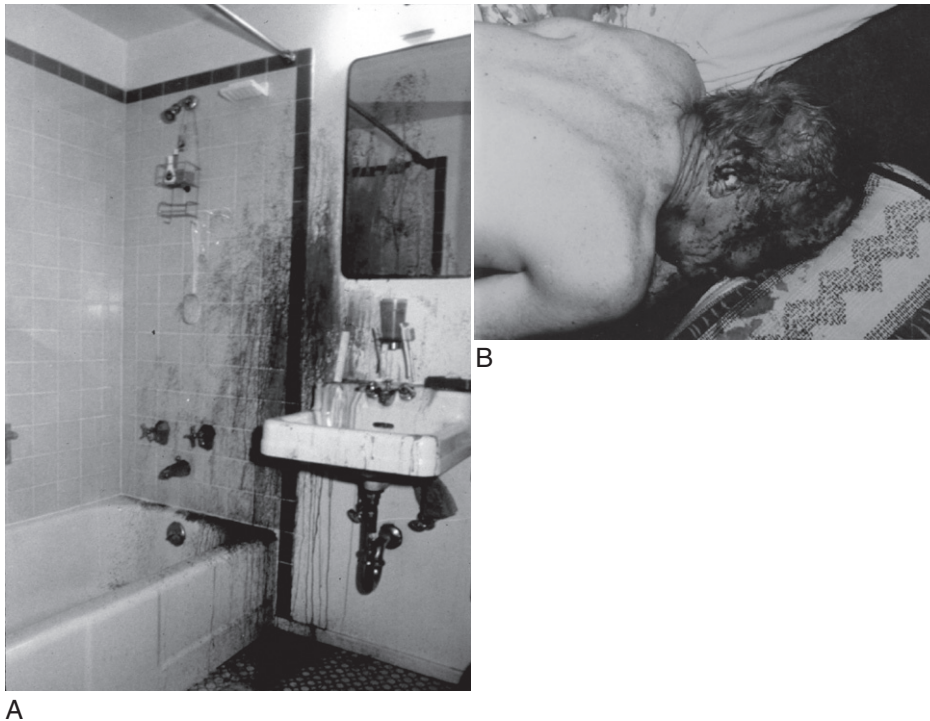


FIGURE 12.5 (A) These drops are from the head of a man beaten with a pool cue, causing arterial spurting. He went into the bathroom and bled on the shower curtain, wall, and mirror. Note that the blood drops do not go on the ceiling but stop near the top of the mirror. This case caused a great deal of concern because it was difficult to believe that the man was not beaten in the bathroom. The defense contended that he had tried to doctor himself. (B) If the initial crime scene respondents had been observant, they would have seen the clean (i.e., not bloodstained) cotton in his ear, proving the defense's contention.

Now, once we got to the scene the cast-off nature of the stains was recognized. This case illustrates that assumptions can cause you serious embarrassment when you report or testify about your findings. If the criminalist had documented the scene and testified about arterial spurting, the defense could have asked the doctor the same questions I did and discredited the criminalist's entire testimony.

To reiterate, before you reach any conclusions regarding bloodstains, you need to determine

- Injuries sustained by the participants (victim and suspect)
- Location and description of the crime scene
- What weapon(s) was used
- Relative sizes of the participants
- Health/fitness issues that may affect the blood flow or patterns
- Bloodstain patterns

Injuries

The location of the injuries to the body and the type of injury sustained will affect the bloodstain patterns. The importance of the location, as it relates to arterial spurting, was discussed previously. One location that causes confusion, one in how it was produced and two in the patterns that result when it is a source of blood, is the hand. In a stabbing or cutting incident, the hands are frequently also cut. These cuts are normally classified as “defense” wounds, but they may be sustained for different reasons other than putting the hands out to stop an attack. One such injury is grabbing the blade of the knife when threatened with it. This happens most commonly in cases between people who are close (husband/wife, lovers, siblings, etc.). The knife is pulled away suddenly, slicing the fingers or the palm.

Another way hands are cut is that the knife may not have a guard between the handle and the blade. The guard is to prevent the hand sliding over the blade; butcher knives do not have a guard, and the bolster (offset of the blade) may not be enough to stop the hand when the knife comes to a stop on bone or a hard surface. This will cause the perpetrator’s hand to be cut (Figure 12.6).

Once the hands are cut, arm movement will cause cast-off stains. Do not assume stains are from the knife or from a tool based on the width of the pattern.⁶ The edge of the hand is narrow and blood comes off in a thin stream or only one finger may be involved with the blood.



FIGURE 12.6 Injury to perpetrator from a knife slip.

⁶ In class, we would find someone who had taken a short course in bloodstain pattern analysis. We would ask them if they could distinguish a cast-off pattern from a hand vs from a knife. When we had a volunteer, we would turn his or her back to one instructor who would produce a pattern in front of the class using the edge of the hand or one finger. The subject was then asked to tell what had produced the pattern. The person could not believe it was from a hand.

Injuries that can result in bloodshed can be classified as

- Abrasions or scrapes
- Incisions
- Lacerations
- Punctures
- Avulsions
- Amputation

See also Chapter 11: Wound Pattern Analysis.

Abrasions

An **abrasion** can be a simple scraping of the knee, like all of us did as children, or it can be a serious road burn resulting in a considerable amount of skin and tissue being removed. Abrasion patterns correspond to the object that the skin brushed or scraped across. They show directionality with regard to piling of the epithelium. Abrasions potentially have trace evidence embedded that could show the type of surface that caused them (Figure 12.7).

Incisions

An **incision** is a cut with a sharp instrument. The edges of the cut are usually well defined; however, certain serrated blades can make jagged appearing cuts. The amount of blood resulting from incisions is determined by several factors, including the location, direction, size, and depth of the cut. The depth of the cuts will determine which blood vessels are damaged. Although not always true, it is normally expected that a deeper cut will result in more blood flow. The larger the cut, the more blood vessels cut. A short shallow wound that cuts an artery will result in more blood than a deep long cut that does not encounter any arteries or major veins.

The shape of any incision wound can vary widely, depending on whether it is along the axis of, or perpendicular to, **Langer's lines**. These are the natural anatomical grain of the skin surface. If a cut is made across Langer's lines, or other areas in which the skin grows, it will be more open,

FIGURE 12.7 An abrasion.



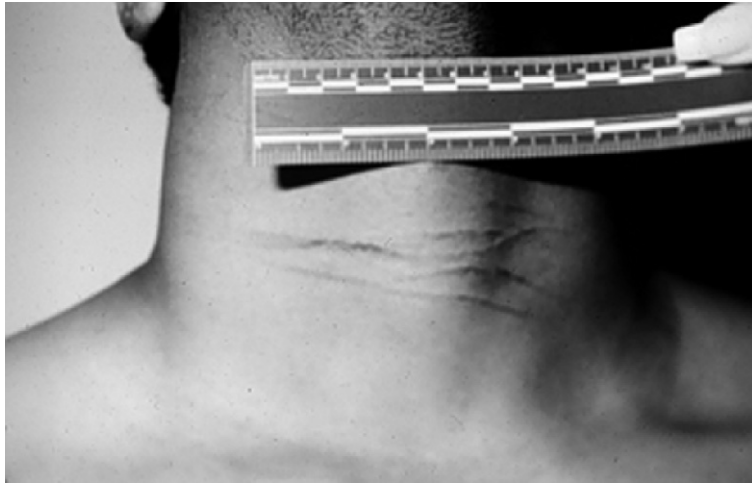


FIGURE 12.8 This man had these slight incisions made by “the same gang that stabbed his wife 87 times.” He was arrested for her murder.

resulting in more exterior bleeding. In other areas, Langer’s lines and muscle tissue fibers, which are arranged relative to the axis of force generation of the muscle, do not line up in the same directions. The muscle tissue will spread the cut even further if the cut is across these fibers. If it is parallel to the fibers, the cut will essentially seal shut, resulting in very little blood flow but more bleeding internally (Figure 12.8).

Lacerations

A **laceration** is a breaking of the skin and tissue. Blunt trauma, clubbing, or some other hard blows to the body frequently result in lacerations. Lacerations do not have clearly defined edges and may show some associated tissue damage with bruising. The flow of blood is also affected by the muscle fibers and Langer’s lines but not to the same extent. Because the fibers are crushed, even when parallel to the blow, blood will come to the surface (Figure 12.9).

Punctures

A **puncture** can be classified as penetrating or perforating wounds. A **penetrating wound** is when something enters or forces into a body, but does not exit. A **perforating wound** is when a wound goes through the body. Penetration results in one hole as a blood source. Perforation results in two or more holes as blood sources (Figures 12.10 and 12.11).

Avulsions

An **avulsion** occurs when a piece of tissue is suddenly lost from the body. This may occur from cutting but is more common in crushing blows. There is usually a large quantity of blood loss associated with avulsions. Extreme avulsions occur in traffic accidents when someone is run over by a vehicle. Parts of the body, or tissue, may be “squirted out” for some distance (Figure 12.12).

FIGURE 12.9 These lacerations to the back of the head were caused by a large crescent wrench.

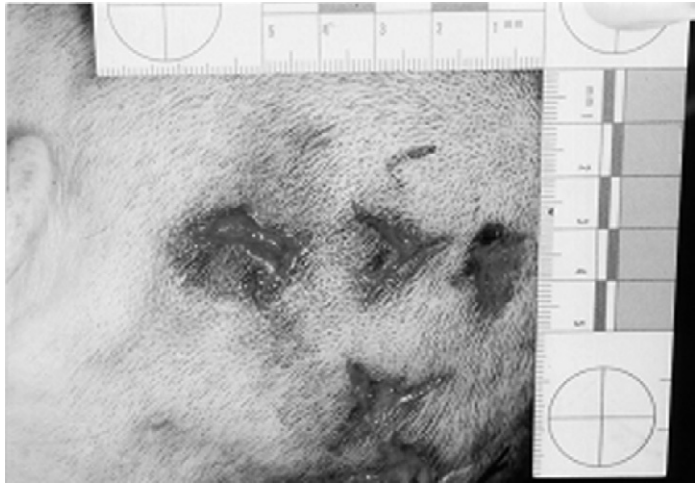


FIGURE 12.10 This is penetration by a shotgun. The shot liner opened just before contact.



Amputation

Amputation is the intentional removal of a part of the body. Amputation will normally result in a considerable loss of blood. Although generally thought of in terms of the extremities, the head can also be amputated, as seen on videos by terrorists.

CASE EXAMPLE

In 1978 I was director of the California Department of Justice Modesto Regional Crime Laboratory. Larry Singleton picked up a 15-year-old girl, hitchhiking in Berkeley, and drove to a remote area in Stanislaus County. There he raped her, chopped off her hands, stuffed her into a culvert, and left her to die. Due to her age her arteries were still elastic. Cutting the arteries completely allowed them to retract up into the arms. When she bent her arms, the blood was sealed in at the elbows.



FIGURE 12.11 This stab wound perforated the knee.



FIGURE 12.12 This woman's head was crushed by a truck.

She managed to walk along the back road to Interstate 5 where she was found by a passing motorist. She survived this ordeal and was able to testify against Singleton.

One of her hands was recovered by a fisherman from the Alameda Estuary. An X-ray of the arm and the hand showed a physical match of the broken bones. Singleton was convicted only of assault. He served 8 of 14 years and was released. He moved to Florida, where he was convicted of murdering a prostitute. He died in 2001 of cancer while awaiting execution.

The Crime Scene

Bloodstain patterns can be found on walls, floors, ceilings, or objects in an environment such as telephones and furniture—basically just about anywhere. However, each environment uniquely limits the precise activities of the persons involved in the incident and the subsequent patterns that may be left behind. They cannot walk in certain areas because of fixed objects within the scene; the blood can only go so far because of the walls; intervening objects can intercept parts of the pattern; and the composition of each surface in the scene varies with regard to accepting and retaining patterns (smooth and rough, wet and dry, etc.). The environmental qualities of each scene are different. They must be studied before a reconstruction is undertaken. The physics and blood dynamics remain the same, but the variables that exist within the environment must be incorporated into the analysis. Often, bloodstain interpretations of greatest confidence are offered without consideration of these highly influential variables.

If possible, it is always preferable to go to the crime scene. This allows reconstructionists to visualize the actions that they are trying to reconstruct in their actual environment. The scene may have changed due to time passage, but reconstructionists still gain an understanding of the dimensions and spatial relationships in the area. Of course, if they are employed by law enforcement, they should go to the scene prior to any evidence collection. There is often information present that cannot or likely will not be recorded properly.

However, it is not enough to simply visit the crime scene. Documentation of the crime scene must also be studied and scrutinized. Ideally, photos and videos will provide the reconstructionist with a scene's general dimension and character at the time it was discovered. They give context and provide close-ups of items, areas, and patterns that may be of particular interest. A competent diagram of the crime scene is necessary to understand where items were found and should enable the reconstructionist to put the items back in place if needed. It shows the pertinent evidence and its relationship to other evidence and objects at the scene. The measurements must include the dimensions of the area and the measurements to the items of interest, including their height. Unfortunately, a proper crime scene sketch or diagram is an investigative rarity. When one is available, it is often incomplete, inaccurate, or illegible. This is an area in which many crime scene technicians need extensive additional training—both in terms of agreeing that scene diagrams are important and in terms of developing the skill to complete them so that they may be of use to others.

If the scene cannot be visited, documentation with complete diagrams and photos of the crime scene becomes all the more important.

CASE EXAMPLE

A man on a bicycle approached a man in a Jeep Cherokee and demanded money that he was owed. The window of the Jeep was broken out, with only a little glass remaining in the door at the bottom of the window. The man on the bike was stabbed in the left side just above the hip. He went to the hospital; the driver drove to the police and reported the assault.

The stories are different. The man on the bike says the driver got out of the car, stabbed him, got back in, and prepared to drive off. He grabbed the window and it broke as he pulled it out.

The driver claims the bicyclist hit the window with his fist and broke it inward. The bicyclist then climbed in the window, hitting at him and forcing him over the console where he had a knife. He picked it up and stabbed the bicyclist in the side in self-defense.

There were no cuts on the biker's stomach from the window glass. The steering wheel was in the way of any stabbing motion to the side of the biker. The height and angle of the stab wound were consistent with the version given by the man on the bike.

A reconstruction using the dimensions and structure of the vehicle and the location of the wound shows that the driver's story was false. Testimony was given regarding the reconstruction and the biker was found not guilty.

Some violent crimes occur in places where crime is no stranger, such as certain bars and buildings (crack houses, etc.). In these places, there may be bloodstains, bullet holes, and who knows what else from previous incidents and activity. These can confuse an interpretation if not recognized up front. In such crime scenes, the interpretation of bloodstains should not be completed until laboratory results are received, identifying the bloodstains as having originated from the actors in the case being worked.

Documentation of Bloodstains

The analysis of bloodstains can be no better than the samples taken and documentation made with respect to the crime scene. It defines the limit of interpretations in every case. There are several correct ways to document a stain; all involve measuring devices and photography of some type. One of the simplest methods is to grid the scene with 2-foot gridlines. The vertical lines must be set using a plumb so they are truly vertical. The horizontal lines must be set using a level. If a close-up is needed, the 4 square foot section can be further divided into 1-foot or even 6-inch squares.⁷

Before and after the wall is "strung," an overall photo is taken as close as possible perpendicular to the center of the wall. The sections are labeled with numbers across and letters from the ceiling using Post-It notes. That way each square has a unique number. Each square having blood in it is photographed with measuring tapes along two of the strings (outside the square) at right angles. The photo should be at a set distance such that the photo shows about 1 inch beyond the square on each side. It must be taken in the center of the square. Use a normal lens (not wide angle or telephoto). Close-up photos with a plumb and a millimeter scale are then taken of specific stains for measurement and further study. These photos will allow you to rebuild the bloodstains at the scene.⁸

⁷ Documenting stains on a wall is described. The same system can be extended to floors, ceilings, furniture, and so on.

⁸ An NCIT-trained evidence technician used this technique on a pattern of blood from a shotgun blast. The surface was the front of a four-unit, two-story apartment building. The shot occurred in front of the right-hand unit and extended to the street at the left. The squares were started from the upper left corner of the building. Unfortunately, by the time he took photos of the squares starting with A-1, he ran out of film just as he got about three squares to the left of the point where the shot occurred. Start with the most important part of the pattern and work out from it. As the photos contain a reference label there is no need to go "in order."

Weapon

To understand subsequent wounds and bloodstain patterns, the reconstructionist should study various weapons and how they are used. This will help with reconstructing how they may have been used in the case at hand or at least provide alternatives for theory testing and elimination. Sometimes, determination of the type of weapon is not possible at the crime scene but can be approximated at the autopsy.

As any weapon is wielded (e.g., a knife, tire iron, or bat), the blood on its surface is subjected to centrifugal forces (moving or directed away from a center or axis), causing the blood to flow along its length. Blood is cast off from those points on the weapon that prohibit further flow. The surface tension is overcome and the blood leaves these points in a series of drops. The quantity and the size of drops depend on the surface area of the weapon covered in blood because that defines the volume that can be present. A pocketknife will produce a smaller pattern than a machete, for example. The length of the weapon also affects the pattern; the longer the weapon, the further potential distance of any castoff as a result of greater forces acting on the blood.

High-speed video has shown that the way the blood leaves an object is not always from a point source.⁹ Hatchets, knife blades, and clubs each have a sheet of blood come off when they are stopped by striking a surface. This sheet breaks up into drops. The head of a hammer and the claws both have sheets come off; however, because the drops are deposited in similar patterns, it would be very difficult to determine for certain which side deposited the blood from examination of the bloodstain pattern.

Beating a blood-soaked sponge is done frequently to demonstrate the way in which blood spatters when hit by various objects. The pattern is not truly the same as that left by beating a person. As it is struck repeatedly, the sponge has less blood; a living body actually has more blood for subsequent blows. In such exercises, more blood should be added after each blow to a sponge, starting with a small amount, to produce a bloodstain pattern realistically.

Blood is neither spattered nor cast off from the weapon until it is present where the blow is landing. The capillaries are compressed and the veins are sealed when the blow lands; it takes time for bleeding to start, during which the instrument is removed. Several bloodletting blows can be delivered to different portions of the head, for instance, without hitting blood. Subsequently, there would be no spatters or castoff from the weapon. There would, of course, be castoff from the head as subsequent blows land and cause sudden movement of the head.

It is commonly held that in order to determine the number of blows delivered by a weapon, the reconstructionist need only count the number of castoff patterns related to a series of blows and then add one for the first blow. The logic is that the first blow occurs in the absence of blood. However, the previous example belies that theory, and a crushing blow with penetration, such as with a hammer, will result in immediate blood on the weapon. In such instances, there will be castoff from the first blow.

Contrary to popular fiction, knives used to stab a person do not have much blood on them. The tissue wipes off any blood as it is removed from the victim, leaving an oily film with just trace amounts of blood. It is only when an area already covered with blood is stabbed through that blood is able to coat the blade of the knife.

⁹ A high-speed video was made at the California Criminalistics Institute. It was shown at a California Association of Criminalists Seminar in 1995 and the IABPA/ACSR joint meeting in Albuquerque in 1996.



FIGURE 12.13 Cuts across the victim's palms and fingers from grabbing onto the knife.

Cuts across the palms and fingers occur when someone grabs onto the blade of a knife. It is subsequently pulled out and slices across the skin. These are not “defense wounds” in the classic sense. Commonly, these kinds of injuries occur when there has been a close relationship between the victim and the knife wielder. The victim in such cases does not believe that the other person is serious and foolishly tries to take the knife from him or her (Figure 12.13).

Bloodstain Patterns

The reconstructionist must understand the nature and occurrence of bloodstain patterns. For this, there is reason to attend at least a 1-week course on bloodstain analysis. The International Association of Bloodstain Pattern Analysts (IABPA) Web site (www.IABPA.org) lists different basic classes that will suffice. There are also some experiments provided at the end of this chapter. These experiments are designed to increase your knowledge regarding bloodstain patterns beyond what the basic classes teach.

The patterns present in a crime scene must be recorded in their entirety for the reconstructionist. In many cases, scene technicians document only the drops and not the overall pattern, either out of ignorance or for having misread the scene. Interpreting any stain under such circumstances is like looking at a single tree to understand the nature of a forest. It is the overall patterns that the reconstructionist must concentrate on. Consequently, it is of greatest value to see the entire stain patterns present at the crime scene, as they were found originally.

Again, when possible, the reconstructionist should go to the crime scene and see everything before it is disturbed. If this is not possible, then everything should be documented or saved in its original condition. In a homicide, the clothing on the body should be photographed, showing all the stains before the body is moved. Then the clothing should be removed at the scene and packaged in paper so that no two stains touch and transfer. This will preserve the stains and any trace evidence present on the clothing. The normal practice of leaving clothing on a body while it is

placed in a body bag and transported to the morgue causes contamination and loss of evidence. The information associated with these stains is destroyed by such practices.

Victim and Suspect

The more reconstructionists know about the participants, the more they will be able to understand and explain about the bloodstains. Their health, fitness, activities, medications, and diseases all work to influence the manner in which their blood flows, and the likelihood of the acts that may or may not have taken place. Reconstructionists should therefore get as much information as possible regarding the victim, including the following:

- Age
- Height
- Weight
- Toxicology/medications
- Health/medical diagnoses
- Fitness
- Activities (schedule of typical day, sports, hobbies, exercise, etc.)
- Addictions (drugs, alcohol, etc.)

This is referred to as victimology; it provides an important baseline of information to consider when interpreting what blood found in association with the victim means.

For example, some medications will cause the blood to flow more freely. Aspirin, Coumadin, and warfarin are drugs that keep the blood from clotting so that a minor wound will bleed more than normal. In older people, the use of Coumadin to prevent clots is common. People with arterial fibrillation may also be on Coumadin, so checking the Medic-Alert bracelet or necklace is a must.

Figure 12.1, which shows a man with a large bruise on his face, illustrates the extreme difference that blood-thinning medicine and age can cause. This will also cause bruising to be more common and to flow more. When blood does not clot, it can result in death or far more bleeding than would be expected from the wounds inflicted.

Illness can also be the reason for death or injury. Advanced cases of cirrhosis of the liver can cause weakened capillaries and veins, for example. Even the simple act of helping someone with this condition to stand will cause him or her to bruise. The same can happen if they bump into a wall or pick up a box; severe bruising can result that mimics an assault. This condition is common among alcoholics, and therefore such a history is a vital consideration.

CASE EXAMPLE

A woman's body was found in her living room. She had bruises on most of her body. The bruises were of different ages (different stages of healing; see Chapter 16: Sexual Assault: Issues in Evidence Examination and Interpretation). There was no sign of the cause of death. The scene was "frozen" until the cause of death was determined at autopsy. The liver was straw colored; this was advanced cirrhosis. She was a secret alcoholic; when we returned to the scene, we found vodka bottles hidden in several locations throughout the house. The husband claimed to be unaware of his wife's drinking problem.

CASE EXAMPLE

An elderly woman's body was found by a friend in her home. There was an injury to the head and blood trails throughout the residence. There was no pattern of violence. We were able to finally determine the starting location of the blood; it was at a corner near the floor. It was learned that she was epileptic. She had apparently fallen in a seizure and struck her head on this corner. Her confused state when she recovered was such that she had not called for assistance. This was ruled a natural death.

It is common for an entire home to be processed as a death scene with little or no attention paid to the contents of garbage cans and medicine cabinets. The medicine cabinet must be checked to determine what types of medicines/drugs the victim may be taking. The reconstructionist should also direct investigators to inquire about the medical condition from the victim's doctor, if possible.

People in good health are going to be potentially more difficult for an attacker to overcome than people in poor health. If they are runners or exercise a great deal, their heart rate will be less than that of sedentary people. Knowing the lifestyle signs will assist in determining these factors. Look for exercise equipment, gym membership cards, pools, bikes, and so on.

The victim's age is also a factor to consider. As a person grows older, the skin becomes thinner and is torn and bruised easily. This is true even without taking Coumadin or similar medications. An older person may not have the strength to thwart the actions of a perpetrator. A person with a heart ailment may have a heart attack due to the bloodletting event. This may result in less blood at the scene than would be expected from the nature of the wound.

The height of the victim relative to the suspect will determine where and at what angle wounds can be inflicted. The same effect can be caused by the victim being in other than a standing position. Knowledge of relative heights allows the reconstructionist to take this fact into account when assessing the wounds.

The activities or hobbies of the victim should also be checked. For example, a martial arts student is less likely to succumb to a direct attack. The defensive and offensive moves he or she makes will also be different from those of a noncombatant-type individual.

Summary

To reiterate, the reconstructionist needs to examine and understand the following to make an informed bloodstain pattern interpretation:

- Injuries sustained by the participants (victim and suspect)
- Crime scene
- What weapon(s) was used
- Bloodstain patterns
- Information about the participants

If the reconstructionist has not thoroughly considered at least three of these areas of consideration, he or she is essentially guessing with regard to any subsequent interpretations.

With these considerations in mind, the bloodstain analyst is better prepared to interpret the stains and present a reconstruction. However, as stated elsewhere in this text, bloodstains are only part of the evidence. Other types of evidence may give even more information and must be considered in any reconstruction. If the hypothesized explanation of the stains is in disagreement with any of the other types of evidence, then the interpretation is disproved and a different hypothesis must be found that will fit all the evidence.

For a descriptive case example, see Appendix II: Bloodstain Pattern Case Study.

REPORTING

In reporting bloodstain pattern interpretations, the use of digital photography is invaluable. Including digital photos of the bloodstain pattern in your text will allow readers to better understand your report. It is difficult to describe stains; a photograph is truly worth a thousand words.

All reconstruction conclusions must be justified. That is, the logic and reasoning must be clearly evident in the reconstruction report—not only the conclusion but also the reasons why other interpretations have been eliminated. This is particularly true if you are reexamining evidence that someone else has examined.

A “sanitized” report is provided as Attachment 1. It concerns a rivalry over a man. The “victim” claims that the man’s new girlfriend and several of her friends attacked her. The tragedy in this case was that the suspect was arrested and spent 18 months in jail awaiting trial because she could not afford bail. The local crime lab had not examined this case because it was a “minor incident” that did not qualify for lab analysis.

ATTACHMENT 1

Case Report

I was requested to examine the physical evidence and photos involved in the case. I was also asked to read the police reports, which included statements by the alleged victim, Ms. H. These examinations were for a reconstruction of this incident.

Statements

The following excerpts from the Police Department Crime Incident Report are Ms. H’s statement as to what occurred:

Discovery page: 13

Police report page: 5

Paragraph 4 line 2

“pushed her to the ground”

Discovery page: 14

Police report page: 6

Paragraph 1

“... after she was pushed to the ground on her back by the suspect, she was turned over by a female.”

“... once she was flipped over onto her stomach, the other two females got out and held her legs.”

Paragraph 2

“... when she was placed on her stomach, she felt her shirt being cut and then felt sharp pains in her upper back area.”

“... she was trying to get away from the females and during this time she had the front of her shirt slit by the suspect.”

“She said she never saw it (the weapon), but that she knew it was cutting her as her [sic] as could feel the blood dripping down her shoulder area.”

Paragraph 3

“... said after she was cut an unknown number of times, she was able to free herself from the suspects.”

The initial report gives the time the incident was called in as Thursday at 1340. The officer was dispatched at 1508. The time of report to time of discovery of the wounds was approximately 1.5 hours. However, according to Officer Y's report on page 4, 2nd paragraph: “I saw that there was fresh blood dripping from these, but that none of them appeared life threatening as it was not deep laceration, but shallow lacerations.”

Alternatives

In crime reconstruction, we test alternative explanations of an incident and determine if the physical evidence supports or refutes those explanations. The other explanation of these injuries and damage to the shirt is that the attack did not occur but the cuts were self-inflicted or inflicted in some manner other than what the “victim” described to the police. This other theory is that the crime was “staged.”

Examinations

I examined the Xerox copies of the photos and had several questions regarding what I saw. I then asked for copies made from the negatives. I still could not resolve some of the questions I had about the shirt. I examined the shirt in the property room of the police department approximately 16 months after the incident.

The following summarizes my findings:

I found no visible bloodstains inside the back of the garment.

I found no soil on the front or back of the garment.

One of the holes in the back lines up with one of the holes in the front.

The cut does not cut the collar or the label area but stops at this point.

The cut is not smooth but is jagged.

The bottom of the cut is smoother than the top.

The cut is approximately 15 inches long, almost half the length of the garment.

In examining photographs of the wounds, I noted two patterns. One is single parallel lines in a “V” shape on both sides of the back; the spacing of these is similar to the spacing between fingers. The other pattern is of three or four parallel lines that are more vertical and horizontal. These have a spacing similar to a dinner fork. There are also single lines.

These injuries could have been made by either the “suspects” or the “victim.” None of the injuries are deep but appear to be scratches (see police report).

The victim states she felt blood running down her shoulder on her back. However, there is no blood on the shirt. There are no blood streaks on the “victim’s” back or shoulder represented in the photos of the injuries.

The officer stated that the wounds had “fresh blood dripping” when he saw the “victim” approximately 1.5 hours after the call to the police department. If the “victim’s” statements were true, the wounds would not be “dripping” blood because blood would clot or dry within the stated time period. She could have reopened the wound by her actions when the officer arrived; however, if the blood was “freshly dripping” then it should be on the shirt. Photographs taken of the injuries do not show “fresh blood dripping.”

Interpretations of this lack of blood and the “fresh blood dripping” are as follow.

1. The injuries were done while the shirt was off and the blood dried before the shirt was put back on.
2. Officer Y mistook clotted blood for freshly dripping blood.
3. The injuries were made just prior to the arrival of Officer Y; however, this would still result in blood on the shirt unless the “victim” held herself in such a manner that the shirt did not contact the back.

The cut in the shirt is jagged toward the top. This is caused by the shirt being “bunched” or folded over in this area. The top of the cut stops at the neck seam. If a sharp instrument (razor blade) was used, I would expect an indication of a cut on the fabric at the collar and the entire cut would be smooth. The jagged cut is more consistent with scissors being used (Figure 12.14).

The “victim” states she was pushed to the ground on her back and then flipped over onto her stomach while two more females held her legs. She states she was held down by four females. The front of the shirt is grease stained from her work; if those areas had come into contact with soil, it should have adhered. No soil was noted on the front or back of the shirt (Figure 12.15).

The “victim” states she was “trying to get away from the females” and during this time she had the front of her shirt slit by the suspect (Figure 12.16). It would be expected that the clothing would be abraded where she was moving and struggling in contact with the cement of the sidewalk. There are no abraded areas on either the front or the back of the shirt. The pants do not show abrasions in the areas of the knees or buttocks in the photographs; however, the pants were not collected for examination. There do not appear to be any abrasions or bruises present on the “victim” that would support her version of the incident.

FIGURE 12.14 The cut in the back of the victim’s shirt.

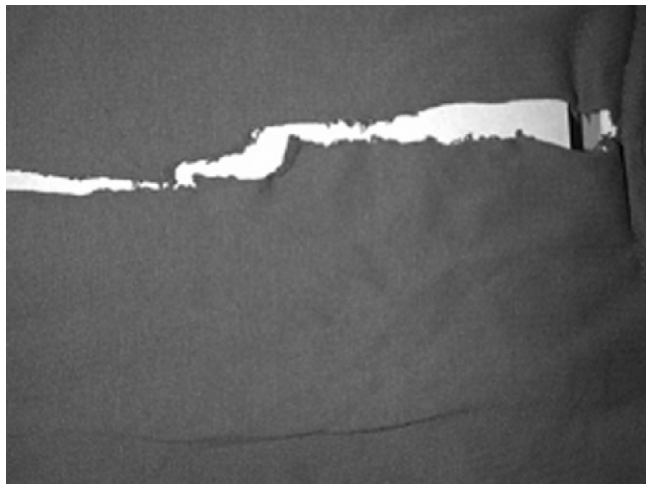




FIGURE 12.15 No soil on victim's clothing.

The victim states that she fought the “four suspects” holding her down. If she had fought, she should have abrasions of her clothing where it moved while in tight contact with the cement. No abrasions were found. The hole through the shirt suggests that the person may have cut the shirt while it was off the body (Figure 12.17).

Conclusion

Based on the previous considerations, it is my conclusion that the evidence does not support the actions described in the “victim’s” statements. I cannot rule out the possibility of staging. Staging can be defined as the alteration or creation of evidence to direct the investigation away from the perpetrator or toward a specific individual.

BLOODSTAIN PATTERN EXPERIMENTS

The following experiments are designed to give the reconstructionist some applied background for court purposes. Although much of what some analysts do may be intuitive, intuition does not fit into the legal picture. It is therefore suggested that reconstructionists keep a bloodstain notebook to document the nature and circumstances of their experiments, as well as any observations and results. The purpose of keeping this notebook is to maintain a concise,

FIGURE 12.16 No abrasions on victim's clothing.



well-organized, and permanent record. It is also recommended that experiments be photographed and an archive of these photos maintained for later reference along with the notebook.

This series of exercises is not all-inclusive; that is, the reconstructionist will see stain patterns at crime scenes that are different from any they will see in these experiments. This is because real life involves dynamic and compounded events. The exercises are designed to acquaint reconstructionists with the empirical research they should do as they encounter new patterns in their cases. It must be noted that when doing casework-related experiments, the reconstructionist should obtain weapons and materials for the receiving surfaces similar to those involved in the case he or she are working.

In conducting the following experiments, there are a number of ways to substitute for human blood. The reconstructionist may use any of the following.

- Blood from animals available from some butchers for use in making blood pudding (a dish out of favor in much of the United States). This blood has been frozen so the cells are lysed (the cell membrane has been disrupted), but the patterns are essentially the same.
- Vinyl or acrylic house paint, which behaves much like blood as it forms a film over the top (like clotting) when exposed to air.
- A mixture of white glue, water, and red food coloring.

The author does not recommend the use of actual human blood, expired blood bank products, or cadaver blood due to potential health hazards.



FIGURE 12.17 This hole penetrates the shirt in the same location, front and back.

EXPERIMENT 1

Drop Volume Determination

Before you proceed with other experiments, you should know how large a drop is normal. Use three different droppers; you will determine the size of the drop from each. Use the same droppers for subsequent experiments.

Supplies

- One plastic medicine dropper
- One glass medicine dropper
- One glass medicine dropper with broken tip
- One 5- or 10-ml graduated cylinder

Drip blood from each dropper into the graduated cylinder to the 1-ml mark. Count the drops as they fall. Use one dropper to put blood on your finger and let it drop into the cylinder. Assume the human body has 6 liters of blood. How many drops of blood are there in the human body? Calculate for each of the droppers ([Table 12.1](#)).

Caution: Do not allow air to cause bubbles in this or any experiment unless specified.

TABLE 12.1 Determine Number of Drops in 1 ml from Different Droppers (for Each, Determine Number of Drops of Blood in a Body)

Dropper	Plastic	Glass	Broken	Finger
Number of drops, 1 ml				
Drops in body				

EXPERIMENT 2

Drop Size

The size of a blood drop is related to its volume. At a fixed height, the source of the blood drop will determine the drop size. Blood drops seen at the scene of a crime will have several different sizes.

Supplies

Various tools (hammer, tire iron, screwdriver, crowbar, etc.)
 Knives of various sizes
 Bottle, broken glass
 Cloth

Drop blood from various tools and surfaces from a fixed height onto clean paper and measure the diameter of the stain, not including the “rays or spines” radiating from the drop (Table 12.2). For example, allow blood to run down the blade of a knife and drip from the tip of the blade; repeat using the handle.

Height _____

EXPERIMENT 3

Drop Size vs Drop Height

Occasionally, you may need to determine the height from which a stain was deposited. At one time, it was thought that this could be determined by measuring the size of the drop.

Several variables involved in bloodshed can only be approximated by experiments. The diameter of a blood drop on a surface is related to the volume, as determined in Experiment 2, and to the height.

TABLE 12.2 Determine Drop Size from Various Objects at Two Different Heights

Item	Drop size	Item	Drop size

TABLE 12.3 Record Diameter of Drops at Various Heights as Given

Height	Diameter	Height	Diameter
2"		3'	
4"		4'	
6"		5'	
12"		6'	
18"		7'	
24"		8'	

Drop blood from a dropper to the target from various heights. Measure the diameters of the drops. Repeat with a dropper of different volume (Table 12.3).

Supplies

Droppers
Tape measure
Target paper

You may continue to increase the heights if you wish.

Plot the measured values vs the height on graph paper.

The velocity is affected by gravity and increases as the distance is increased. Depending on the size and shape of an object, the air resistance will affect the velocity as well. The object will reach a certain velocity, termed terminal velocity, at which time it will no longer accelerate regardless of the height. The velocity at which the drop strikes the paper is related inversely to the drop diameter. The smaller drops encounter more air resistance and will reach terminal velocity at a lower elevation.

Questions

1. How reliable are height estimations based on examinations at the scene?
2. Does drop size affect terminal velocity?
3. At what height is the terminal velocity reached?

EXPERIMENT 4

Drop Shape and Size vs Target

The type of material that the blood lands on will affect both the size and the shape of the drop.

Supplies

Droppers
Target materials

Smooth: paper, glass, plastic, rocks, rayon cloth

Rough: paper towel, sandpaper of various grades, wood, cement

Absorbent: tissue, carpet, cotton cloth

Drop blood from a fixed height onto the various target materials. Record the size, not including spines or rays.

Questions

1. What is the difference in the shape of drops on a smooth surface vs a rough surface?
2. Is there a size difference?
3. How is the drop affected by absorbent materials?

EXPERIMENT 5

Angle of Impact

When a drop strikes a surface at an angle other than perpendicular (90 degrees), it will appear elongated. The drop forms an ellipse depending on the angle, and a tail of excess blood will point in the direction of travel. High-speed videos have been used to document this phenomenon, as has still photography. This experiment is designed to test the hypothesis regarding the relationship between the angle and the ratio of the width to length of the drop.

Supplies

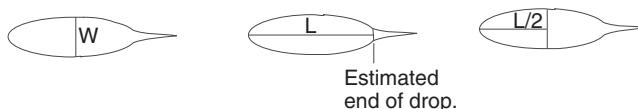
- Dropper of known volume
- Copy paper
- Target stand
- Tape measure or yardstick (meter stick)
- Card stock (poster board)

Note that a target stand may be made simply by cutting grooves into one side of a 4×4 block of wood to a depth sufficient to support the card stock. The angles of the grooves should be approximately 10, 20, 30, and 40 degrees. When the block is stood on end, the angles will be 80, 70, 60, and 50 degrees. The block should be varnished to prevent the blood from absorbing into the wood.

Drop at least five drops of blood from a specific height onto paper taped to a piece of card stock and inserted into a slot on the target stand. Take down immediately and allow to dry. Repeat the experiment using each slot on the target block.

1. Determine the widest point of each drop and record the measurement.
2. Measure the length of the drop:
Total length (not including the tail)
From widest point to the beginning of the drop. Multiply result by 2 (Figure 12.18).

FIGURE 12.18 Ratio of W/L vs angle of incidence.



3. Plot W vs L on graph paper
Plot W vs $L/2 \times 2$ on graph paper
4. Calculate the mean value of L , $L/2$, and W for each angle (and height).

Is the relationship a straight line? A straight line would indicate a direct relationship between the width and the length of the drop. If the plot does not result in a line, then the length versus width ratios used for angle incidence would be valueless. The degree of variation from a straight line indicates the error in the process.

5. For each drop, divide the width by the length and calculate the mean value of this ratio for both L and $L/2$.
6. Plot average ratios vs the angle of incidence.
The line should look like the sine curve from $x = 0$ to $x = 90$.
Again, the deviation is part of the error in the process.
7. Take the arc sine of the ratios and compare these values to known values from sine tables or a calculator.
8. Prepare a series of standard ellipses for each angle using a CAD program. Compare the ellipses to your drops. Could you use this series for estimating the angle of incidence? How does the accuracy compare?
9. Use a laser with a circular hologram (a smiley face will do). Make the shape of the ellipse produced by the hologram the same as your drops. Measure the angle between the laser beam and the surface. Plot these angles. Compare the accuracy with that of the previous methods.

Repeat Experiments 3–5 with air in the blood so that the drops have bubbles.

EXPERIMENT 6

Blood Transfers

Blood is found at the crime scene as transfers from the suspect, victim, or objects on which it has been deposited from the original source. These transfers may be primary, secondary, or tertiary on objects in between the source and the deposit. In other words, there is more than one possible origin—the transfer need not come directly from the blood source. Transfers may also show motion.

Supplies

- Dish
- Cloth swatches of various materials
- Various tools
- Paper
- White cotton cloth
- Rolling objects: piece of pipe, coin, marbles, tennis ball, baseball, etc.

Cloth Transfers

1. Pour blood into a petri dish or other suitable flat dish.

2. Dip a swatch of cloth into the blood.
3. Dab the cloth repeatedly onto a piece of paper. Note the different patterns depending on the weave of the cloth. (Record these patterns in your notebook using red ink.)

Tool Transfers

4. Smear blood onto various surfaces of tools.
5. Touch the tools to paper.
6. Strike the paper (on a block of wood) with the tool.
7. Wrap the tool in a piece of white cotton cloth.

Can you recognize the tool from the blood pattern that has been transferred to the paper or cloth (Steps 5–7)?

Shoe Transfers

8. Step in a pool of blood with a shoe heel or a sports shoe. Step repeatedly on the paper in different areas until the print no longer shows.

How many steps show blood? Are there individual characteristics of the shoe showing in the prints?

Smear Blood

9. Deposit a few drops of blood on a smooth surface (paper).
10. Using a dry cloth, wipe through the blood as if trying to clean it up.
11. Use a piece of the same cloth and wet it with blood. Swipe the cloth across the surface of the paper.
12. Try different surfaces such as glass and varied drying times.

Compare the resultant smears. Can you discern a difference in the smear left by the dry cloth (wipe) and the smear left by the wet cloth (swipe)?

Rolling Transfers

13. Roll various objects through a deposit of wet blood.

Can you identify the object from the pattern?

14. Cause the object to spin, if possible, as it goes through the blood.

How does this affect the pattern?

EXPERIMENT 7

Inside vs Outside

Is it possible to determine which side of a piece of cloth the blood is deposited on? This question will arise in crime scene work or regarding clothing submitted to the laboratory for examination. The answer may be quite significant in the interpretation of stains. The differences can be subtle; these experiments will help you become acquainted with those differences.

Supplies

Cloth swatches, various materials
Droppers

1. Drop a single drop on one corner of a piece of cloth.
2. Drip five drops into one spot on the opposite corner.
3. Allow to dry.

Observe the stains on the top versus the bottom. Note the diameters, color, and the surface characteristic of the stain. Are there differences due to the quantity of blood?

EXPERIMENT 8

Impact Spatter Patterns

Liquids may be dispersed when acted on by sudden forces. The number, size, and energy of the drops coming from the source will depend on several factors, including, but not limited to, the size and shape of the object struck, the size and shape of the object imparting the energy to the liquid, the amount of energy involved, the viscosity of the liquid, and the surface tension of the liquid.

The simulation of blood coming from various parts of the human body due to blows, cuts, and gunshots is difficult. However, lacking volunteers to receive blows, sponges may be used to soak up blood and receive the blows.

Supplies

Cardboard targets (~2 feet square as a minimum)
Sponges
Wood block
Butcher paper
Tools (hammer, pipe, bat, coat hanger, belt, etc.)
Old long-sleeved shirt

1. Soak sponge with blood.
2. Set target approximately 1 foot from block.
3. Strike sponge with overhand blow directing the blood toward the target.
4. Repeat using each tool. Use a new target each time.

Note the quantity, size, and shape of the drops. Relate these patterns to the energy involved in the blow. These experiments show the variations that may be produced in bloodstains produced by blunt force.

5. Strike a wet sponge with one fist while holding the other hand next to the sponge. You are simulating a beating in which a person is struck with a fist while being held in position with the opposite hand. Observe the pattern produced on the sleeves of your clothing.
-

EXPERIMENT 9

Cast-off Patterns

The blood transferred to the instrument used to deliver blows will, if enough is present, be thrown from the instrument as the instrument is moved or stopped suddenly. This phenomenon is known as castoff. Centrifugal force is acting on the blood during the swing to cause it to leave the object. The force overcomes the surface tension and viscosity, and the blood is cast from the object. The surface capacity (i.e., the amount of blood that the surface can hold) and the shape of the edges of the instrument used are the primary factors relating to the resultant patterns. A knife will leave a single pattern of small drops, a machete a larger pattern, and a claw hammer may leave a double pattern.

Supplies

- Tools of various shapes
- Knives of various sizes
- Ball bat
- Piece of pipe
- Broomstick or police baton
- Butcher paper

To conduct these experiments, you will need to use an area that will not be harmed by blood (or whatever you are using) or will need to cover all surfaces with butcher paper.

Dip each tool into blood, swing the tool as if striking something, and bring it back to strike again. Alternatively, strike a sponge and lift to strike again repeatedly.

EXPERIMENT 10

Step, Kick, or Stomp

The shoes and trousers worn by a person can indicate the manner in which the shoes were stained. The subject may have stepped in the blood while trying to give aid, but he or she may have kicked or stomped the victim. The patterns produced in each instance are distinctive.

Supplies

- Rubber boots
- Sponges
- Large rock

1. Pour a pool of blood. Step in the pool. Examine the soles of the boots.
 2. Soak the sponge with blood. Kick the sponge. Examine the patterns on the boot and the trousers.
 3. Stomp the sponge. Examine the sole for blood showing direction on the vertical surfaces of the design. Examine the pattern of drops on the trousers.
 4. Stand in front of the sponge. Drop a large rock into the sponge. What is the pattern produced on the boots? On the trousers?
-

EXPERIMENT 11

Gunshots into Blood

The patterns produced by bullets striking blood are different from the patterns produced by blunt objects. The energy imparted to the liquid by bullets is greater over a small surface area than delivered with a tool. This greater energy causes greater dispersal of the liquid. This results in a “misting” of the blood, producing very small droplets.

In conducting experiments using firearms, follow all safety rules and regulations. Also, never load more than one bullet at a time because you will want to inspect the target after each shot. Put all empty weapons down when going downrange.

Supplies

- Firearms
- Ammunition
- Cardboard targets
- Paper
- Framework
- Rubber bands
- Sponges

A framework for suspending sponge and paper for recording the patterns can be built using a few lengths of PVC pipe and connectors.

Affix a sponge between two pieces of cardboard using rubber bands and place it in the framework. Pour blood onto the sponge (the sponge will absorb the blood if it is slightly damp).

1. Shoot the target from 5, 3, and 1 foot, 6 and 1 inch, and contact. Record the patterns after each shot.
2. Shoot the target from 5 feet using different calibers. Record the carry-through on a back target.
3. Vary the distance of the back target as you shoot from a set distance.
4. Shoot through a cardboard target suspended in front of the “sandwich” to see the back spatter. You may have to remove the front piece of cardboard to get any back spatter. Vary the distance of this front target.

Questions

1. How far does the misting effect extend?
 2. How far does the back spatter extend?
 3. What can you tell about the caliber of the weapon by examining the patterns?
 4. Can you determine the point of origin of the blood from the patterns?
-

EXPERIMENT 12

Skeleton or Ghost Drops

Skeleton or ghost drops are the dried edges of drops that have been wiped away. The purpose of this experiment is to determine the time required for these to form.

Supplies

Dropper
Target material
Tissues
Stopwatch
Thermometer

Drop blood onto a nonabsorbing smooth surface. Wait 5 seconds and then wipe the blood away with a tissue. Repeat this process in 5-second intervals for a total of 2 minutes. Record the amount of ghosting remaining and plot it against the elapsed time since deposition.

Repeat the experiment at different temperatures.

EXPERIMENT 13

Drop into Drop

Blood drops are not always separate but will drop from a source into the same location, causing different patterns. This simple experiment will familiarize you with the patterns produced.

Supplies

Dropper
Targets (glass, smooth paper, rough paper, concrete)

1. From 2 feet, drip blood onto a target such that the drops land in previous drops as much as possible.
2. Place a side target so that the blood will splash onto a vertical surface.
3. Repeat for the different targets.

Note the “misting” appearance. Examine the droplets. Which way are the tails pointed? On the vertical surface, could this be confused with a gunshot?

Is there a difference in patterns due to the texture of the surface on which the blood lands?

EXPERIMENT 14

Surface Effects

The previous experiments show how blood behaves normally. However, the surfaces encountered at a crime scene are not always normal. They may be coated with various materials, such as furniture polish, oil, and soap. This experiment allows you to determine what effects these contaminants may have on the shape of blood drops and stains.

Supplies

Dropper
Clean glass plates (~5 × 8 inches)

Furniture polish
Household oil
WD-40
Bar of soap
Detergent
Alcohol
Paper targets
Mounting board
Target stand
Spray bottle(s)

1. Set a glass plate in the target block at 30 degrees.
2. Drop air-free drops onto the target from 6 inches.
3. Record the shapes.
4. Repeat but coat the plate with a thin film of
 - Water
 - Alcohol
 - Furniture polish
 - Oil
 - WD-40
 - Soapy solution
 - Detergent solution
5. Repeat the previous experiments using a paper target.

How does the coating change the drop shape?
Follow range safety rules.

EXPERIMENT 15

Movement

Blood-shedding activities are seldom static. Blood is shed by moving persons and objects or may be deposited on a moving surface. These experiments are a starting point in research into the patterns caused by movement.

[Pizzola and colleagues \(1986\)](#) performed experiments using a motorized belt pulley apparatus to produce moving targets. Their experiments can be reproduced in essence by having someone pull the target as you drip blood onto it. The purpose is to determine if there is a difference in moving the target vs the source.

Supplies

Dropper
Roll of butcher paper

1. Place approximately 25 feet of paper on the floor.
2. Hold the dropper at a constant height throughout the experiment.
3. Drip blood as you walk along the length of the paper. Vary your velocity.
4. Drip blood from a stationary position and have someone pull the paper.
5. Using square pieces of paper, drip blood onto the paper as you

Move your hand in a circular motion

Move your hand and the paper in the same direction

Move your hand and the paper in opposite directions

Move your hand 90 degrees to the direction of the paper movement

Move your hand 45 degrees to the direction of the paper movement

Questions

1. What effect does a moving target have on the shape of the blood drop?
 2. Is there a difference in the drop shape between the movement of one vs the other?
-

EXPERIMENT 16

Walk, Jog, or Run

Blood is dripped while the victim and suspect are moving. They may be walking or running; the pattern of the drops is different for each movement. This is due to the movement of the body and arms as a person increases speed. The arms swing in larger movements; therefore an injury that is shedding blood down the arm or hand will leave a pattern that you can reproduce. An injury that causes blood to run down the leg will also cause different patterns. This experiment will assist you in becoming familiar with these patterns.

Supplies

Plastic wash bottle (if not available, a drinking water bottle with the nozzle top will do or, better, a soap bottle with a nozzle top)

An outdoor location that will show the stains but can be washed off

Garden hose

Fill the bottle with blood. Adjust the nozzle so that there is a constant drip of blood. Invert the bottle.

1. Walk at least 10 yards holding the bottle so that the hand is in a normal position and swings normally.
2. Repeat at a jog, but go 15 yards.
3. Repeat Step 2 at a run.

Sketch the patterns. Are all the drops going in the direction of travel?

EXPERIMENT 17

Door Movement

Blood may strike a door that is moving or is moved while the blood is wet. The pattern is changed by opening or closing the door, especially if it is moved rapidly and slammed closed or banged against the wall.

Supplies

Blood bottle (see Experiment 16)
Door
Butcher paper

1. Cover the door, the adjacent wall, and the floor under the door arc with butcher paper. The paper on the door can have the waxed side out to simulate the varnish or finish on a door.
2. Deposit blood on the back of the door in different locations (i.e., near the hinge, near the center, and near the knob).
3. Slam the door against the wall. Record stains.
4. Slam the door closed. Record stains.

Questions

1. Are these the changes in the patterns you predicted?
 2. Which deposit shows the most change? Why?
 3. Did blood go to the wall? To the floor?
-

EXPERIMENT 18

Air Movement

Bloodshed can be in environments that have air movement. The movement may be caused by a fan, an open window in a vehicle, or even by sneezing or coughing. Air movement can cause confusion regarding bloodstain patterns at a crime scene.

Supplies

Compressed air
Rubber or plastic tubing
Droppers
Paper
Wire loop, 1/4- to 1/2-inch diameter

1. Hang the paper vertically; cover the floor in front of the paper.
2. Hold the dropper so that a drop is at the end but not falling 1 foot from the vertical paper.
3. Hit the drop with a blast of compressed air.
4. Record the pattern.
5. Repeat the experiment at 2 and 3 feet.
6. Repeat the experiment at 1, 2, and 3 feet using the wire loop with a film of blood.

Note the appearance of the patterns. Do these appear similar to other patterns produced by another experiment? How could you distinguish between the two?

7. Drip blood in front of a fan directed at the target.
8. Drip blood in front of a fan directed at 70 degrees to the target.
9. Put the fan in a box or the firearms framework. Drip blood onto the blades.

Questions

1. How does wind affect the blood drops?
 2. How does this relate to a moving vehicle?
-

EXPERIMENT 19

Diluted Blood

Not all blood at a crime scene will be 100% blood. Some will be diluted with various body fluids and tissues, and some will be diluted by rain or some other water source. You should know how the patterns change as blood is diluted.

Supplies

Water
Targets
Droppers
Target block
White cotton cloth

1. Prepare several dilutions of blood (95, 90, 80, and 50% blood).
2. Perform angle experiments using the different dilutions.
3. Get blood on your gloved hand. Wash your hand over a cloth target.

Questions

1. What difference in the drip shapes does dilution make?
 2. Would you be able to determine that blood at a crime scene was diluted?
 3. Would you be able to distinguish stains deposited on clothing during a beating from those that were splashed onto clothing by washing blood from something?
-

EXPERIMENT 20

Crossing Patterns

Bloodstains can show a sequence of events when two types of patterns overlap.

Supplies

Target
Dropper

1. Suspend the target vertically.
2. Drop blood onto the vertical target until it starts to run down.
3. Using a gloved hand, wipe across the blood.
4. Drop more blood above the smear and allow it to cross the smear.
5. Repeat Step 4, but rotate the target 45 degrees.
6. Repeat Step 4, but rotate the target 90 degrees.
7. Allow the smear to dry and repeat the last three experiments.
8. Repeat Step 2, then turn and drop more blood so that it crosses the wet streak.
9. Repeat Step 8 except allow the first streak to dry first.

In each instance, how can you tell which is first?

EXPERIMENT 21

Which Was First?

It is sometimes possible to determine which shot was first if blood was shed near where the weapon was fired. A revolver is used in this experiment because the cylinder blast also causes an interesting pattern. This is also an example of location evidence.

Supplies

Target
Dropper or blood bottle
Revolver
Ammunition

1. Suspend the target vertically so that it is parallel with the direction of fire at the range. (Obey all safety regulations at the range.)
2. Load one chamber of the revolver.
3. Hold the revolver against the target pointing downrange.
4. Drop blood in front of the muzzle, in front of the cylinder, and at the other end of the cylinder.
5. While the blood is running past the cylinder, fire the gun.

Questions

1. What happened to the three blood trails?
 2. Why is the spatter in different directions?
-

EXPERIMENT 22

Blood on Tire

Blood on the side of a vehicle has already been simulated; however, the forces on the stains on a tire are different.

Supplies

Vehicle
Dropper
Driver

1. Drop enough blood onto a tire to cause it to run.
 2. Accelerate the vehicle slowly. Stop slowly and examine the pattern.
 3. Repeat but brake hard.
 4. Repeat but accelerate fast.
-

EXPERIMENT 23

Drying Time

You will be asked on the witness stand how long it takes for blood to dry. The answer is complicated, as you will determine in this experiment.

Supplies

Humidity chambers
Clock
Sponge
Substrate (examples)

Paper
Paper towel
Glass sheet
Piece of terry cloth towel
White cotton cloth
Piece of polyester cloth
Piece of nylon carpeting

1. Make stains on three pieces of one substrate (equal quantity of blood on each).
2. Place one in a humidity chamber with a wet sponge and seal.
Place one in a chamber with a desiccant and seal.
Place one in a box with no lid (room humidity).
3. Determine the times for the stains to dry.
4. Repeat at various temperatures.

How do you answer the question?

EXPERIMENT 24

Blood Absorption

Supplies

Burette

Soil, sand, sponge, carpet, cotton cloth, disposable diaper, newspaper

1. Adjust burette to drip separate drops.
2. Drip 1 cc onto each substrate.
3. Observe the size of the stain on each.
4. Repeat, except pour the entire cc of blood on the substrate at one time.

Questions

1. Was the size of the stain consistent with a given volume?
 2. Were you correct in your prediction of the difference when you added the cc all at once?
 3. How do these experiments assist you in interpreting bloodstains?
-

EXPERIMENT 25

Estimating Volumes

Supplies

Substrates

Glass

Paper

Carpet

Cotton cloth

Scissors

Scalpel

Analytical balance

Dropper

1. Weigh the substrate before you add blood.
2. Add a known volume of blood to the substrate.
3. Weigh the substrate again.
4. Allow the substrate to dry.
5. Weigh the substrate again.

At this point, you know how much the sample weighed to begin with and how much it weighs now. Therefore, you know the amount of water loss from the blood.

The problem is that you cannot weigh the before and after at a crime scene. It has been proposed that the quantity of blood can be estimated by weighing a cut out portion of the substrate and an unstained piece of equal dimensions.

6. Obtain second pieces of the substrate equal in size to the originals.
7. Weigh these second samples.
8. Subtract the weight of the second sample from the weight of the first plus the dried blood.

You now have an approximation of the amount of blood deposited at the scene. This should always be approached as a last resort; you should have a very good reason for trying to determine the quantity of blood present. This is only an approximation because blood has differing amounts of solids in different people. Getting an exact equal piece of carpet, bedding, or whatever is never going to happen; it is approximately equal.

Questions

1. How much water was lost from the blood?
 2. Does this agree with the published ranges?
 3. Do you have enough experiments to calculate a “standard error” in a controlled situation?
-

SUMMARY

Bloodstain patterns are the visible record of the bloodshed at a crime scene. *Bloodstain pattern analysis* is the examination of the shapes, locations, and distribution patterns of bloodstains for the purpose of interpreting the physical events that caused them. It is premised on the theory that bloodstain patterns are characteristic of the forces that created them.

Bloodstains are among the most useful forms of physical evidence in the reconstruction of a crime. They are present in almost all cases involving violence where there is bloodshed. They may also be present in burglaries, hit-and-runs, and many other crimes. Most recognize their present value for the identification and comparison of the blood, often with DNA testing, which assists in determining whose blood is present and where. However, bloodstains can also provide information for reconstruction of the incident that is far more useful in investigations and court proceedings than that derived from other technologies. Bloodstain patterns—their existence, shape, volume, and location—are of tremendous reconstructive value. There may be no doubt as to who shed the blood, but the nature of the stains deposited at the scene may yield great information about what events took place and how they occurred.

The reconstructionist needs to examine and understand the following to make an informed bloodstain pattern interpretation:

- Injuries sustained by the participants (victim and suspect)
- Crime scene
- What weapon(s) was used
- Bloodstain patterns
- Information about the participants

If the reconstructionist has not thoroughly considered at least three of these areas of consideration, he or she is essentially guessing with regard to any subsequent interpretations. With these considerations in mind, the bloodstain analyst is better prepared to interpret the stains and present a reconstruction. However, as stated elsewhere in this text, bloodstains are only part of the evidence. Other types of evidence may give even more information and must be considered in any reconstruction. If the hypothesized explanation of the stains is in disagreement with any of the other types of evidence, then the interpretation is disproved and a different hypothesis must be found that will fit all the evidence.

QUESTIONS

1. Define bloodstain pattern analysis.
2. List one pitfall of bloodstain analysis short courses.
3. Explain the importance of livor mortis in crime reconstruction.
4. Explain the difference between a penetrating wound and a perforating wound.
5. Explain the importance of victimology in bloodstain pattern analysis.

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Shooting Incident Reconstruction

Part I

Bruce R. Moran

It's not what you look at that matters, it's what you see. —*Henry David Thoreau*

Key Terms

Ballistics; Bow effect; Bullet wipe; Chisum trail; Deflect; Fragment; Lead splash; Penetrate; Perforate; Pinch point; Primary impact; Projectile paths; Ricochet; Shooting incident reconstruction; Terminal point

This chapter and the next discuss general concepts in the investigation of shooting incidents, first by presenting the basic knowledge required and then by showing its application to reconstruction. There is, throughout, an emphasis on the reconstruction of events that occur at such scenes using a comprehensive approach. This includes pre- and postshooting incident considerations.

Considerations for the forensic scientist are numerous in a shooting incident reconstruction. To this end, the author has attempted to organize the discussion into a chronological progression of considerations that include a philosophy of critical thinking; an introduction to various specific shooting incident/firearms-related phenomenon that offer reconstructive information integrated with other forms of physical evidence; practical approaches to reconstructive techniques that can be applied during the direct investigation of shooting scenes and/or resolving reconstructive issues that inevitably arise after the fact; and practical considerations gleaned from a review of sources from investigative and/or physical evidence prepared by various professionals in law enforcement and forensic science. Specific sections will occur in the following order:

1. The process of shooting incident reconstruction
2. Firearms and shooting incident reconstruction
3. Ammunition and shooting incident reconstruction
4. Projectile holes, impact sites, and ricochets
5. Projectile paths
6. Shooter location, position, and orientation

7. Gunfire involving vehicles
8. Reconstruction considerations involving shotgun evidence
9. Crime reconstruction and shooting incidents

Within the confines of this work, detailed descriptions of specific methods and procedures associated with shooting incident reconstruction are not practical. Emphasis will be placed on introducing the reader to an overall approach to shooting incident investigation and reconstruction. This will facilitate expanded vision through critical thinking and questioning that will contribute to improved recognition of potential information garnered from shooting incidents. The ideas set forth in this chapter will better equip the reader to approach these investigations and thereby recognize pieces of the puzzle that might otherwise remain mute, along with providing the best representation of such observations with regard to the application of the scientific method. This in turn will contribute to a more successful resolution to any shooting incident reconstruction.

SHOOTING INCIDENT RECONSTRUCTION—A PROCESS

Shooting incident reconstruction is the process of identifying specific events that have occurred during a shooting incident. It also provides explanations of how those events happened through careful consideration of investigative information and its correlation with the physical evidence. The entire process is dependent on gathering information from a variety of investigative and physical evidence sources. Additionally, the process is cyclical in that as information becomes available, questions emerge, and these questions prompt investigation, research and/or analysis, and testing of possible solutions to resolve the problems that arise. The information is evaluated continually, and reconstruction of the incident evolves through a process of elimination as answers to these questions are provided. The end product of this process is (1) elimination of events that are impossible, (2) consideration of events that are improbable but possible, and (3) an offering of events that are most probable and best supported by evaluation of the evidence available. Ideally, all possible theories, or scenarios, will be eliminated except one. In the case of shooting incidents, the process can assist in identifying key elements such as

- Number of participants involved
- Number and types of firearms involved
- The manner in which a firearm was fired
- The distance from which a firearm was fired
- The location, position, and orientation of a firearm at the moment of discharge
- Direction of projectile paths within a shooting scene
- The presence and type of any intervening objects struck during the flight of bullets fired
- Location(s), position(s), and orientation(s) of participants at the moment of any discharge(s)
- Sequence of shooting events that occurred

In reality, it is the exception rather than the rule that all elements of a shooting incident are completely reconstructed. For example, the flight of fired bullets within the confines of a building, their impact with intervening objects, and terminal penetration into a wall occur within a fraction of a second and are impossible to see with the naked eye. However, evidence of their

flight in the form of bullet impact sites, ricochets, and bullet holes, and each bullet itself, bears witness to this instant in time. Each can be readily observed, documented, and studied. These observations, correlated with known principles of physics and knowledge of bullet behavior, either established previously or determined through empirical experimentation under similar conditions, can be used to reconstruct the bullet path. Repeating this process in shooting scenes where multiple shots are fired allows the reconstructionist to record these moments in time indirectly. Although these brief moments by themselves are insufficient to resolve reconstructive questions, they can provide very useful clues when correlated with other sources of investigative information and/or physical evidence present at the scene.

In other cases, there may simply be a paucity of information available to confidently reconstruct certain segments within a shooting incident. What is important to realize is that the reconstructionist can only work within the limitations of the information at hand and the limitations of the reconstruction process itself. Within these limitations, the reconstruction process is an evolving event in that conclusions of the reconstructionist may be modified with the addition of new information; the spirit of which is discussed in more detail in the following section. Ideally, it may be possible to reasonably eliminate all but one theory or account when sufficient information is gathered and properly interpreted. There are indeed rewarding times when all the physical evidence supports one particular account or explanation of a shooting incident and refutes all other theories.

The reconstructionist may depend on the following sources of information to assist him or her in reaching conclusions:

- Direct examination of the shooting scene
- Crime scene reports, photos, and diagrams
- Investigative reports, including witness and suspect statements
- Physical evidence reports including the examination of firearm-related evidence, blood pattern interpretation, footwear and tire track evidence, trace evidence, and toxicological findings
- Autopsy reports and diagrams of deceased participants
- Medical reports of injured participants
- Results of experiments conducted specifically to test possible solutions to questions and issues identified during the course of the shooting scene evaluation

An attempt to address these sources of information is included in this writing.

Shooting incident reconstruction is most effective when a comprehensive approach is taken. This includes considerations of events before, during, and after the shooting incident. By following a comprehensive and thorough approach to assessing a shooting incident, examining physical evidence, and correlating it with other investigative information, it may even be possible to successfully resolve unanticipated questions or hypotheses that may develop.

APPLICATION OF THE SCIENTIFIC METHOD

Before continuing, it is important to establish an all-important link between the process of shooting incident reconstruction and the practice of sound science using the scientific method. The degree of success of the former is ultimately dependent on the practice of the latter. The process of shooting reconstruction is ultimately concerned with the best determination of

events that have taken place and the most reliable explanation of how they have occurred in a shooting incident.

Achieving this end requires systematic thinking about a problem(s) associated with the incident being investigated and, if possible, solving it. This is addressed by answering questions developed to address the problem. The answer to these questions leads the reconstructionist to a solution or, in some cases, more than one solution to the problem. Frequently, the solution may be so basic that the reconstructionist who solves the problem may not have consciously followed a predetermined process for approaching it. However, in situations that are more complex, the requirement for a formal means of problem solving becomes an essential element in reaching solutions in an efficient and reliable manner. This is when the reconstructionist gets out the heavy lifting equipment of the scientific method necessary to address such problems.

If one is to become familiar with the scientific method, then a working understanding of the definition of science is in order. [Lastrucci \(1967, p. 6\)](#) defines science as “an objective, logical, and systematic method of analysis of phenomena, devised to permit the accumulation of reliable knowledge.” So too is the goal of the reconstructionist by which the accumulation of reliable knowledge will be employed to answer questions in a shooting incident. Lastrucci also advises that “science is an intersubjective method; it is available to any interested and competent person; it is not the special province of a favored few” (p. 6). In other words, there is no requirement to be a “scientist” to employ a scientific approach to shooting reconstruction. The scope of the scientific method can be viewed as the entire range of human interest because “it is not the field of study but the type of problem posed that determines whether or not a scientific approach can be profitably employed” (p. 17).

The *scientific method* is nothing more than a formal process of problem solving. What distinguishes between the scientific method and science is that the former usually leads to the latter. The scientific method consists of (1) stating the problem, or what it is that will be investigated; (2) gathering information about the problem; (3) forming a hypothesis that attempts to provide an explanation for the problem; (4) developing controlled experiments to test the hypothesis; (5) recording and analyzing data; (6) forming a conclusion about the validity of the hypothesis; and (7) if the hypothesis is proven false, form a new hypothesis and repeat Steps 4, 5, and 6 ([Gryzbowski et al., 2003](#)). The author would submit that the reader has likely employed the scientific method informally as a routine matter of course when solving everyday problems.

Traditionally, the evaluation process involved in general crime scene investigation and reconstruction is based on individual expertise built on training and experience. It is founded on formally developed scientific principles developed from basic research conducted in all the physical science disciplines. The crime scene investigator and reconstructionist are generally not concerned with the formal basis for how the scientific method is used to develop scientific theory employed within the multitude of these science disciplines. Rather, reconstructionists, while performing routine casework, are engaged in applied science. For example, reconstructionists concerned with shooting incident investigation routinely make use of such fields as physics, chemistry, microscopy, trigonometry, geometry, ballistics, and pathology during the course of their work. Tests and methods employed by the reconstructionist can be linked to these recognized scientific disciplines that have been well established using the scientific method. Borrowing from these disciplines, the practitioner addresses such questions (problems) as:

1. Was this cartridge case ejected from that gun?
2. Was the bullet that struck the decedent a result of a direct impact or from a ricochet off some intermediary target?
3. How far away was the shooter when the shot was fired?
4. Was the decedent in a defensive or offensive posture when the shot was received?

Finding solutions to these types of routine problems does not require classical “basic research” using the scientific method. This might lead one to think that we are not applying the scientific method when conducting this type of investigation. However, we are indeed applying the scientific method but, in the main, not in a formally structured way. However, physical evidence encountered in crime scenes lends itself readily to formal scientific investigation when it becomes necessary to employ it to resolve reconstructive problems (Moran and Murdock, 2003). Because this work is concerned with the investigation of shooting incidents, events that occur from the use and/or misuse of firearms offer some special and unique opportunities to apply the scientific method formally. In this regard, Haag and Haag (2004, p. 1) rather succinctly note that

... because of the wide variety of firearms and ammunition types, the relatively predictable behavior of projectiles and firearms discharge products, the chemistry of many of these ammunition-related products and certain laws of physics may be utilized to evaluate the various accounts and theories of how an event took place. These phenomena are used to reconstruct such things as the sequence of events, the location of one or more impacts, etc.

Using an all-inclusive approach, the reconstructionist must first focus on the issues in the case itself and then consider any physical evidence within the context of those issues. This is simply accomplished by asking many questions before proceeding headlong into the investigation. Whether using the scientific method formally or informally, the reconstructionist must first of all be practical in ascertaining the specific circumstances of the case. Second, they must make systematic evaluations based on those circumstances by defining the important issues and questions. Third, they must determine what is known and what is in dispute. Finally, they must ultimately design and test possible solutions to these questions based on the information obtained from these considerations. Indeed, physical evidence in regard to shooting scene investigation is conducive to examination and the designing of tests to address solutions to such issues using the scientific method. It should be regarded as a cross-check with which to assess various solutions, theories, accounts, or scenarios that may be offered during the reconstructive process.

Perhaps the most important consideration in the reconstructive process is that the practitioner within this discipline should not set out to “prove” anything. Rather, he or she should provide a voice that best represents the significance of information gathered, observations made, and conclusions rendered within the tenets of sound science through application of the scientific method. Within this framework the reconstructionist must also be prepared to consider alternatives to the most probable solution or solutions and be willing to devise examinations and/or experiments to test these lesser possibilities. If one does not follow this principle, then one is not practicing the reconstruction process for the purpose for which it is intended.

CONSIDERATIONS DURING DIRECT INVESTIGATION OF THE SHOOTING INCIDENT

Getting firsthand knowledge of the shooting is most desirable. The reconstructionist should become involved in the investigation of a shooting incident scene at the earliest opportunity so that relevant issues or questions can be identified as early as possible to maximize the potential to recognize the reconstructive value of the physical evidence. This has great advantages both to the reconstructionist providing the service and to the user agency in that observations will be made within the context of the entire scene and that the significance of observations will be most fully realized by direct participation in the scene investigation.

The reconstructionist should approach the shooting scene investigation with “big picture” thinking that is not limited to the task directly in front of him or her. Information regarding the conduct of participants and incidents occurring prior to, during, and after the incident being investigated can add significant insight into the significance of potential evidence to be gathered at the scene and what experiments or testing will be conducted to resolve issues. This approach reduces “tunnel vision” when considering potential evidence encountered at the shooting incident scene. Additionally, any observations made, evidence recovered, and/or examinations conducted during this process should be sufficiently documented and supported. The work should be conducted and documented in such a manner that any interested party reviewing the work product of the reconstructionist will understand what was done and why the conclusions were reached. If they wish to repeat the work, they should reach the same conclusions.

Preinvestigative Consultation

Keeping in mind the categories of questions to be answered, a preinvestigative consultation should be conducted with investigators or officers having the greatest knowledge of the whole incident. This will allow the reconstructionist to assemble as much information as possible prior to processing the scene. Gathering information concerning the circumstances of the incident is highly desirable at this point, as it can help focus the investigation and/or alert the reconstructionist to key considerations and/or observations that may be overlooked if such inquiries are not made early on. It is important to keep in mind at this stage that personal bias, an inescapable trait inherent in all human endeavors, must be acknowledged and set aside whenever possible. Accounts provided by participants in the shooting incident, witnesses, and even explanations or hypotheses offered by investigative personnel should not be assumed as accurate or erroneous. These accounts should simply be treated as information upon which some crime scene investigation steps will be made. This practice should be applied equally throughout any information gathering conducted in later stages of the reconstructive process through the review of investigative reports, interviews, or offered by police officers, investigators, prosecutors, plaintiffs, defense attorneys, or defendant(s).

Such inquiry should include any information that can be obtained about the conduct of participants and any known events that occurred prior to the incident. Has any explanation(s) of discharge(s) by shooting participants and/or witness(s) been offered? This might include the location and/or positions of participants during the incident. Were the shooters and/or other participants stationary or moving during the incident? What was the manner in which the

participant(s) held the firearm(s)? Was the firearm held in a normal shooting position or in an awkward orientation typical of “gangland”-style shooting postures? Was the shooter standing, kneeling, or lying down when operating the firearm? What was the approximate height of the firearm during its use? Was the shooter using a barricade to support the firearm during its operation? In what way was the firearm discharged? Did the shooter first arm the firearm prior to discharging it? Were any safety mechanisms manipulated prior to or during operation of the firearm? Was the firearm fired in double action or single action? Were there any observed malfunctions or problems during use of the firearm? Was the firearm discharged by being dropped or during an observed struggle with another participant? What events occurred after the shooting incident and what was the conduct of the participants involved during this time? Answers to these types of questions serve to provide a starting point from which the reconstructionist may begin an assessment of potential physical evidence. Ultimately, this assessment may either support or refute this source of information in the always evolving process of reconstructing events at a shooting scene.

The Walk-Through

After as much information as possible is gathered concerning the circumstances of the incident, a careful walk-through of the shooting scene should be conducted with a minimal number of personnel to assess the scene, identify items of evidence, prioritize processing of the scene, and establish an overall plan. A suggested ideal number of personnel should be the investigating officer in charge of the scene (or person most familiar with the scene), the consulting forensic investigator/reconstructionist, and a photographer (to record photographically any areas that might potentially be disturbed by the walk-through process). At the conclusion of the walk-through, the investigating officer in charge and the forensic investigator/reconstructionist should establish a plan of priorities for processing the scene to address such issues as impending weather that may destroy or hamper documentation and collection of evidence, security issues with regard to high-traffic areas, the availability of daylight, and the establishment of a team(s) of investigative personnel to process the scene most effectively. If applicable, arrangements should be made for an aerial ladder truck to conduct overhead photography and/or aerial photographs to be taken at this time.

RECONSTRUCTION WITHOUT THE BENEFIT OF PERSONAL INVOLVEMENT IN THE ORIGINAL CRIME SCENE INVESTIGATION

Direct involvement in the investigation of an original shooting incident scene as outlined previously is the ideal situation for reconstructive purposes. Unfortunately, this opportunity is by far the exception rather than the rule. Often, reconstruction issues are an afterthought of the primary investigation. It is more than likely that the reconstructionist will be approached long after the fact to address such reconstructive issues. In this situation, the reconstructionist must initially rely on the information provided by others, including police officers, investigators, forensic scientists, prosecuting attorneys, and defense counsels. This information will likely be obtained through the review of crime scene reports, diagrams, photographs, investigative

reports, documented interviews, and medical/pathological reports. Information may be offered verbally in the form of theories by police officers, investigators, prosecutors, and defense attorneys. Although these offerings are made in good faith, as cautioned previously, they should be assumed as neither accurate nor erroneous. This approach should be conducted in the spirit of remaining as objective as possible, thereby minimizing the chance of any preconceived influence that could restrict the vision necessary to consider all possibilities no matter how seemingly absurd they might be. At some point during later stages of the reconstructive process when the reconstructionist has had an opportunity to evaluate these sources of information (and possibly conduct independent examinations or tests), there will be an opportunity to form one's own conclusions.

As with the initial walk-through and preinvestigative consultation conducted at a crime scene, information gathering should be obtained through verbal inquiry as well as review of written reports and other sources of documentation. Working blindly from written reports alone, in the author's experience, will often limit the effectiveness of the reconstructionist. The author therefore spends much time on the phone consulting with key investigators and/or the assigned prosecuting attorney and/or defense attorney to supplement information gathered from these written records in an effort to obtain a clearer overall picture of the case. To this end, some excellent questions along the following theme, as suggested by [Haag and Haag \(2004\)](#), should be asked in the early stages of the reconstructive process:

- Tell me about this case. What are the issues?
- What do you believe happened?
- What do any witnesses to the incident say happened?
- Did the shooter provide an explanation?
- What is and what is not in dispute in this case?
- What are the competing hypotheses (theories)?
- What does the autopsy report or medical records (if there was a gunshot wound without a fatality) reveal?
- What other evidence has been collected beyond that which has been submitted to the laboratory?

These types of questions serve to identify key issues in the case and thereby increase the potential for recognizing the significance of any physical evidence that might be available for evaluation and can be used to cross-check other sources of investigative information.

The following discussions in this chapter outline in more detail physical evidence considerations to introduce various specific shooting incident or firearm-related phenomena that offer reconstructive information, integrated with other forms of physical evidence, and other sources of investigative information that are encompassed within the reconstructive process.

FIREARMS AND SHOOTING INCIDENT RECONSTRUCTION

Proper documentation of the condition of firearms recovered at the scene is critical to the shooting incident investigator. Subtle but important observations concerning the condition of the firearm and its use during the incident are easily lost forever if a thoughtless approach to the examination is conducted at the scene. Failure to make such observations may make the

difference in being able to distinguish a homicide from a suicide, offensive versus defensive postures of shooting participants, potential mechanical problems or malfunctions of the firearm, evidence that might support an intentional versus unintentional discharge of the firearm, or whether the scene was staged. Careful visual examination of firearms should be made, followed by contextual photos. Only then may the firearm be handled. Close-up photography is then necessary to document significant observations.

Considerations regarding the firearm at the scene (within practical limits) and during laboratory examination follow.

Preliminary Considerations

Any knowledge concerning the history of the firearm prior to and after the incident may provide relevant context during direct examination of the firearm at the scene and/or submitted for examination at the forensic laboratory. Such considerations should include how the firearm was normally stored and in what condition it was prior to the incident. For example, was the firearm cleaned and oiled previously or was it in dirty or rusty condition? Was a loaded magazine kept in the gun or stored separately? How was the gun loaded or typically prepared for use? What was the specific manufacturer(s) of ammunition used in the firearm (that is, bullet type, weight)? What was the source of this ammunition and is it available for examination?

Location and Position of the Firearm

The location and the position of the firearm in the scene and its relationship to other items of evidence should be considered and documented carefully during the first stages of the investigation. Observations relative to the location and position of decedents in suicides, accidental deaths, and suspicious deaths may be especially critical to the successful resolution of investigations. Subtle but important observations that can mean the difference between a genuine suicide and the detection of a staged homicide, for example, can be missed irretrievably if proper attention is not paid to these considerations. Preparation of shooting scene diagrams supplemented with appropriate orientation photographs is paramount to recording observations. Further, these are of great value in resolving questions or issues that may be developed well after the immediate crime scene investigation is completed.

Trace Evidence Considerations

Trace evidence, being typically fragile and susceptible to change or loss during handling of the firearm, should be considered and documented prior to or as soon as it is practical during the examination of the firearm at the scene or, if not practical, documented and preserved on the firearm in such a manner that these materials may be collected during laboratory examination at a later time. Hair, blood, and tissue may be encountered on both exterior and interior surfaces of the firearm. The presence of this material not only provides potential associative evidence with the source of such material, but may also provide valuable information concerning the distance from the victim that the firearm was fired. This is most notable in contact, near-contact, and other close range shooting circumstances or in situations where there is a struggle over control of

a firearm. Interpretations of the patterns of these materials are often of greater importance than their mere presence alone. For example, high-velocity impact blood spatter patterns commonly associated with gunshots on the exterior of a firearm suggest a close range shot (Figure 13.1). Additionally, microdroplets of blood observed inside the muzzle of the barrel are indicative of contact or near-contact range shots. Transfer stains such as swiped, wiped, or specific patterns resembling the surface from which blood has originated can be indicative of how a firearm may have been handled during or after bloodshed has occurred.

The presence of finger-and palm prints may also be encountered on external and internal surfaces of the firearm. This form of trace evidence also plays a dual role in the reconstructive process from an associative standpoint to the source of such evidence as well as the orientation of such prints on the firearm (Figure 13.2) in regard to how it may have been handled by the shooter and/or other participants of a shooting incident. For example, the presence of a palm print around the grip of a handgun may suggest the identity of the operator of the firearm, whereas the presence of fingerprints of the decedent oriented backward on the barrel of the firearm may support statements by the shooter of the firearm that the decedent grabbed the gun during a struggle.

Gunpowder particles and residues encountered on the interior surfaces of the barrel, the chamber, and the breech suggest that the firearm has been fired since last cleaned and may provide information concerning the manufacture of the ammunition used during the incident. The presence of smoke halos around the forward surfaces of the chambers of a revolver cylinder may provide valuable information about the number and sequence of shots fired from such weapons.

The existence of fibers on a firearm can provide evidence of the location where it was stored prior to the incident, such as the pockets of a particular garment worn only by one of several individuals suspected of involvement in a shooting incident. Bits of fabric caught on the tang of a hammer may support statements that the firearm became caught on such material during a struggle, causing the hammer to be inadvertently cocked without the operator's knowledge. The presence of lint in the bore of the firearm may support statements that it was not fired at all during the incident (Figures 13.3 and 13.4). Metal deposits in the bore may provide valuable



FIGURE 13.1 High-velocity blood spatter documented on the face of the muzzle and along the sides of the barrel of this firearm provided significant support that the gun was in close vicinity to the decedent at the time the fatal shot was fired.

FIGURE 13.2 The location of this thumbprint on the back of the slide of this pistol is significant in that it is in the vicinity of the expected position for pulling back the slide to arm the weapon or possibly to operate the safety lever just below it.



FIGURE 13.3 The presence of lint inside the barrel bore, as well as inside all the chambers of the cylinder of this revolver recovered at a shooting scene, provides strong evidence that it was not discharged during the incident.



clues about the composition of the bullet or bullets. The presence and nature of primer lacquer debris adhering to the internal surfaces of the breech may provide helpful information concerning the design of the cartridge case or cases fired in it.

The presence of materials such as paint, sheetrock, concrete, asphalt, grass debris, or soil and their location on the firearm may shed light on the type of surface or surfaces that a firearm may have come into contact with as a result of situations where the firearm has been dropped or subjected to a hard impact of some kind. Any significant observations made should be recorded with close-up and orientation photographs prior to the collection of samples.

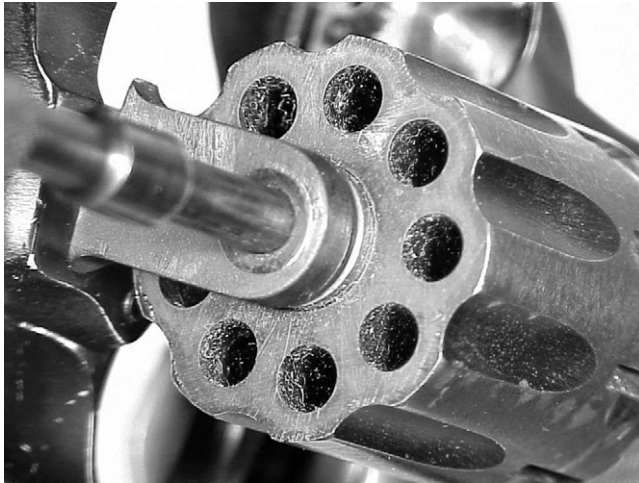


FIGURE 13.4 The presence of lint inside the barrel bore, as well as inside all the chambers of the cylinder of this revolver recovered at a shooting scene, provides strong evidence that it was not discharged during the incident.

Condition and Configuration of the Firearm

Careful observation concerning the condition and configuration of the firearm also plays an important role in the potential discovery of significant clues that could shed light on the circumstances of a shooting incident. These observations should be noted and documented with photographs during the course of the examination of the firearm at the scene, within the limits of a field examination, and during more detailed examinations that can be conducted in the laboratory.

The examination should include an overall assessment of the exterior condition of the firearm. This should include an inspection of the firearm for signs of damage; broken, bent, or missing parts; or evidence of mistreatment that could affect the function of the firearm. An appraisal of any modifications to the firearm such as obliterated serial numbers or a sawn-off barrel or stock should be made. Signs of rust or corrosion of the finish, and most significantly, on any parts that could affect the function of the firearm should be noted. For example, corrosion between the frame of the firearm with the hammer and/or trigger can potentially influence the force necessary to pull the trigger. Modifications to internal parts of the firearm (typically observed during laboratory examination) may also play a significant role in resolving questions that arise in shooting incidents.

The configuration of the firearm should be carefully assessed, photographed, and documented prior to manipulating the action or moving any of its parts, or prior to touching it at all (Figure 13.5). For example, the position of any externally set safety mechanisms or decocking levers should be noted. Additionally, the position of the hammer (cocked, half-cocked, uncocked), when present, should be documented. Load indicators present on some firearms that alert the operator of a cartridge in the chamber should be noted. The position of the slide or bolt on repeating arms should be checked. The orientation of the cylinder should be indexed with respect to the frame of revolvers prior to disengaging or removing it from the firearm. Failure to do so will result in loss of the position and sequence of any cartridges fired and/or unfired in the chambers of the cylinder or the position and sequence of tell-tale smoke halos around chambers from which fired cartridge cases have been removed.



FIGURE 13.5 Close-up photography displaying the condition of this pistol adequately documents its condition prior to handling it. The hammer is cocked, the safety is off, and the magazine is still in the pistol.

A mark with an indelible marker on the cylinder next to the frame will allow the examiner to replace the cylinder in the proper position.

The manner in which the firearm is loaded should also be documented. An inventory of any unfired cartridges in the magazine, their manufacturer, description, and order of loading in firearms so equipped should be conducted as well as whether the magazine is inserted properly into the firearm or separate from it. The presence/absence of an unfired cartridge or fired cartridge case in the chamber should be noted as well. Additionally, signs of malfunction of the firearm such as a fired cartridge case caught in the breech of repeating arms may also provide significant evidence relative to the circumstances of the case (Figures 13.6 and 13.7). The position and sequence of any fired cartridges, unfired cartridges, or empty chambers in the cylinders of revolvers should then be described as well as the direction of the cylinder rotation (Figures 13.8 and 13.9). These observations can provide subtle but significant clues, for example, in the investigation of suspicious deaths and suicides as to whether a revolver cylinder has been manipulated after last having been fired or support evidence of postshooting activity by participants of a shooting incident.

*Editor's
Note*

EXAMINATION OF AMMUNITION

Much can be said concerning the general forensic examination of ammunition components fired from rifled firearms in terms of (1) determining the specific caliber and manufacturer of fired bullets and cartridge cases through study of their endless variety of manufacturing features; (2) generating lists of manufacturers and models of candidate firearms that could be responsible for firing bullets and cartridge cases by classifying rifling impressions appearing on the sides of fired bullets, and/or cycle-of-fire markings imparted on various locations of the cartridge case resulting from their interaction with various internal parts of firearm mechanisms;



FIGURE 13.6 This photo, taken by investigating patrolmen, depicts a semiautomatic pistol recovered from under a bed mattress that was later identified as having fired bullets recovered during the attempted homicide of a police officer. Note that the slide “appears” to be in a rear-locked position.



FIGURE 13.7 This close-up photo, taken by an astute police officer, documents a jammed cartridge in the chamber of the pistol. This key form of documentation corroborated statements made by witnesses that the suspect pointed the gun at police officers but failed to fire the gun.

and (3) comparing individualistic tool marks imparted on fired bullets and cartridge cases for the purpose of identifying a specific firearm that fired them when such guns are available for examination. This type of information is by far the most commonly requested form of investigative lead provided by the forensic science laboratory and addresses the most obvious of reconstructive questions. Unfortunately, it is the author's experience that the majority of requests for information stop at this level and few questions are asked concerning the interaction of the fired projectile or the ejected cartridge case with the scene or the firearm itself. This lack of awareness and/or interest inadvertently denies the requesting party the potential for attaching additional significance to this category of physical evidence in resolving questions about specific events that have occurred within a shooting scene.

If the reconstructionist is involved in the initial investigation of a shooting scene, a conscious effort to visually note the appearance of projectiles recovered should be made prior to collection

FIGURE 13.8 Documenting the contents as well as the position of each chamber in a revolver cylinder can make the difference between determining a homicide versus a suicide. Note the firing pin impression clearly depicted in the primer of the cartridge case at the 11 o'clock position. The remaining chambers contain unfired cartridges with no firing pin impressions.



FIGURE 13.9 The presence of a powder halo or flare around the forward surface of the chamber containing an expended cartridge case provides further evidence that only one shot was fired from this revolver.



and packaging. Such observations made during the course of the investigation by the astute investigator, such as (1) the presence of trace evidence on the projectile, (2) damage to the projectile surface, and (3) overall deformation of the projectile, can offer valuable information about the surfaces the projectile may have come into contact with and the manner in which the projectile interacted with that surface during the incident. These observations in turn may provide immediate clues to assist the investigator in reconstructing the paths of projectiles that have traveled within the scene. If these observations are possible during the initial investigation of the scene, they can provide significant insight into the manner in which projectiles traveled during the incident being investigated and can lead to more thorough and complete documentation. However, such observations may not be practical at the scene and should be left to the examiner in the laboratory who is better equipped for conducting more sophisticated visual examinations with

the assistance of microscopes and relying on appropriate instrumentation and analysis to assist in characterizing trace materials. This information can be integrated with other information initially gathered at the scene by the reconstructionist when it becomes available.

Trace Evidence Considerations

When two things come into contact with one another, there is a propensity for an exchange of materials between the surfaces of those items. This mutual exchange, known as Locard's principle, has great potential to provide witness to the identity of surfaces that an object has come into contact with and is often applied to the examination of fired components recovered from shooting incidents with great effect. For example, the presence of red paint on the edge of a fired cartridge case mouth might suggest that it has come into contact with the only red painted surface located in a shooting scene. This information, in combination with knowledge of the firearm from which it was fired and the firearm's ejection pattern characteristics, could assist in approximating the location of the operator of the firearm at the moment the questioned cartridge case was ejected. Another example is the presence of powdered glass embedded in a fired bullet recovered from a decedent that might be confidently associated with the only bullet hole in a plate glass window among numerous bullet holes present in other items at the scene. This information could potentially shed light on the direction from which the fatal bullet was fired. Some common trace evidence materials often encountered with fired bullets are sheetrock/wallboard, glass, soil, asphalt, wood and plant material, bone fragments, tissue, blood, hair fragments (see [Figure 13.10](#)), paint, plastic, rubber, and fibers.

The order of the layers of trace materials adhering to a fired bullet, as well as their location, is indicative of the sequence of intermediary objects or surfaces it struck, passed through, or penetrated during its flight ([Figure 13.11](#)). For example, a bullet exhibiting fabric material preceding a layer of wood fibers over a layer of wallboard material above a layer of blue paint might suggest that the projectile has passed through a blue painted wall and then through a fabric surface of some kind such as a furniture item or possibly a clothing item worn by a wounded participant



FIGURE 13.10 The bullet depicted in this photograph was recovered from the ground in the vicinity of a decedent who had been shot to death. One of the wound tracks was through a wound to the head. Results of DNA analysis of the tissue and comparison of hair on this bullet involved in this multiple victim/participant shooting incident revealed that it had not struck the decedent but, rather, had passed through a surviving shooting victim.

FIGURE 13.11 The fabric impression in the wood fibers adhering to this bullet could provide conclusive evidence that it passed through a hollow-core door before impacting the Kevlar fibers of a bullet-proof vest worn by a police officer involved in a shooting incident.

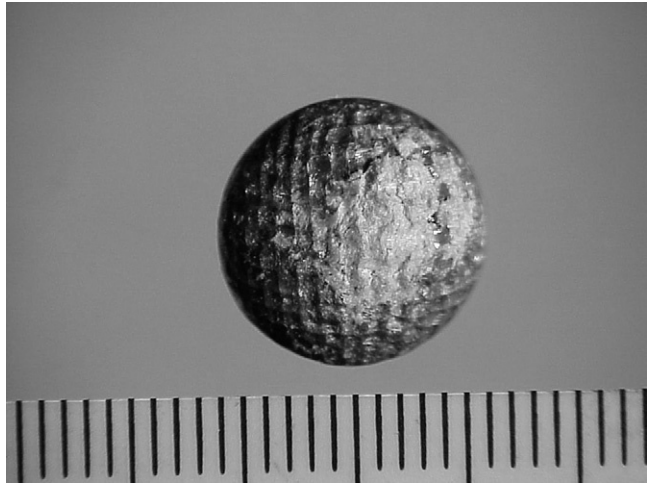
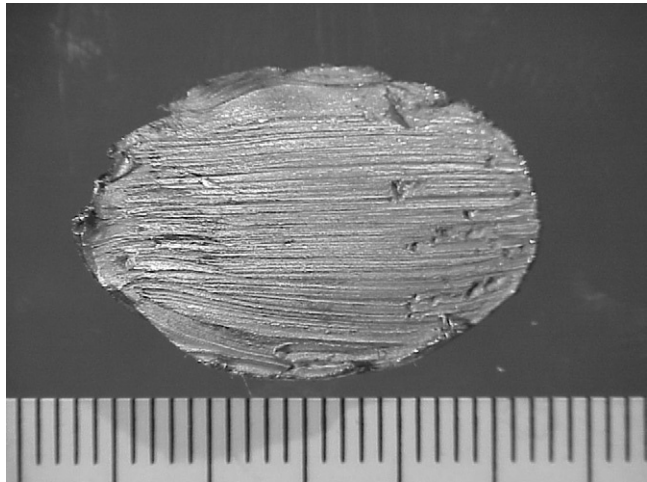


FIGURE 13.12 The surface appearance of this lead bullet suggests that it struck a rough textured surface (concrete) at a shallow angle (20 degrees). Analysis of microscopic particles embedded in inclusions among the scoring marks may reveal the identity of the surface struck.



involved in the incident being investigated. Given a closed set of items struck in a shooting scene, such a projectile may be conclusively associated with a particular bullet path to the exclusion of all other bullet trajectories at the scene through a process of elimination.

Even in the absence of materials that are readily observed with the unaided eye, laboratory examination of fired bullets, cartridge cases, and other ammunition components in the laboratory can reveal the presence of materials that can provide important clues about the nature of material(s) that these items have come into contact with at a crime scene. Such laboratory analysis as stereomicroscopy, infrared photography, polarized light microscopy, scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis, infrared spectroscopy, chemical tests, and serology are commonly employed to characterize such materials. This information can provide investigative clues contributing to a more thorough reconstruction of events ([Rathman and Ryland, 1987](#)). For example, the detection of microscopic pieces of material such as minerals

common in soil embedded in the surface of a fired bullet might suggest contact with such a surface, and the manner in which it is embedded in the surface of the bullet may indicate the direction of impact with that surface relative to the flight path of the bullet (Figure 13.12).

In cases where projectiles have passed through or deflected off intermediary targets, the acquisition of reference samples from those surfaces is desirable to confirm the identity of materials that have transferred onto the projectile(s). Having a general sampling of common surfaces in a shooting scene to establish a baseline of the shooting scene environment should be considered regardless of whether it is known at the time if intermediary targets are involved. These would include samples of such common materials as carpet, wallboard, upholstery, curtains, paint, metals, asphalt, concrete, tile, cinder block, and so on. Any observations made by examiners at the laboratory at some later time in regard to trace evidence from intermediary targets may raise the question of the source of the intermediary target that produced the trace material on the projectile. Typically, by the time these laboratory observations are made it is too late to return to the scene to recover reference samples for comparison.

Bullet Surface Damage Considerations

Locard's exchange principle can be extended beyond the transfer of trace evidence such that when two objects come into contact with one another they may also damage or deform one another. Haag and Haag (2004) have suggested four basic substrate categories useful in considering the potential for reconstructive information from impact surfaces that include (1) unyielding surfaces such as concrete, stone tile, or steel plate; (2) yielding/malleable surfaces (that can be further subdivided into homogeneous and nonhomogeneous in their composition) such as sand, sod, asphalt, wood, sheet metal, or sheetrock; (3) frangible, yielding surfaces (that can be further subdivided into homogeneous and nonhomogeneous in their composition, such as cinder block, bricks, or concrete); and (4) liquid surfaces (a special case of a homogeneous, yielding surface).

The appearance of surface damage to fired projectiles can add valuable indicators of the type of surface(s) struck during the bullet's flight and often supports any trace evidence embedded in or adhering to the bullet's surface (Rathman, 1987). It is recommended that the examiner be familiar with the morphology of surface damage to various types of bullets that have struck common materials. Conducting empirical studies in controlled conditions with such materials and/or studying the empirical work reported in the literature will go a long way toward accomplishing this.

Generally speaking, the relative texture of hard materials such as rough concrete, asphalt, steel plate, and linoleum will impart their texture to the bullet surface. For example, a bullet deflecting off rough concrete will likely exhibit a rough striated textured surface where it has contacted this material, whereas a bullet deflecting off a smooth steel plate will likely exhibit a relatively smooth textured surface within the area of contact (Figure 13.13). A bullet deflecting off a soft forgiving material such as soil, sand, or sod can exhibit scoring marks in a configuration resembling bow wave-like patterns similar in appearance to the waves passing around the bow of a boat termed by Haag and Haag (2004, p. 48) as the **bow effect** (Figure 13.14).

Tempered glass is a relatively hard smooth surface. A bullet striking an intact tempered glass window at an angle will likely exhibit a smooth flat impact damage area oriented at an angle roughly the same as the impact angle of the bullet. When the first bullet passing through it

FIGURE 13.13 The surface appearance of this lead bullet suggests that it struck a smooth surface (linoleum floor) at a shallow angle (10 degrees).



FIGURE 13.14 The bow wave-like pattern of scoring marks exhibited on this lead bullet is indicative of deflection off of soft yielding material, such as sand or soil. This bullet deflected off of dry loose sand at an incident angle of 10 degrees. Note the granules of sand embedded in the bullet, which could potentially be further characterized using SEM-EDX analysis.



fractures the tempered glass, the internal stresses built into the glass will fracture into numerous small irregularly shaped cubicle sections. The window will often remain intact while in this condition. A subsequent bullet fired into the now previously fractured tempered glass window typically exhibits an irregularly shaped impact damaged area containing a faceted appearance resembling the irregular texture of the irregularly shaped prefractured glass surface. This knowledge can provide the reconstructionist with the order of two bullets striking the same window (Figures 13.15 and 13.16). More concerning tempered glass as a potential impact surface will be discussed in a later section of this chapter.

Bullets passing through or impacting in a direction orthogonal (perpendicular) to certain materials with little or no lateral movement may sometimes have the texture of the impacting surface imparted on the bullet in the form of an impression (Figure 13.11). For example, a bullet passing through a metal screen door may exhibit an impression of the metal screen pattern.



FIGURE 13.15 Radial fractures surrounding the bullet hole in the center of this tempered glass automobile window indicate damage from the first bullet that passed through it. The two remaining bullet holes exhibiting an absence of radial fractures and surrounded by classic cube/rectangular-shaped fractures were subsequently produced. However, it is not possible to sequence them further due to the dynamics of tempered glass fracture behavior.

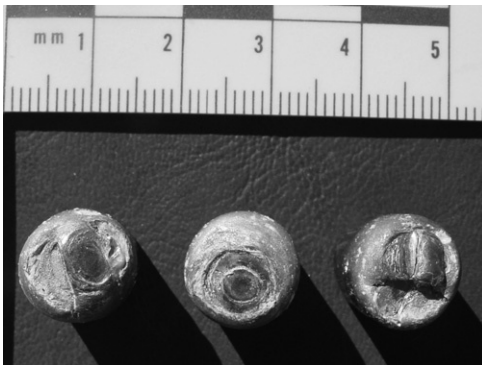


FIGURE 13.16 The three bullets producing the holes in the tempered glass window in [Figure 13.15](#) exhibit damage revealing the identity of the first bullet to strike the window. The bullet in the center exhibits powdered glass embedded in the jacket surface and deformation indicating that it has struck a smooth, hard surface of the unbroken window. The bullets to each side struck the window subsequent to the first bullet because they exhibit powdered glass embedded in very irregular faceted contours resulting from impact with the prefractured cubicle-shaped glass surface.

The weave pattern of fabric on clothing items, fabric awnings, and bullet proof vests can be imparted as an impression on the bullet that strikes these materials. This author has also observed the impressed patterns of textured plastics in automobiles imprinted on the surface of bullets.

Bullet Deformation Considerations

The type and extent of bullet deformation is the third major consideration that contributes to gathering information about the manner in which a projectile has interacted with materials it has struck. Bullet deformation can provide an indication of impact angle, most notably with hard unyielding surfaces such as steel, concrete, and tempered glass. Generally speaking, when a stable bullet strikes a hard unyielding surface at an angle it will deform in a manner such that the displacement of the bullet material will roughly mimic the angle separating the axis of the bullet and the plane of the impacting surface. This angle of deformation can be measured with simple angle measuring tools to estimate the impact angle ([Figure 13.17](#)).

FIGURE 13.17 Deformation of this full metal jacketed bullet is an indicator that it struck a solid surface at an angle (30 degrees). An estimate of the impact angle can be made by measuring the angle of deformation relative to the long axis of the bullet.



As bullets yaw, or rotate off center, this angle determination will only be an estimate. If a bullet is tumbling, the angle is unrelated to the long axis of the bullet.

The amount of deformation, given the same material and impact angle, is dependent on impact velocity. Impact velocity is related to the distance the bullet has traveled. This relationship is especially useful in estimating distances of bullet travel in long-range shooting incidents and is discussed in a subsequent section of this chapter.

Armed with knowledge acquired from the aforementioned three considerations, the reconstructionist may be in a position to identify the types of materials and the manner in which a bullet has come into contact with those materials during its travel. In a closed set of possibilities (which is often the case in a shooting incident), it is possible to identify specific objects that a bullet has struck using a process of elimination. This is useful in estimating the direction from which a bullet has traveled in cases where information about the position of the shooter is not known. It may lead to the successful detection of bullet holes or bullet impact points not discovered previously or it could ultimately lead to an estimate of shooter position, especially when correlated with other converging clues, such as the location of fired cartridge casings, gunshot residue patterns, or footwear impressions.

Editors' Note

PROJECTILE HOLES, IMPACT SITES, AND RICOCHETS

Visual Examinations with the Unaided Eye

As discussed previously, the appearance of surface damage to fired projectiles can add valuable indicators of the type of surface(s) struck during the flight of a bullet. Conversely, the appearance of the impact site by a bullet can provide clues about the composition of the projectile that struck a particular surface, the angle of impact, and the direction from which it was traveling when it struck that surface. Methodical examination of the shooting scene should be conducted to detect the presence of projectile holes, impact sites, and ricochets. Detection of defects is

typically accomplished through recognition of their characteristic appearance supplemented with chemical tests (to be discussed in the following section).

Distinguishing projectile holes and defects from nonfirearm-related anomalies can be a difficult task in certain cases. It is recommended that the examiner be familiar with the morphology of projectile entry and exit holes, impact sites, and ricochet sites in a variety of common materials such as sheetrock, wood, rubber, plastic, sheet metal, plate glass, tempered glass, laminated windshield glass, sand, soil, sod, concrete, and asphalt. A study of common defects produced by nails, screws, bolts, screwdrivers, drills, and other common household items is recommended to develop the expertise of the examiner. A study of dents and grazing damage from common household items such as hammers should also be conducted to build confidence in distinguishing these types of defects from projectile ricochets and impact sites.

The examiner should also be familiar with the following terms in regard to bullet impact behavior:

Perforate: when a bullet passes all the way through an object

Penetrate: when a bullet enters and remains in an object it strikes

Deflect: a change in the direction of the bullet path by means of penetration or perforation of an object.

Ricochet: a change in the direction of the bullet path by means of impact with an object.

Fragment: when a bullet breaks up into smaller portions (typically resulting from impact with an object).

Primary impact: the location where a bullet first comes into contact with an object during its flight path.

Secondary/tertiary/etc. impact: second, third, etc. location(s) where a bullet comes into contact with objects during its flight

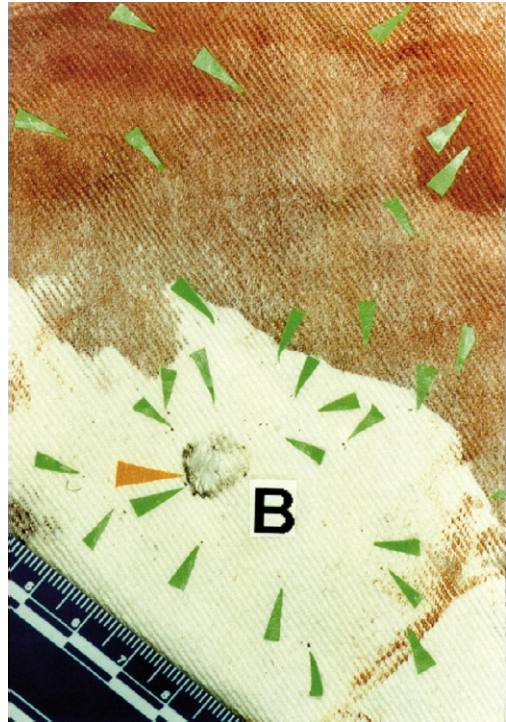
Terminal point: location where the bullet comes to final rest

Chemical Tests to Assist in Visualization and Characterization of Bullet Impact Defects

Some of the most common materials used to manufacture bullets are lead, copper, aluminum, and copper–zinc alloys. Additionally, when a bullet is fired, it is covered with a thin layer of gunshot residue materials composed of dark organic carbonaceous by-products of burned gunpowder (nitrocellulose in modern-day gunpowder) and consumed primer constituents (barium, antimony, lead, and other inorganic compounds). When determining if damaged areas are caused by bullet impact, Locard's exchange principle once again plays a significant role. When the bullet strikes an object, traces of the residues adhering to it, as well as the relatively soft metals that make up the bullet itself, are typically transferred to the margins of the hole created when such an object is perforated or penetrated. The material deposited around the margins of the hole appears as a dark-colored ring referred to as a **bullet wipe** (Figure 13.18). These same materials can be transferred (deposited) within the boundaries of defects on impacted surfaces caused by bullet impact or deflection (ricochet).

A number of field tests to detect metals commonly associated with projectiles (such as lead and copper) can be applied to suspected projectile defects to corroborate the visual identification of a suspected projectile hole, impact site, or ricochet. The most common of these tests are the

FIGURE 13.18 The bullet entry hole displaying classic “bullet wipe” favoring the left edge of the defect is depicted in the material of a pair of light-colored pants. Green arrows indicate the locations of gunpowder particles. The orange arrow indicates the location of a microscopic fragment of copper. These observations suggest that a copper jacketed bullet struck the garment at an angle from left to right fired from a gun at a distance of approximately 1 or 2 feet.



sodium rhodizonate reagent for the presence of lead and the dithiooximide (DTO) reagent for the presence of copper. Lead in the presence of sodium rhodizonate forms a brilliant reddish-purple color (Dillon, 1990a). A color change from reddish-purple to blue with the addition of dilute hydrochloric acid increases the specificity of this test for the presence of lead (Figure 13.19). Copper in the presence of DTO forms a mossy green color (Haag, 1989). These tests serve a dual purpose in that a positive color reaction indicates the presence of lead and/or copper as well as the distribution of these materials within or around the suspected defect. The reagents can be applied directly with sprayers in cases where the surface in question is a light color and absorbent, such as an unpainted wood surface containing a questionable bullet hole or graze mark.¹ An alternative lifting method can be employed for dark-colored surfaces, items that are not transportable, nonporous, and/or remotely located or difficult to reach. The lifts can also be retained for instrumental analysis (Haag and Haag, 2004).

Filter paper moistened with a 50% white vinegar solution in contact with the surface for 10 minutes will lift the lead pattern. A second paper moistened with 20% household ammonia solution in contact with the area for 10 minutes will lift the copper pattern. These papers are dried, covered with other sheets of filter paper, and transported to the laboratory

*Editor's
Note*

¹ These tests should only be performed by laboratory personnel because of the hazards associated with the chemicals.

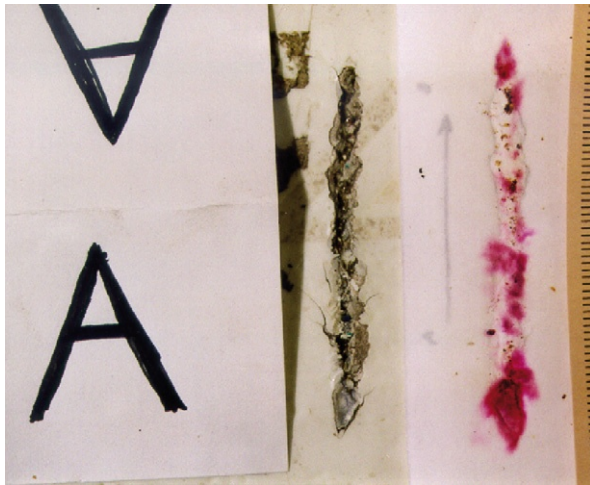


FIGURE 13.19 This gouge in a linoleum floor is actually a bullet ricochet site. Note the strong rosy-red color reaction associated with the presence of lead (a common constituent of bullets) along the margins of the defect as represented by the filter paper transfer treated with sodium rhodizonate reagent. This reagent can be useful in the field for detecting obscure defects that might not be recognized as damage caused by bullet impact.

These tests are fairly simple to perform, sensitive, and useful for determining whether an otherwise obscure defect may be associated with the impact of a projectile. Moreover, the presence of lead and/or copper in the immediate vicinity of a defect that resembles a classic bullet hole or impact site adds significant weight to the examiner's confidence that he or she is indeed dealing with a bullet hole or impact site. Additionally, the presence of lead only versus the presence of lead and copper or copper only in the margins of a bullet hole can also be useful in distinguishing between nonjacketed lead bullets and copper jacketed or coated bullets that have struck a questioned surface. Such knowledge is useful to the reconstructionist, for example, in including or excluding participants in a shooting incident if the type of ammunition each shooter was using can be established.

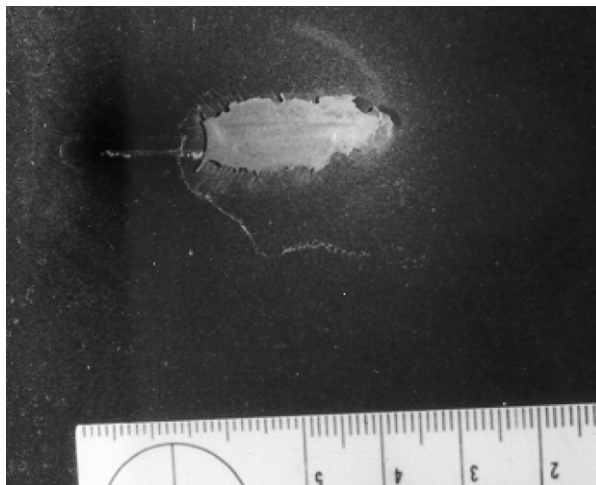
There may be occasions where the proximity of the muzzle of a suspected firearm is in close vicinity to a projectile defect on a questioned surface. It is in these cases where the deposit of gunshot residues expelled from the muzzle of the responsible firearm becomes a possibility. Although it is most desirable to collect the item suspected of containing gunshot residue for transport to a laboratory facility where tests for such materials can be performed in more desirable conditions (clothing items in particular), there may be occasions where this is not possible. Prior to any chemical testing, complete documentation of the defect or pattern using measurements, drawings, and photographs with scales should be performed. The Griess reagent in the presence of nitrites (commonly associated with consumed modern-day gunpowder) forms a bright orange color reaction (Dillon, 1990b). The Griess reagent is facilitated by using a lifting technique on questioned areas in the field. The resultant pattern developed using this reagent should be carefully documented and photographed with scales for potential comparison to test patterns produced by candidate firearms that may be recovered to estimate muzzle distance as well as orientation to a questioned target surface. Muzzle-to-target considerations are discussed more in depth later.

Tape Lifting Bullet Holes and Other Defects

Tape lifts and preprepared adhesive discs applied to bullet holes and impact sites prior to performing the previously described field chemical tests are simple and effective ways to collect such materials for follow-up instrumental analysis such as SEM-EDX analysis. Such instrumental analysis is more sensitive in the detection of common bullet constituents such as lead and copper, in addition to being able to detect other metals that can be indicative of bullet construction such as nickel, aluminum, steel, and molybdenum as well as constituents of the primer material in cartridges associated with the fired bullet. Microinfrared analysis can also be employed on such samples for characterizing organic materials associated with bullet strikes, such as lubricants, and burned/unburned gunpowder residues/particles transferred from the surface of the projectile to the object.

Tape lifts can also serve to supplement photographic documentation of bullet holes and defects. They are often effective in recording surface disturbance characteristics exhibited by such defects that can be used to determine bullet direction of travel, angle of impact and/or deflection, and angle of penetration or perforation. After all of the appropriate photographs, measurements, drawings, and samples have been collected for the chemical tests, this method can be used to record additional surface disturbance characteristics that might not be sufficiently recorded in photographs. For example, telltale “boat-wave” fracture patterns in painted metal surfaces such as automobiles associated with bullet ricochets are indicative of bullet path direction (Mitosinka, 1971). These patterns can be visualized very effectively by applying fingerprint powder to the defect area. The developed pattern is then transferred using a tape lift to a latent print card as a permanent record (Figures 13.20–13.22). Similarly, applying fingerprint powder to bullet holes and defects in general can be employed using the same technique to supplement photographic documentation.

FIGURE 13.20 The author was requested to examine a possible bullet ricochet site on the roof of a passenger car reportedly involved in a gang-related shooting incident. The two occupants of the vehicle stated that they had been fired upon from occupants of another vehicle as the vehicles were passing each other in opposite directions. The occupants further stated that the shooting was unprovoked. Officers were suspicious of the truthfulness of the statement and were interested in what could be determined about the direction of bullet travel that caused the damage to the roof of the car. The defect indeed resembled a classic ricochet site and furthermore gave positive sodium rhodizonate and DTO tests for the presence of lead and copper, respectively, suggesting that the damage had been caused by a grazing strike from a copper jacketed bullet.



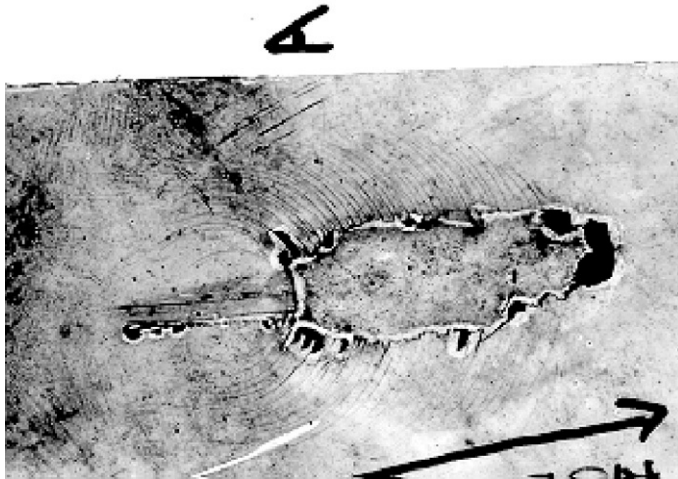


FIGURE 13.21 The defect area was treated with fingerprint powder and tape lifted to record the overall morphology that included characteristic boat-wave fractures in the surrounding paint. Characteristics of the defect indicated that the bullet struck the roof of the car at a very low incident angle while traveling from passenger side to driver side.

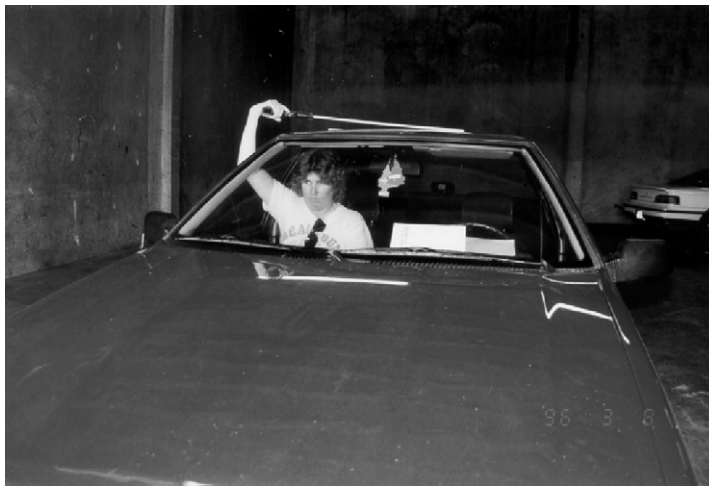


FIGURE 13.22 These observations did not support the statements offered by the occupants of the vehicle. Furthermore, it was demonstrated, as recorded in this photo, that evidence supported a more likely scenario that the passenger in the front seat had fired a shot directed toward the driver side of the vehicle with his arm extending from the passenger side window. While doing this, he inadvertently struck his own vehicle during the incident.

Casting Bullet Holes and Other Defects

Photographs are limited to two dimensions. Casting bullet defects have the added advantage of registering their three-dimensional contour. Displacement of the impacted surface (most notably in malleable materials such as sheet metal) can be permanently recorded and subsequently measured. These data are useful in estimating such parameters as bullet velocity and impact angle by comparing measurable displacement with defects in similar materials produced under controlled test conditions. Mikrosil casting material is a reliable product for recording the three-dimensional detail of such defects for further examination on most surfaces. It is also an excellent product for recording the finest details on the surface of such impacted surfaces. Casts can then

be examined in the laboratory to more critically determine bullet incident and deflective angles with appropriate experimentation if the need arises. Additionally, in situations where an identified bullet hole, impact site, or ricochet is located on an item that is not practical to collect, these recording techniques, in conjunction with photography and the aforementioned chemical tests, are the next best alternative for follow-up examinations at the laboratory. In certain instances, it is possible to associate recovered projectiles with ricochet sites by comparing impressed and striated tool marks produced on either item resulting from one surface marking the other. There are documented accounts where this has been accomplished by comparing the markings appearing on casts of bullet impact ricochet sites to the surfaces of recovered bullets (Patty et al., 1975).

DETERMINING THE DIRECTION OF PROJECTILE TRAVEL AND ANGLE OF IMPACT BY EXAMINATION OF BULLET HOLES, IMPACT SITES, AND RICOCHETS

Once a defect is identified as a projectile hole, impact site, or ricochet, information about the manner that the projectile interacted with the impacted item should be made. Considerations such as the determination of projectile hole or impact site, such as entrance versus exit, entrance angle versus exit angle, and direction of travel, will provide useful information about reconstruction issues during the course of a shooting investigation while at the scene and for resolving issues that may develop as the investigation continues long after the scene has been processed. For example, determining the approximate direction and angle of impact in which a bullet struck an object while at the scene may provide immediate clues to assist the investigator in reconstructing the paths of projectiles that have traveled within the scene. This information may serve to identify the presence of other bullet impact sites associated with the bullets' travel through a scene and assist greatly in determining from which direction a bullet was fired or directed toward. This information, given a closed set of participants involved in a shooting incident, may serve to include or exclude certain shooters involved when corroborated with other sources of investigative information. This information may also serve to eliminate or include certain areas or locations from which a shooter could have discharged a firearm.

The dynamics of bullet interaction with various materials and the morphology of holes, impact sites, and ricochet sites exhibited by the material surfaces struck are predictable. For example, it is a general rule that the deflecting angle of a projectile striking a hard unyielding surface such as concrete or plate steel will be significantly lower than its incident angle (Rathman, 1987). Additionally, the deflecting angle of a projectile striking a yielding surface such as sand (Haag, 1996) or water (Haag, 1979) is higher than the incident angle. Another phenomenon observed in low-angle impacts with sand is that departing bullets demonstrate consistent left or right deflection in accordance with the twist direction of the responsible firearm (Haag, 1979). Similarly, the morphology of defects created by striking bullets is characteristic for various materials and can be useful for providing reconstructive information. For example, bullets striking a surface such as a painted car door (or other painted sheet metal surfaces) at a nonorthogonal angle will characteristically create an oval-shaped hole. Bullets (and spheres in the case of shotgun pellets and buckshot) have a circular component in their shape. The profile of this shape when projected over a flat surface at a given angle has a trigonometric relationship such that an estimation of

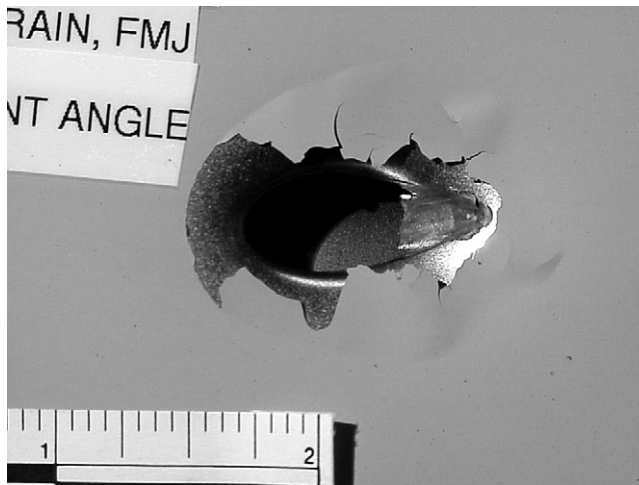


FIGURE 13.23 The oblong shape of this bullet entry hole indicates that the bullet passed through this painted sheet metal in a nonorthogonal direction. Measurement of the width and length of an oval that approximates the contours of this hole and use of trigonometry can be used to estimate impact angle. This bullet impacted the surface at 30 degrees, traveling from right to left.

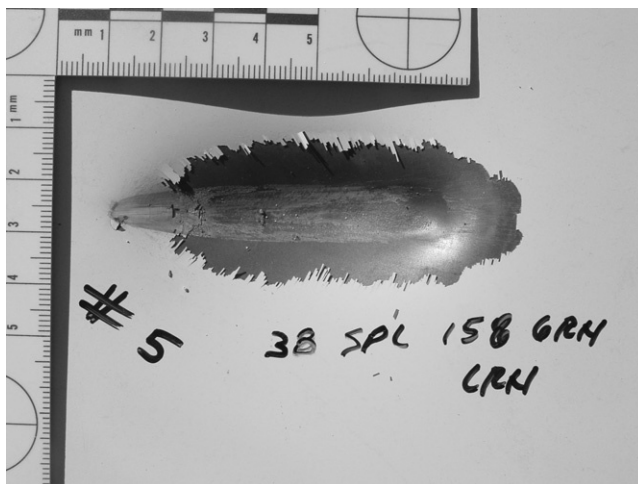
impact angle can be approximated by dividing the width by the length of the oval and calculating the arcsine of this value (Barr, 2001a) (Figure 13.23). This phenomenon can be used to make approximate estimates of impact angle in other materials as well, including wood, wallboard, and other common materials encountered in shooting incidents (Barr, 2001b). Additionally, in the case of painted sheet metals, the direction of impact can be determined by examining the direction of the metal that has been displaced (metal is pushed in the direction of travel). In many cases, when the bullet first engages a painted sheet metal surface, a small area of paint will be crushed into the metal surface as the bullet passed by this point. This **pinch point**, as termed by Haag and Haag (2004), occurs at the entry side of the oval-shaped hole and therefore is also very useful in determining bullet direction of travel (Figure 13.24). There is also a critical angle when a projectile of a particular design striking the surface of a specific material will no longer be able to perforate/penetrate it and begin to deflect off the surface, creating a ricochet site. These thresholds, which are typically at low incident angles depending on the material and bullet design, can be quite helpful in estimating angle of impact.

In the case of ricochet sites, a number of predictably observed indicators of bullet direction can be observed given the type of surface and/or the construction of the bullet striking that surface. The presence of an elliptical/parabolic-shaped transfer lead-in mark (Haag and Haag, 2004) produced by the bullet as it first contacts a surface at a low incident angle can also establish the entry side of a ricochet mark (Figure 13.25). In some cases, impressions of the rifling characteristics on the bullet are transferred to this area of the ricochet (Hueske, 2003), which provide potential clues about the rifling characteristics of the firearm. Again, in painted sheet metal surfaces, as the bullet grazes across the surface prior to deflection, the relatively brittle paint layer on top of the metal forms a series of fractures in a characteristic boat wave-like appearance (Hueske, 2003), giving an excellent indicator of direction. A unique ricochet mark is termed the **Chisum trail** by Haag and Haag (2004) (named after criminalist Jerry Chisum who first characterized it in the United States; see Figure 13.26).

FIGURE 13.24 This bullet hole exhibits classic indicators of its right-to-left direction as it passed through a car door: (1) a pinch point or small area of crushed paint at the apex of the parabolic-shaped “lead-in mark” on the right side of the defect, (2) metal at the left edge of the hole is pushed inward and in the direction of bullet travel, and (3) remnants of boat-wave fractures along the margins of the chipped paint.



FIGURE 13.25 This ricochet damage on a car door was caused by a shallow angle of incidence from an impacting 38 caliber Special lead round-nose bullet moving from left to right. Note that the classic parabolic-shaped lead-in mark at the left edge of the defect and the feathered edges of the boat-wave fractures also indicate direction of bullet travel.



occurs on flat unyielding surfaces as the bullet departs the surface. It is caused by the right or left edge of a flattened bullet remaining in contact with the surface after the main body of the bullet has lifted off the surface. This asymmetrical extension of the ricochet mark will be on the left side if the bullet was fired from a firearm having left twist rifling and on the right side in the case of a right twist firearm.

A feature termed **lead splash** (Haag and Haag, 2004), caused by the impact spatter and vaporization of lead that deposits on the downrange side of nonperpendicular impact angles, typically associated with lead bullets and jacketed bullets with exposed lead noses, is another morphological feature that can be used for interpretation of lead projectile impact direction (see Figure 13.31).



FIGURE 13.26 A lead bullet deflecting off of a linoleum floor surface traveling from right to left at 20 degrees produced this ricochet mark. Note that the asymmetrical extension of the graze mark favoring the lower edge, termed the Chisum trail, is caused by the left edge of the impacting bullet remaining in contact with the surface after the main body of the bullet has lifted off the surface while rotating in a counterclockwise direction from the left twist rifling of the firearm that fired it. If the asymmetry were extended to the upper side, it would indicate a right twist rifled barrel. This indicator of rifling twist direction could potentially be used to include or exclude the involvement of candidate firearms in a shooting incident.

Because glass is a very common material in both structures and vehicles, a brief discussion of projectile deflection/perforation characteristics, as well as the potential for sequencing order of bullet impact limited to their examination while at the shooting scene or when reviewing crime scene photographs, is warranted. Glass is generally classified into plate glass (common in standard household windows), tempered glass (common in many household and industrial applications, such as shower doors and side windows of vehicles), and laminated “safety” glass (common in front windshields of vehicles). The morphologies of impact sites and holes through these classes of glass are significantly different as follow.

Plate Glass

When projectiles perforate *plate glass*, a predictable cone-shaped fracture occurs around the periphery of the hole created on the downrange side of the glass (Figure 13.27). The shape of the hole will generally be round with orthogonal impact and progress to an increasingly exaggerated elliptical shape as the angle of impact decreases (Murdock et al., 1987). Radial and concentric fractures will also radiate out from this cone-shaped hole, which resembles a spider web (Figure 13.28). Radial fractures are also of use in sequencing the order of bullets that pass through the same sheet of plate glass (but not laminated or tempered glass as discussed later). In plate glass, radial fractures created by a previous bullet hole will block progression of the radial fractures in a subsequently produced bullet hole (Murdock et al., 1987).

The symmetry of radial fractures that surround the bullet hole in plate glass is dependent on the angle of impact. Generally, the elongated fracture lines point away from the direction of impact. Thus by observing the blockage of these fractures, bullet holes can be sequenced relative to each other. It is also possible to determine the direction of bullet travel by careful examination of the direction of conchoidal-shaped “rib marks” on the edges of radial and concentric fractures (Kirk, 1974). Therefore, pieces of glass should be collected for examination by the laboratory when the conical hole is missing.

FIGURE 13.27 The presence of cone fractures on the downrange side of bullet holes in plate glass as depicted in this photo provides a clear indicator of bullet direction.



FIGURE 13.28 The radial fracture extending from the lower left bullet hole blocks radial fractures extending from the upper right bullet hole, indicating that the lower left hole was created first in this plate glass window.



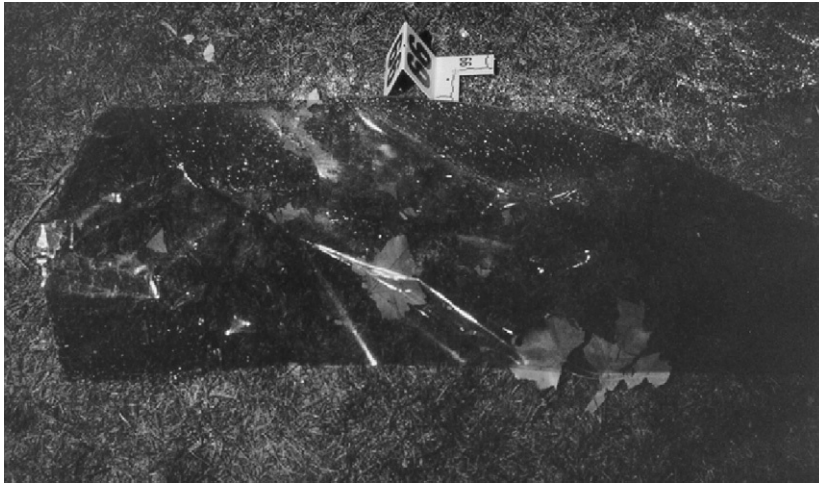


FIGURE 13.29 A tempered glass passenger window was completely shot out by a load of buckshot in an officer-involved shooting. Although it was not possible to determine the locations of the projectile holes in the tempered glass, the window tinting covering the glass provided this information.

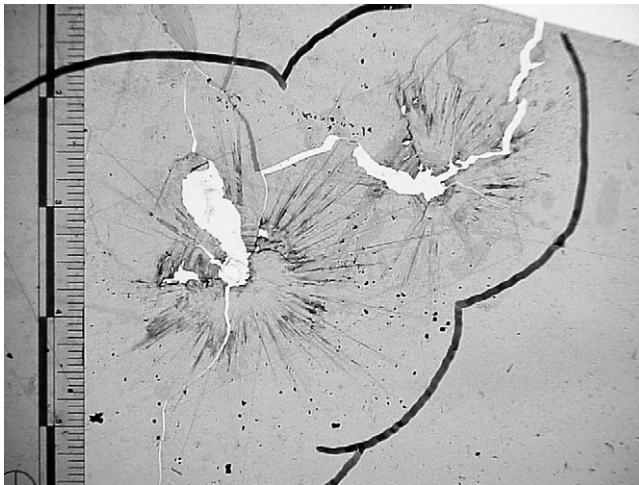
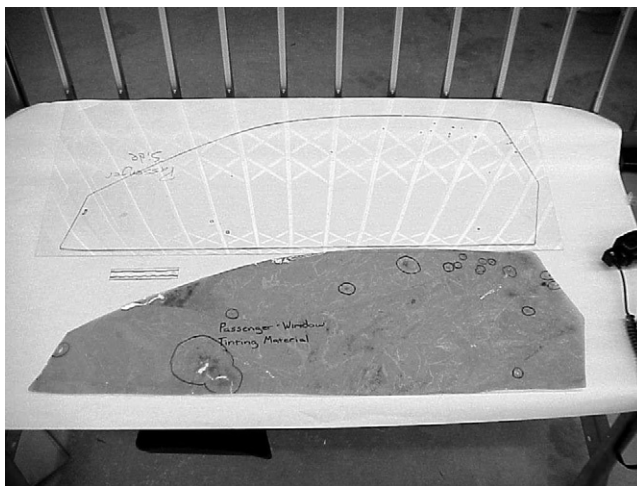


FIGURE 13.30 Lead splash marks surrounding the holes produced by impacting buckshot were observed in this close-up photo of the window tinting collected from the shooting scene. In this example, the splash pattern is circular in shape and suggests a fairly orthogonal direction of impact.

Tempered Glass

Tempered glass, because of its purposeful design (built-in internal stress), is much stronger than plate glass of the same thickness. When it is defeated by impact it will fracture into many small cubicle/rectangular-shaped fragments within a fraction of a second. This is a desired feature of this glass design because it reduces the potential for serious injury. Unfortunately, interpreting the direction of bullet impact/perforation is more difficult. This is because once broken the window is extremely fragile and will often result in large portions of the window falling out

FIGURE 13.31 Window tinting with the registered buckshot holes was used as a template to trace the passenger window in a section of clear Plexiglas. The Plexiglas was then inserted into the window frame of the vehicle to reconstruct the location of the buckshot holes to facilitate the estimation of the projectile paths that passed into the vehicle.



of the frame with the slightest of movement. Consequently, partial or complete loss of the fractured areas around the bullet hole(s) needed for interpretation is a common occurrence (Figures 13.29–13.31). Even when the glass pane remains intact sufficiently to preserve projectile holes, cone fractures are extremely shallow and difficult to interpret.

The ability to sequence the order of bullets striking tempered glass is limited to the first shot; all others are subsequent. The first bullet striking the glass will create radial fractures that propagate for a short distance around the hole and then degrade quickly into the classic cubicle fracture pattern described previously. Any subsequent bullets striking the glass will merely push sections of the prefractured glass from the pane as they pass through it. These subsequent holes therefore have an identical appearance (see Figure 13.15). The morphology of damage exhibited by the first striking bullet is significantly different from those that strike subsequent to the first shot. Because unbroken tempered glass offers a very smooth hard impact-resistant surface, the first bullet striking it typically exhibits a smooth, flat area of deformation most noticeable in full metal jacketed style bullets. Additionally, the angle between the plane of the deformation relative to the axis of the bullet is an approximate indicator of the angle of bullet impact (Rathman, 1993). In contrast, bullets of the same construction that subsequently push through the relatively nonresistant, multifaceted surfaces of prefractured glass segments exhibit significantly less overall deformation. The impacted surface is also not smooth but multifaceted in contour and typically has substantial fragments of glass embedded in it (see Figure 13.16).

Fractured tempered glass presents a serious preservation problem because of its vulnerability to complete loss from the supporting frame due to vibration or agitation associated most notably with moving vehicles either during the course of a shooting incident and/or attempts to transport the vehicle for further examination. A vigilant effort to examine and document damage to this glass should be made prior to transportation if possible. Extreme care to preserve any surviving portions of glass should also be made in preparation for transport.

Even when substantial portions of glass are missing from a panel of tempered glass, any surviving radial fractures still intact at the edge of the supporting frame can be extrapolated back to a convergence point to accurately locate the position of the first bullet to strike the glass (Prendergast, 1994).

Bullets striking at a low angle will ricochet from the surface. Lead bullets leave a comet tail, or a *Chisum trail*, that shows the direction and maybe the twist. A bullet can be ricocheted off the glass after it is broken; however, only a hole is left where the bullet pushed the glass in. No comet tail; no bullet passed through. This can be quite confusing.

Editors'
Note

Laminated Glass

Laminated glass is composed of two preformed sections of plate glass with a thin polyvinyl plastic layer in between. It is used primarily for windshields of vehicles. Laminated glass also poses its own unique challenges to bullet impact interpretation. Cone fractures can be used to interpret the direction of bullet impact; however, it has been the author's experience that cone fractures can occur on both sides of the glass but are typically much more prominent on the downrange side. Because of the slope of windshield glass (typically approximately 30 degrees in most passenger vehicles), most bullets fired through them at eye level will produce oval-shaped holes. The orientation of the long axis of the oval is an indicator of bullet direction.

Laminated glass offers a surprisingly hard and impact-resistant surface in addition to its nonorthogonal orientation on automobiles. Consequently, it is not uncommon for bullets to strike the glass sufficiently to fracture the glass layers on both sides of the laminate but deflect off the windshield without perforating it. In the case of extremely low angles of incidence (about 5 degrees or less), the bullet deflects off the surface of the glass, creating a transfer mark. It may also create a small area of radial cracks at the impact point, as well as a series of crescent-shaped fractures resembling boat-shaped waves, that provide a reliable indication of bullet direction across the glass (Van Arsdale, 1998).

Sequencing of bullet holes in windshield glass by examination of the radial fractures emanating from them is unreliable due to continued propagation of the fractures. Vibrations from later shots extend the cracks of earlier shots, giving false impressions of shot sequence.

PROJECTILE PATHS

Determining or reconstructing the actual path(s) that a projectile(s) has taken in a shooting incident scene will provide useful information regarding the location(s) and position(s) of participants and the location of any intermediary targets struck. For the purpose of determining projectile paths within a distance of 100 feet (absent striking an intermediary target), the investigator can assume that the projectile(s) is traveling in a straight path given the accuracy and precision of the methods with which these determinations can be made. Indoor scenes are typically sufficiently restrictive in their dimensions to qualify under this condition. In these situations, the probe and string method for bullet path determination is typically used. For outdoor scenes that involve more lengthy distances but are less than 100 feet, the laser method may be a more practical technique of choice for bullet path determination. For distances greater than 100 to 200 feet, gravity and atmospheric conditions will begin to have an effect exceeding the accuracy/precision of the aforementioned techniques. In this case, long-range ballistic programs will become useful for estimating bullet paths. For purposes of this discussion on shooting scene reconstruction, the methods are described briefly as follows.

Probe and String Method

This method of projectile path determination employs the use of a probe (rods of various diameters) to represent the impacting and/or exiting and/or deflecting direction of the projectile that has interacted with a given surface.

Two Points of Reference

Projectile paths are determined most accurately when the projectile has passed through two or more surfaces (Figure 13.32). For example, a 6-inch residential wall of sheetrock construction that has been perforated by a projectile offers a much more dependable means of projectile path determination than a single layer of sheet metal. The probe is used to connect these two points to represent or visually illustrate the projectile path by passing the rod through the projectile hole(s). Different size probes can be employed to accommodate variations in projectile hole diameters.

Single Point of Reference

The ability to accurately estimate projectile paths through a single surface is diminished greatly and will be dependent on the nature of the material struck and the thickness of that material. Generally, the greater the thickness of the material that a projectile has penetrated or perforated, the more confidently the bullet path estimation can be determined. A foam headrest in a vehicle provides a more dependable means of projectile path determination than a single pane of window glass.

Brightly colored string can be used to extrapolate the projectile path represented by the probe in both incoming and outgoing directions as desired. Colored Post-It notes can be folded over the string at intervals to better visualize the paths (Figures 13.33 and 13.34). The use of string is most applicable in indoor situations. It can also be used outdoors where distances involved are reasonably short.

FIGURE 13.32 Probing bullet holes to represent bullet paths is most accurate when the probe connects two points. Single surfaces with projectile holes can provide useful bullet path information depending on the material and the thickness. Probes of various thicknesses and colors are being used by the author to represent numerous bullet paths through the door of this pickup truck.





FIGURE 13.33 Brightly colored red string was used to extrapolate the paths of buckshot that passed through a wooden sign and continued into the vehicle while the door was in the open position. This reconstruction was conducted while the vehicle was in its original position at the scene.



FIGURE 13.34 This photograph illustrates the bullet path from the perspective of the shooter. Colored strings with colored Post-It notes attached at 2-foot intervals for increased visibility in the photograph represent these two bullet paths.

Laser Method

In situations in which projectile path distances are lengthier, as in outdoor shooting incidents, use of a laser device can be employed to extrapolate the estimated projectile path illustrated either by the previously described probe and string method or by direct application of the laser to represent the projectile path without the use of probes. A laser pen can be used for preliminary

FIGURE 13.35 Laser beams illustrating bullet paths can be recorded by taking prolonged photographic exposures in darkened conditions. The laser beams depicted in this photograph illustrate the paths of bullets striking a vehicle. Lasers are good for extrapolating bullet paths over long distances. Printed with permission of Mike Haag.



projectile path estimation and for guiding other examiners to likely locations to which projectiles may have traveled after passing through or deflecting from intermediary targets. For more accurate projectile path documentation, commercial laser devices on a tripod should be used (Figure 13.35).

Measuring Impact, Deflective, and Exit Angles

Once a projectile path has been illustrated using either the probe and string or the laser method, the location as well as the path of the projectile must be documented and described. These representative paths should be photographed and the representative directions described in terms of azimuth (compass) directions and inclination angles (vertical angle). This is accomplished most conveniently using angle measurements in reference to the vertical and horizontal planes. These angles can be either measured directly using a variety of angle measuring tools (i.e., protractors for azimuth angles and inclinometers or electronic levels for inclination angles) or calculated using measurements and trigonometric functions (Figure 13.36). Additionally, these representative bullet paths, when photographed properly in the correct planes of view, may be approximated reliably using the photographs.

These angle measurements and descriptions are useful for such tasks as extrapolating bullet paths empirically or mathematically and calculating shooter positions along an established bullet path given known heights of shooting participants. The author has found it difficult to decipher some verbal descriptions of bullet paths in written crime scene reports. This is because angle measurements are relative to the particular plane of reference being used. In the previous description, for example, the azimuth component could be described from the point of view of the shooter facing the west wall (NATO method of description) instead of using the plane of the west wall as the reference. In this case, it would be described as 60 degrees north to south (or right to left from the shooter's perspective). Both of these descriptions are correct, but they are relative to these two different planes of reference. Correlation of any crime scene diagrams that illustrate the described bullet paths is very helpful in supplementing such descriptions to minimize confusion.

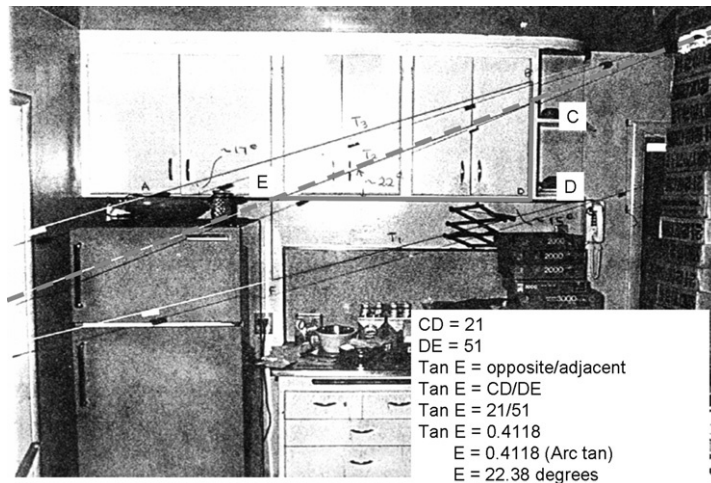


FIGURE 13.36 When photographs are taken in proper perspective, it is possible to estimate bullet path angles. In this example, the author was able to calculate inclination angles of three bullet paths progressing from right to left and downward in this photograph using the cabinet in the background as a reference for establishing right triangles relative to the bottom edge and sides of the cabinet. In this case, the right edge (CD) and bottom edge (DE) of the cabinet formed the legs of a right triangle for the middle bullet path (dotted line). Dividing the length of CD (21 scale units) by DE (51 scale units) and multiplying this ratio against the arc tan value equals approximately 22 degrees. Careful examination of the photo reveals two other triangles drawn in by hand relative to the remaining two bullet paths.

It should be noted that such bullet path determinations are an approximation and are subject to a number of variables that will affect the accuracy and precision of these estimates, including (1) the effect of the medium a bullet passes through or deflects from on incident versus reflective angles and (2) the variance of probe placement through projectile holes (Garrison, 1996). Studies conducted by the author and experience by other examiners² suggest that repetitive measurements of predetermined bullet paths are usually within 2 or 3 degrees of the target value. Subsequently, it is

² The following experiment directed by criminalists Chris Coleman (Contra Costa County Sheriff Department) and Bruce Moran (Sacramento County District Attorney's Office) was conducted at a California Association of Criminalists Northern California Firearms Study Group—Bullet Path Reconstruction Workshop held at the Alameda County Sheriff's Training Facility in Pleasanton, California, on March 3, 2005:

A series of mock walls simulating standard sheetrock construction separated by 2 × 4 stud sections were prepared by Coleman. A total of 12 bullets were fired through the prepared wall sections at known angles. Participants were asked to measure the bullet path azimuth and vertical angle components using the probe and/or laser method. Each participant measured the azimuth and vertical components of these bullet paths using protractors and inclinometers. Twenty-eight participants working in two-person teams took a total of 312 measurements. Data were collected from each participant and summarized on an Excel spreadsheet by Coleman. It was noted that the participants' measured results were within 1 to 3 degrees of the target value. Maximum variation between measurements of the participants was within 5 degrees.

Note: very similar results were obtained by approximately 25 participants in an exercise using the same experimental design conducted by Luke and Mike Haag at the Forensic Shooting Scene Reconstruction Course, Prescott, Arizona, attended by the author in November 2004. It is the understanding of the author that Mike Haag has been accumulating data from previous exercises conducted in earlier classes and intends to publish data at some point.

generally acceptable to conservatively report a ± 5 degree variation from the measured result as a range of possibility for estimating bullet path directions.

The investigator's ability to predict the positions of shooters in an incident is restricted to his or her ability to reproduce an accurate bullet path, as discussed previously. The string and probe method, as well as the laser method, of bullet path reconstruction is essentially an extrapolation of a line between two points (e.g., entrance and exit hole in a standard residential wall). This is straightforward but does not take into account the effect of deflection angles as a function of the medium through which the bullet passed. Deflection as a result of perforating/striking an object rather than rebounding off of surfaces (ricochet) is used to describe deviations in any direction from the projectile's normal flight path (Haag and Haag, 2004). There can be significant changes in bullet direction depending on the medium through which the bullet passes and the design of the bullet. For example, tempered glass (Thornton and Cashman, 1986) and laminated windshield glass (MacPherson and Finsel, 1996) can affect bullet deflection by as much as 10–20 degrees. Bullet path determination and resulting shooter position reconstruction are approximations, and conclusions made should be reported conservatively. It may be necessary to perform empirical tests to study the effect of a specific target material(s) on bullet deflection resulting from perforation when this consideration is significant to the resolution of reconstructive issues.

Photographic Documentation of Illustrated Projectile Paths

Photographic documentation of illustrated projectile paths is an essential step in the shooting reconstruction process. Proper photographic documentation of illustrated projectile paths will be important in supporting the examiner's reconstructive conclusions, providing graphic illustrations to investigators and police personnel, attorneys, the court and jury, and/or any party interested in reviewing the reconstructionist's work.

Photographs of bullet paths illustrated by either the probe and string method or the laser method should be taken to represent the azimuth and inclination components of the projectile path and parallel to the axis of the bullet path in both directions (Figures 13.37 and 13.38). Photos should be taken at the same height as the location of the impact or exiting projectile defect to minimize photographic distortion of the projectile path. If a photograph is to be used later for measurement of inclination angles, it is essential that the film plane in the camera be in alignment with the azimuth direction of the bullet path to achieve the proper perspective for accurate measurement. Use of ladders and/or elevating equipment is essential in obtaining azimuth (overhead) views of projectile paths. At outdoor shooting scenes, it is sometimes desirable to perform overhead photography from a fire truck aerial ladder (Figure 13.39). Overall aerial views of the shooting scene from airplanes or helicopters are also highly desirable (Figure 13.40).

Photography of bullet paths using the probe and string method during daylight hours can be most effective when bright fluorescent-colored string for maximum visibility is used. Hanging colored Post-It notes folded over on themselves at 2- or 3-foot intervals along the string can add increased visibility.

A method to photo document projectile paths using the laser technique involves spraying the entire laser beam along the bullet path with commercial photographic fog in darkened conditions during an open shutter camera exposure, which will create a continuous beam



FIGURE 13.37 This photograph of bullet paths is taken in reference to the horizontal plane. Note that the photograph is taken at the level of the bullet entrance holes to minimize distortion.

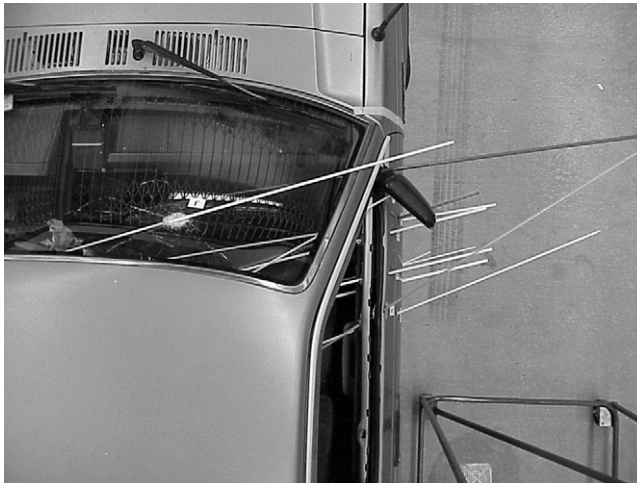


FIGURE 13.38 This photograph depicts bullet paths in reference to the vertical plane. Note the use of a stepladder to obtain the correct perspective directly over probes.

representing the illustrated bullet path. However, the fog technique is cumbersome and susceptible to weather conditions. An alternative is to move a piece of white paper attached to a clipboard along the laser beam. When done correctly, the person spraying the fog or moving the clipboard is not seen in the photograph.

FIGURE 13.39 Overhead photographs of shooting scenes using an aerial ladder truck are extremely useful in illustrating the shooter position(s) in relationship to other objects and/or participants in a shooting scene.

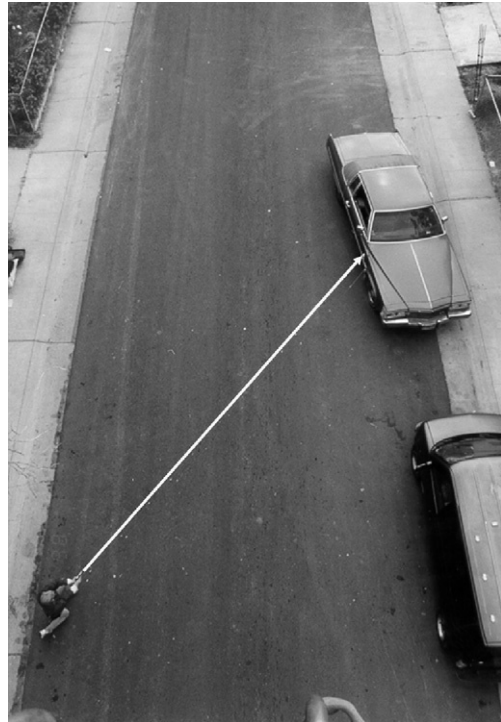


FIGURE 13.40 Aerial photographs of the entire shooting scene are recommended in outdoor shooting scene investigations.



Long-Range Trajectory Determination

The majority of shooting incidents involves relatively short distances, the flight time of the bullet is measured in fractions of a second, and for all practical purposes the bullet is traveling in a straight line. Shooting participants and objects in the scene that are in motion at the time shots are fired can be considered stationary during the bullet's flight (Haag and Haag, 2004). Each shot fired registers a very brief moment in time and, in essence, amounts to a snapshot of the shooting incident.

In situations in which distances are greater than 100–200 feet, gravity and drag will begin to have an effect on the path of the bullet, causing it to curve. Additionally, as the distance traveled increases, the bullet's flight time can be lengthened to several seconds or longer and may become a significant reconstruction issue. Efforts to estimate a shooter's position therefore become significantly more difficult. This is encountered most typically in cases that involve victims struck down by wayward bullets fired by people celebrating a holiday or by hunters or target shooters who have missed their intended target. Often, the shooter has no idea that he or she has wounded or killed the victim (Figures 13.41–13.44).

The study of bullets in motion is called **ballistics**. The term ballistics is often erroneously associated with the discipline of firearms identification (involving the determination of whether a certain firearm has or has not fired a particular bullet or cartridge case). An in-depth discussion of ballistics is beyond the scope of this work. In general, however, to derive meaningful information for reconstructive purposes, it is necessary to employ long-range ballistic programs to estimate these curved projectile paths.

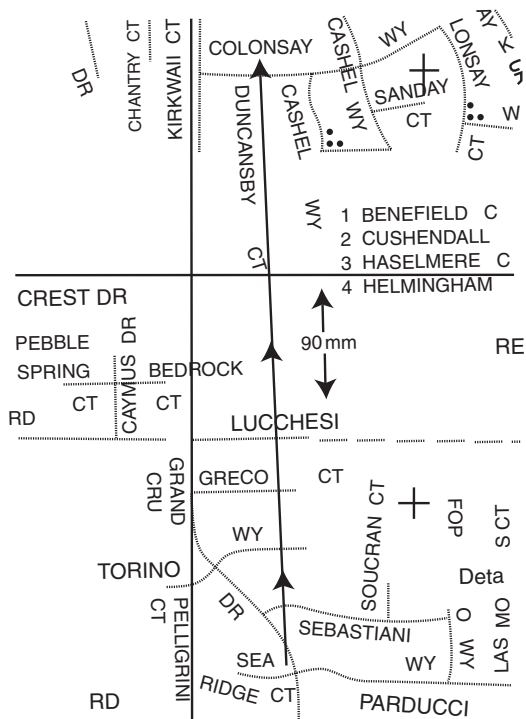


FIGURE 13.41 This bullet was recovered from the floor of a child's bedroom in a residential neighborhood. Investigation revealed that it had entered through the roof of the residence.

FIGURE 13.42 Approximately one-half mile from this location, this .45 Auto handgun was recovered from a citizen who was reportedly firing it “straight up into the air” to scare car thieves away. The author concluded that the bullet had been fired from the pistol after comparing rifling impressions on test-fired bullets to the rifling impressions exhibited on the questioned bullet.



FIGURE 13.43 The distance the bullet traveled was estimated to be approximately 2650 feet based on calculations made from a street map between the position of the shooter and the child’s bedroom.



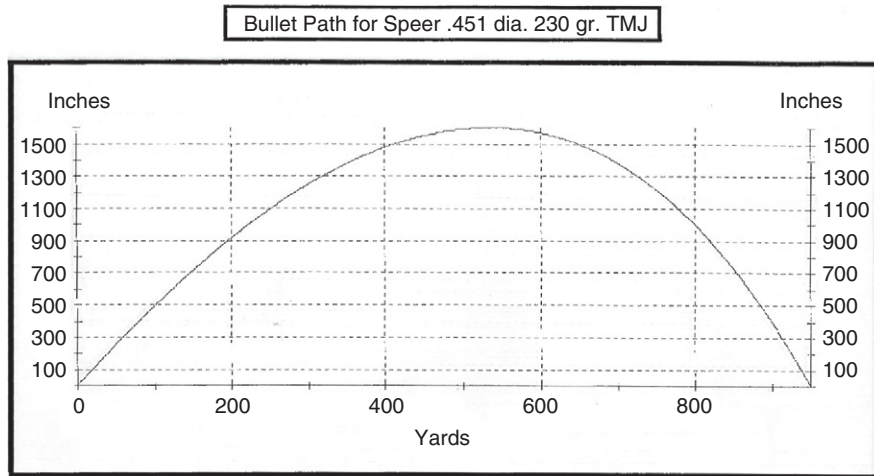


FIGURE 13.44 Information concerning the aerodynamic flight characteristics of a caliber .45 Auto full-metal jacketed bullet fired from a 4-inch barreled caliber .45 Auto pistol was used to calculate the terminal velocity of the bullet as it struck the child's residence and the angle of departure of the bullet in order to reach the child's residence from a half-mile away. The calculated angle of departure was determined to be between 8 and 12 degrees. This relatively horizontal departure angle did not support statements by the shooter that he fired shots "straight up in the air."

SHOOTER LOCATION, POSITION, AND ORIENTATION ALONG ESTABLISHED BULLET PATHS

The Three Zones of Shooter Position Possibility

In cases where a bullet path can be confidently established using either the probe and string or the laser method from bullet hole, ricochet, and impact site evidence at the scene, it becomes possible to begin a process of considering various shooter locations along the bullet path and possible shooter positions/orientations at those locations. When the bullet path is on an incline either up or down, a suggested approach is to consider what the author has coined as the three zones of shooter position possibility along such established bullet paths that have been extrapolated through the extremes of the shooting scene. These zones are (1) most probable, (2) improbable but possible, and (3) impossible.

This is conducted through a process of elimination where the investigator has knowledge of the shoulder height of the shooter and the maximum height that the shooter can reach. A person of the same height and build as the suspected shooter is selected to model various shooting positions along the extrapolated bullet path represented by a string or a laser beam with the same type of firearm used. The model or shooter is directed to move along the extrapolated bullet path while maintaining the barrel of the firearm in exact alignment with the represented bullet path. The shoulder height and height of maximum reach are key measurements because they are used to establish the thresholds among these three zones of possibility. For example, working backward along a downward-directed bullet path to the item struck, these zones are described and associated threshold distances among these zones would be established as follows.

Zone 3: Impossible

The model or shooter is directed to move backward along the bullet path (i.e., the height of the bullet path is increasing as distance to the item struck increases). When the shooter reaches a point where he or she is unable to physically align the barrel of the firearm in the bullet path as a result of (a) being unable to reach high enough to place the firearm in a position of alignment or (b) reaching some physical barrier that terminates the extrapolated bullet path such as a wall or large intervening object to the bullet path, a distance from this point to the target is measured and reported as the beginning of Zone 3 (Figure 13.45). Any distance greater than this threshold measurement would be in the impossible one.

Zone 2: Awkward (Improbable) but Possible

This zone includes a range of distance where the shooter is able to physically align the barrel of his or her firearm with the bullet path but in a manner that is awkward and/or difficult to achieve. This typically occurs (in the case of a downward directed shot) when the height of the bullet path exceeds the top of the shooter's shoulders. For the purpose of this example, the shoulder point shooting position is the highest elevation of natural shooting stances before the shooter is required to raise the height of the firearm above the level of the shoulders. Any



FIGURE 13.45 Impossible: Any distance equal to or greater than the distance represented by the arrow is reported as the zone of impossibility, as the shooter is no longer able to place the firearm in alignment with the reconstructed bullet path.

level above this height precludes the ability of the shooter to obtain a normal “sight picture” (i.e., ability to align the front and rear sight on the target).

Additionally, as the height above shoulder level increases, the shooter is placed in an increasing position of awkwardness until such point as the shooter is no longer able to align the firearm with the bullet path (threshold between Zone 2 and beginning of Zone 3). Once the outer limit of possibility is established, the model or shooter is directed to move forward along the bullet path until the string or laser beam just touches the top of the shoulder. The distance of the shooter from this location along the bullet path to the item struck is measured. The range between this distance and the threshold distance marking the beginning of Zone 3 is reported as the improbable zone (Figure 13.46).

Zone 1: Most Probable

In this downward-directed shooting example, any height lower than the height of the shoulders allows the shooter to easily achieve a number of standard shooting positions where a normal sight picture can be achieved (i.e., shoulder point, kneeling shoulder point, and prone position) as the height of the bullet path decreases. The distance between the beginning of Zone 2 and the item struck is reported as the probable zone (Figure 13.47).



FIGURE 13.46 Improbable but possible: The shooter is able to physically align the barrel of his or her firearm with the bullet path but in a manner that is awkward and/or difficult to achieve.



FIGURE 13.47 Most probable: The bullet path is at a height equal to or lower than the top of the shooter's shoulders and can be achieved easily by the shooter in a number of standard shooting positions. The distance between the beginning of Zone 2 and the target is reported.

Figures 13.45–13.47 depict an example of these zones within a relatively short distance due to the steep incline of the bullet path into the vehicle. However, as the incline of the bullet path decreases, the shooter zones of possibility will increase. In cases in which the bullet path is level or near level, this process will not be applicable and reconstruction will be required to rely on other sources of investigative and/or physical evidence to estimate shooting positions along such bullet paths. The author has found this method to be an effective tool for either supporting or refuting suspect or witness statements.

This process is most effective when conducted at the original shooting scene while it is still in control of investigative personnel. Unfortunately, such knowledge of the shooter in many cases is unavailable during the crime scene examination stages of such investigations. However, if appropriate measurements and crime scene photographs have been obtained during the crime scene documentation process, it is possible to return to the original scene after the fact to reconstruct the bullet path and demonstrate these zones of possibility (Figure 13.48) and make such estimates through the use of trigonometric calculations in conjunction with scale diagrams of the scene.

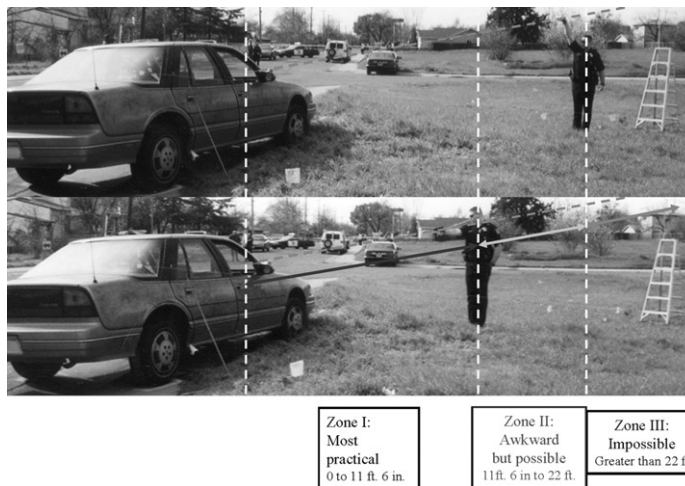


FIGURE 13.48 This composite of two photos (used as a court exhibit by the author) demonstrates graphically the threshold positions among Zones 1–3 of shooter location possibility with associated distances along a reconstructed bullet path using a model of similar height and build as the suspected shooter. Note that the model is standing at shoulder point in one photo and in the second photo is demonstrating the farthest point where the gun can just barely be aligned with the projected bullet path that has been extrapolated with string. The model is using the same make and model of firearm used in the incident. The ladder in the background is being used to support the end of the string representing the bullet path. The vehicle was towed back to the shooting scene and placed in its original position using photographs and crime scene measurements to conduct this reconstruction.

FURTHER NARROWING SHOOTER POSITION POSSIBILITIES

Gunshot Residue Patterns and Muzzle to Target Distance Determination

The investigator may be able to further limit the shooter's position within the previously described zones of shooter possibility by considering the presence of any gunshot residue patterns that have been detected on an object(s) along the bullet path. The presence of any discernible gunshot residue patterns (Figures 13.49 and 13.50) typically restricts the muzzle of the firearm to within a distance of 4 feet from the item.

A comprehensive discussion on muzzle distance determinations is not the focus here because there are numerous treatments of this topic in the literature. However, for purposes of general reconstructive considerations, a brief description of gunshot residue and the patterns it produces when expelled from the muzzle of a firearm and its usefulness is warranted.

When a firearm is discharged, a variety of materials are expelled from the barrel in addition to the bullet. Such firearm discharge products include fine carbonaceous particles or soot from incomplete combustion of the propellant; unburned and partially burned powder particles; metal particles stripped from the bullet; bullet lubricant; and inorganic elements from the cartridge primer, such as lead, barium, and antimony in traditional U.S. center-fire ammunition and possibly other elements in some of the recently developed lead-free ammunition formulations. The heavier materials are propelled from the muzzle as a very fine spray within the gas cloud of lighter materials emerging from the firearm. The aerodynamic qualities of this aerosol/gaseous

FIGURE 13.49 The presence of discernible gunshot residue and /or particle patterns associated with a reconstructed bullet path can be used to further restrict shooter location within the zones of shooter possibility. As demonstrated in this reconstruction, very fine sooting is present around the periphery of the bullet entrance hole in this vehicle.

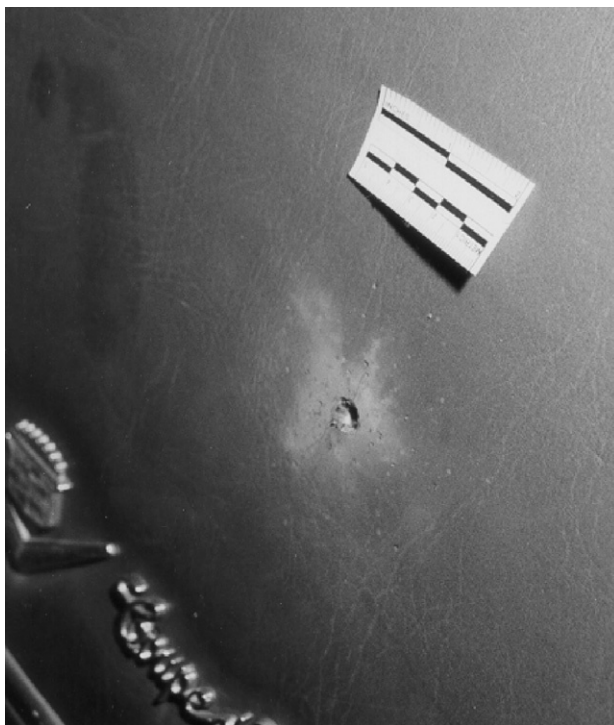


FIGURE 13.50 The converging information provided by the bullet path as demonstrated by the probe with the presence of fine sooting around the bullet entrance hole suggests a muzzle-to-target distance of no more than 1 foot.



cloud are very poor and consequently are propelled forward for a very short distance relative to the travel of the bullet. However, their distribution and general appearance on items they are deposited on will change with distance. This correlation can be used to estimate the muzzle-to-target distance. The author uses the following five zones of distance associated with the

general appearance of gunshot residue deposits as described by Haag (2004) as a general guideline in estimating muzzle-to-target distance without the benefit of producing test patterns with the suspected firearm and ammunition.

Zone I: Contact

Causes blast destruction, tearing of the skin or cloth; soot and powder particles mostly on the inside of the garment and/or driven into the wound. The outline of certain parts of the firearm (e.g., barrel bushing and front sight) may be printed in the skin adjacent to the entry hole.

Zone II: Near-Contact (1–4 Inches)

Causes intense, dark sooting with dense deposits of unburned and partially burned powder particles located around the bullet hole; blast destruction still possible in clothing and even in skin in some cases; powder tattooing on the skin.

Zone III: (3–8 Inches)

Causes some medium to light gray sooting with a roughly circular “shotgun” pattern of powder particles around the bullet hole. Powder tattooing is still possible, particularly with dense and/or poorly burning powders.

Zone IV: (6–36 Inches)

No visible sooting. Widely dispersed powder particles often adhere loosely to the receiving surface. The distribution pattern is usually circular at closer distances but may become poorly defined to nonexistent at greater distances. Chemical tests can be employed to raise latent powder or gunshot residue patterns on garments.

Zone V: (3–4 Feet or Greater)

No discernible firearm discharge products present. Bullet wiping present around the margin of the entry side of the bullet hole regardless of range.

The previous descriptions assume that the firearm was pointed perpendicular to the receiving surface. Actual distances associated with Zones II–IV will vary to some extent depending on the type of firearm, the length of the barrel, and ammunition used, as well as the shape and composition of the receiving surface. In cases in which gunshot residue deposits are produced on surfaces where the firearm is oriented in an increasingly nonperpendicular angle to the receiving surface, the overall shape of the pattern will change to an increasingly exaggerated oval shape.

The distribution of the gunshot residue material will also become increasingly uneven across this overall oval pattern, with a greater density of soot or gunpowder particles being deposited on the side of the oval closest to the muzzle.

The examiner must be aware of the evidence dynamics. If the clothing object is leather, for instance, and it was still on the victim, transported in a body bag, removed and packaged in a bag, removed and allowed to dry, and then rolled back up and put in a bag it would lose all powder particles that weren't burned into the leather. This happened in a police officer shooting, and the officer was accused of shooting the decedent from a long distance. He had knocked the officer down and was trying to stab him. The officer shot past his own foot while lying on his back. There was gunpowder on his pants leg to support his story.

Editors' Note

In reality, the most reliable method of estimating muzzle-to-target distance is by comparing the size, shape, and distribution of the previously described gunshot residue/particulate materials of the questioned pattern to test patterns produced at known distances using the suspected firearm and the same ammunition under the same conditions (i.e., angle and orientation).

An additional consideration involving the deposit of gunshot residue that can be helpful in narrowing the shooter location and position/orientation is the detection of aerosol or gaseous gunshot residues that escape from either the ejection port of autoloading firearms or the cylinder gap (space between the forward end of the revolver cylinder and the forcing cone of the barrel). These will deposit on items that are in contact with or within a few inches of the gun. For example, the backward extrapolated bullet path of a bullet hole 2 feet above the floor in a hallway that passes through a doorway of another room and terminates in the opposite wall behind the door at a height of 6 feet might suggest a number of shooter possibilities in Zones I and II. However, the detection of a cylinder gap pattern at the edge of the doorway leading into the hallway in close alignment with the extended bullet path would strongly suggest that the shooter fired the shot from the doorway using the edge of the door opening as a barricade as opposed to being in the hallway or farther back in the adjoining room. When the side of the revolver is in contact and/or very close to the surface of an item, such as a wall or clothing, the distance between the gunshot residue pattern created by the muzzle end of the revolver and the cylinder gap pattern can give an estimate of the barrel length, as well as its location and position/orientation (Figures 13.51 and 13.52).



FIGURE 13.51 A woman was shot fatally through the head by her boyfriend at point-blank range using a .41 Magnum revolver. The bullet passed laterally through the base of the skull from left to right, exiting the decedent and deflecting off a wall switch plate. The bullet path through the head, the bullet impact site on the switch plate, and bloodstain patterns in the vicinity provided strong evidence that the decedent was in a semistanding/crouched position with her head pinned against the wall when the fatal shot was fired. The defendant claimed that the decedent “grabbed the revolver and the gun went off.” This autopsy photograph depicts a linear cylinder gap gunpowder stippling/tattoo pattern on the back of the decedent’s left wrist, indicating that this area of the left arm was in close vicinity to the side of the revolver frame at the moment the fatal shot was fired.



FIGURE 13.52 A properly scaled computer model depicting the female decedent (using Poser) was constructed and imported into one of the crime scene photographs in which the decedent received the fatal shot. The anatomical model depicts a likely position of the decedent, including orientation of the left arm in relationship to the likely location of the revolver and shooter (not shown) at the instant the shot was fired. Deposition of the cylinder gap pattern on the back of the decedent's left wrist suggested that she was attempting to parry the gun away rather than grabbing for it.

Firearm Ejection Pattern Considerations

The firearm ejection pattern may also assist in further limiting the shooter's position along an extrapolated bullet path (Figures 13.53 and 13.54). Ejection patterns are subject to numerous variables, such as the design of the firearm, the ammunition used, the height and orientation of the firearm, the nature of the receiving surface or surfaces, and the position and location of intervening objects that ejected cartridge cases may strike. Generalizations made without the benefit of conducting ejection pattern tests should be done with extreme caution. If the firearm and ammunition used are available for testing, the more variables that can be controlled, the more confidence the reconstructionist will have in reproducing an accurate representation of ejection patterns. Given adequate testing, it may also be possible to make some conclusions in regard to whether a shooter is stationary or moving when cartridge cases are ejected from a firearm.

Consideration of the receiving surface for ejected cartridge cases is also a very important factor in estimating shooter position. Generally, when conducting ejection pattern tests, the author documents the location where the ejected cartridge case first comes into contact with the receiving surface, as well as the location of the cartridge case after it has bounced to its terminal resting place. Two resulting ejection patterns are therefore established that can be useful when correlated to a scene that has both hard surfaces, such as concrete or asphalt, and soft, yielding surfaces, such as sand, loose dirt, or grass (Figures 13.55 and 13.56).

FIGURE 13.53 Probes illustrating the bullet paths in the side of this vehicle support statements by police officers that the suspect, while driving the vehicle, was firing his handgun in the direction of pursuing police vehicles.



FIGURE 13.54 The bullet paths that struck the side of this vehicle can be achieved most reasonably in the manner being demonstrated by a model of similar height and build as the suspect in this officer-involved shooting incident. Note that the pistol in question is oriented horizontally with the ejection port side up. This orientation was significant in that an ejected cartridge case was recovered inside the vehicle directly behind the driver's seat. The ejection port is on the right side of this firearm. The sideways orientation of the pistol accounts for ejection of a cartridge case over the left shoulder of the shooter and into the restricted space behind the seat and the cab wall. Additionally, the model demonstrating this orientation noted that it was much easier to achieve this sideways orientation than a vertical orientation while seated in the driver's seat.



There is the potential for further movement of ejected cartridge cases at the scene due to rolling of cartridge cases on inclines, wind, postshooting activity of participants involved in the shooting incident, postincident activity by citizens and/or moving traffic, postincident activity

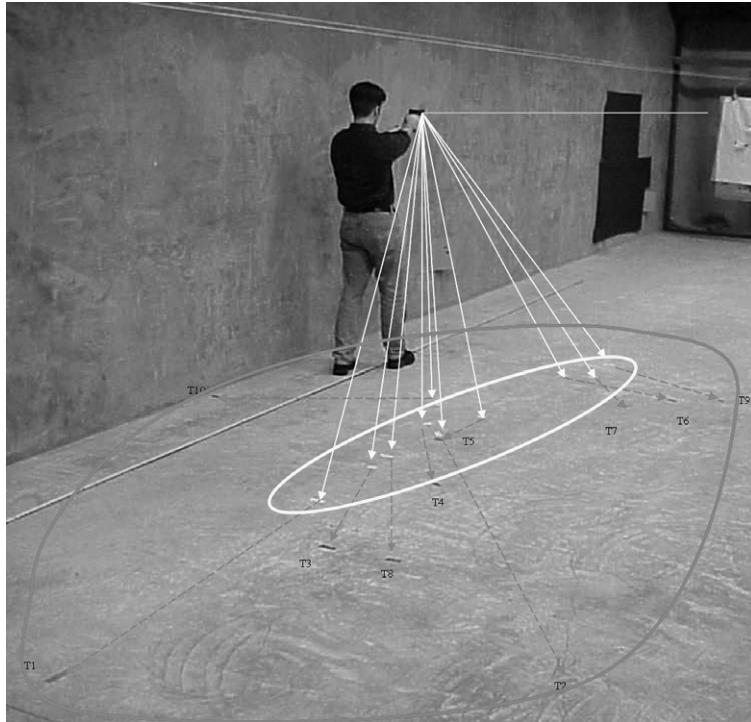


FIGURE 13.55 Consideration of firearm ejection patterns associated with certain firearm designs can contribute to limiting shooter positions along an established bullet path. The small oval represents the location where ejected cartridge cases first struck the smooth concrete surface of the testing area. The larger oval represents the final resting positions of the ejected cartridge cases after bouncing on the hard concrete surface. The smaller oval represents the distribution of cartridge cases that would likely land in soft, giving surfaces, such as sand, soft dirt, or grass, where little bounce is expected. The larger oval represents the distribution of cartridge cases on hard, unforgiving surfaces, such as concrete or asphalt, where significant bounce is expected.

of emergency personnel responding to the scene, and postincident activity by police and investigative personnel.

PRESENCE OF INTERVENING OBJECTS ALONG BULLET PATH

The presence of a wall or other large intervening object, such as a tree or large vehicle, along the bullet path may further limit the possibilities, even though the height of the bullet path is still within Zones 1 or 2. The hood of an automobile may restrict a shooter's ability to fire shorter range shots into the windshield within Zone 1, depending on his or her ability to reach over the hood.



FIGURE 13.56 The presence of ejected cartridge cases associated with known ejection characteristics of the rifle used in this shooting reconstruction restricted the shooter to the area of the doorway as the most likely shooting position even though there were many shooting positions possible, both forward and rearward, along these bullet paths. This scene was reconstructed by (1) placing several boxes with bullet holes back in their original positions (in the foreground just outside of this photograph), (2) extrapolating the bullet paths using the probe and string method, and (3) illustrating the location of ejected cartridge cases documented during the initial investigation. Good measurements and photographs were key to making it possible to accurately place the boxes and ejected cartridge cases back in their original locations.

SUMMARY

Shooting incident reconstruction is the process of identifying specific events that have occurred during a shooting incident. It also provides explanations of how those events happened through careful consideration of investigative information and its correlation with the physical evidence. The entire process is dependent on gathering information from a variety of investigative and physical evidence sources. Additionally, the process is cyclical in that as information becomes available, questions emerge, and these questions prompt investigation, research and/or analysis, and testing of possible solutions to resolve the problems that arise. The information is evaluated continually, and reconstruction of the incident evolves through a process of elimination as answers to these questions are provided. The end product of this process is

1. Elimination of events that are impossible
2. Consideration of events that are improbable but possible
3. An offering of events that are most probable and best supported by the evaluation of the evidence available

Reconstructionists should be aware of various specific shooting incident or firearm-related phenomena that offer reconstructive information. When integrated with other forms of physical evidence and other sources of investigative information, an understanding of the events that occurred is the reconstructive process. Physical evidence considerations include firearms; ammunition; projectile holes, impact sites, and ricochets; projectile paths; shooter locations, positions, and orientations; gunfire involving vehicles; shotgun evidence; and crime reconstruction in shooting incidents.

QUESTIONS

1. Explain the difference between perforate and penetrate.
2. What is “squaring the vehicle” and when is it necessary?
3. List the four categories that are useful in considering the potential for reconstructive information from impact surfaces.
4. Explain the difference among primary impact, secondary impact, and terminal point.
5. Define the Chisum trail.

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14

Shooting Incident Reconstruction

Part II

*Bruce Moran***Key Terms****Choke; Gauge; Shotgun bore; Squaring the vehicle; Vehicle orientation**

This chapter discusses advanced applied concepts of shooting incident reconstruction. It also assumes a basic level of firearms knowledge on the part of the reader. Major topics include shooting incident reconstruction in consideration of gunfire involving vehicles, issues associated with shotguns, the use of diagrams and illustrations, participant clothing, autopsy protocol review, crime scene report review, crime lab protocol review, witness statement corroboration, and reconstruction through role play.

GUNFIRE INVOLVING VEHICLES

Vehicles, because of their mobility, confront the reconstructionist with additional considerations. They can be involved as a platform from which gunfire can be directed, as well as a receptacle for receiving fired bullets and related ammunition components. Scenes involving automobiles that have been struck by bullets or had firearms discharged in them are quite common. Because of their mobility, the author considers a vehicle a crime scene *within* a crime scene and treats them as a subset of an overall shooting incident.

Documenting and Reconstructing a Moving Crime Scene

The examination of vehicles requires considerations that are both unique and challenging when compared to other shooting scene environments. For instance, construction of the modern-day vehicle offers a multitude of materials that include sheet metal, steel and/or aluminum support members, tempered safety glass windows, laminated glass windshields, a

variety of plastics, insulation materials, foam padding, upholstery, rubber moldings, weather strips, and card stock (Garrison, 2003). These materials introduce numerous frangible, malleable, hard, and soft impact surfaces that result in significant variance in both penetration and deflection characteristics (Haag and Haag, 2004). Additionally, auto body components such as doors provide anything but a homogeneous medium for receiving bullets. They contain window rolling mechanisms, internal locking mechanisms, remote control devices, electrical harnesses, soundproofing, and support members.

Bullets often strike these complex arrangements of internal parts concealed from view. To the unwary examiner, this may result in erroneously estimated bullet paths through the auto body components in which they are contained, if such hidden intermediary targets go undetected.

The aerodynamic design and styling features of vehicles also offer a unique problem in the determination of projectile paths. Unlike walls, floors, and ceilings in a structure or the edge of a sidewalk and a telephone pole in a street shooting, there are no true coordinate reference points available for measurement of projectile defect locations or for projectile path determination in a vehicle.

Squaring the Vehicle

To orient the reconstruction of events within a vehicle, the examiner must create a set of artificial vertical and horizontal coordinate reference points. To accomplish this, the vehicle can be referenced to three principal axes: its longitudinal axis from front to back, its vertical axis, and a width axis. Establishing a common reference point along these three planes allows the location of bullet defects and bullet paths associated with those defects to be described accurately in three-dimensional (3D) space.

Once these common reference points are established to specific locations on the vehicle, they can then be used to plot the location of bullet defects and their associated bullet paths capable of correlation with its surroundings relative to the orientation of the vehicle at the scene. This approach is referred to as either **squaring the vehicle** (Haag and Haag, 2004) or placing the vehicle in a box.

One technique used to square the vehicle involves establishing the extreme limits of the vehicle's length and width by surrounding it with lengths of string stretched tautly among four tripods. These tripods serve as the corners of the box. They are placed so that the string is just touching the front bumper, rear bumper, and both sides of the vehicle. The strings must also be parallel to the longitudinal axis of the vehicle and a plane perpendicular to the longitudinal axis (Garrison, 2003). All measurements are then referenced to these lines. Vertical or height measurements are referenced to ground level. However, keep in mind that these measurements are relative to the height and attitude of the vehicle in the conditions in which it is being measured, either at the scene or at some other location.

An alternate vehicle squaring method used by the author involves selecting a location on the vehicle (such as the edge of a door) to establishing a vertical reference line using a 4-foot level marked with colored masking tape (Figure 14.57). A second reference line parallel to the axis of the vehicle (measured from the wheel hubs of the vehicle) is also established (Figure 14.58).

These artificial coordinate reference lines are then located in the vehicle diagram and used to locate subsequent projectile holes and defects throughout. Defect locations can then be measured using tape measures from these references with the employment of levels and plumb bobs (Figure 14.59). Angle measurements in both the azimuth and vertical planes can be accomplished using a variety of protractors, levels, and plumb bobs (Figure 14.60). This technique

FIGURE 14.57 Note vertical and axial reference lines for plotting the location of bullet defects and measuring azimuth and inclination angles of bullet paths.

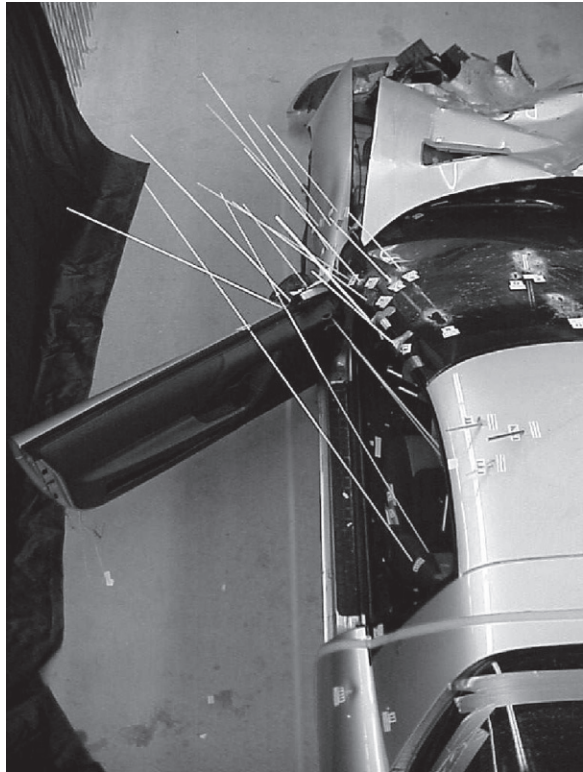


FIGURE 14.58 An artificial reference line is established by snapping a chalk line at known distances from the axles of the vehicle. Colored masking tape is applied to the line for better visualization, as seen here.



lends itself well to accurate location of bullet holes, defects, ricochets, and measurement of bullet paths at or through these locations. It is also sufficient to plot bullet paths in 3D computer-aided diagrams (Figure 14.61).

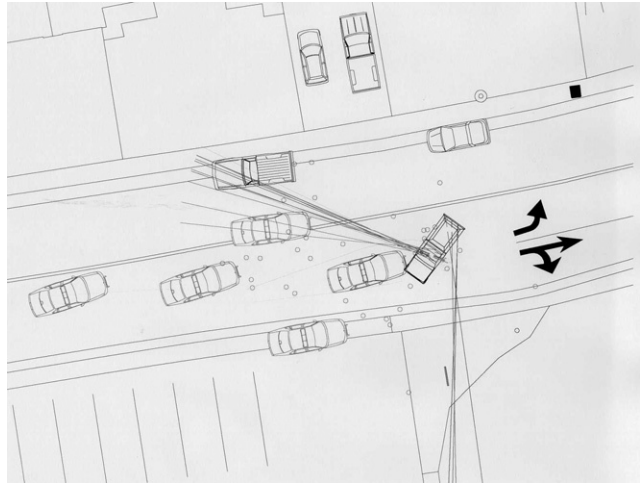


FIGURE 14.59 A 4-foot level, measuring tape, and plumb bob are used to accurately plot the location of bullet holes using the reference line. Measurements taken using this method can generate accurate scaled computer-aided design (CAD) diagrams of the bullet paths through the vehicle that can be imported into other scaled CADs of the shooting scene.



FIGURE 14.60 A protractor is employed to measure azimuth angles of various bullet paths represented by probes in this vehicle. Note the longitudinal reference line on the ground and a parallel reference line using string between two tripods that can be slid up and down to the various heights of the probes for convenient/accurate measurement with the protractor.

FIGURE 14.61 Computer-aided designs illustrating accurate to-scale reconstructions can be prepared from hand-drawn diagrams when appropriate. In this example, a scaled CAD of bullet paths in a vehicle prepared by the author was imported into a scale CAD of the entire shooting scene prepared by the investigating police agency. The bullet paths were then extrapolated throughout the scene for further study.



Vehicle Orientation

Vehicle orientation, or its position relative to the bullet path and the ground, is influenced by a number of factors.

Vehicles are often moving when struck by bullets. Vehicle movement can change both orientation and attitude. While a vehicle is in motion, the suspension systems, as well as centrifugal and acceleration/deceleration forces, cause it to sway and tilt in multiple alignments. These alignments are further complicated when the vehicle is traveling over changing and uneven terrain.

Stationary vehicles do not often rest on level surfaces: they may be parked on crowned areas of road, they may be oriented in nonlevel positions when straddled over curbs, or they may simply be parked on uneven ground.

Tires struck by bullets may deflate and alter the level of the vehicle as well. This depends on multiple variables, including the design of the bullet. Resulting bullet holes may cause total deflation of a tire within a second or two or a very slow deflation lasting 15 or 20 minutes.

All of these variables must be established and considered while evaluating vehicles that have been struck by fired bullets/projectiles. It is therefore prudent for the reconstructionist to make a concerted effort to inquire into the full circumstances of the shooting incident. Knowledge about the orientation of the vehicle when it was struck, as well as a review of any photographs or video taken of the vehicle at the scene, is necessary for the identification of as many of these variables as possible. These must be taken into account prior to estimating the most probable bullet path angles (Figures 14.62–14.63). When vehicles are transported from a shooting scene prior to examination for the purpose of reconstructing bullet paths, making the aforementioned inquiries becomes even more important (Haag and Haag, 2004).

Drive-By Shootings

Drive-by shootings, which involve a moving vehicle, are a common occurrence in the United States. In these situations, expended cartridge cases are often dispersed from the moving vehicle, while at the same time the vehicle is potentially receiving incoming bullet strikes from shooters



FIGURE 14.62 Vehicles present additional challenges to the reconstruction of bullet paths due to their mobility, flexible suspension, and travel over varying terrain when receiving fired bullets. Bullet paths registered in vehicles are relative only to the vehicle at the moment it is struck in whatever orientation it may be in, given the previously mentioned conditions. Therefore, it is important to document the orientation of the vehicle while still at the shooting scene to account for as many variables as possible. In this case, the author used a laser level device on a short tripod as a reference beam relative to the height of the edge of a roadway to document the longitudinal inclination of the vehicle body using the axles as reference points.



FIGURE 14.63 The lateral tilt of the vehicle is measured using an inclinometer at the scene to document its orientation relative to the terrain, which can later be used to correct estimated bullet paths determined after the vehicle is towed.

outside of it. Although challenging, the distribution of fired cartridge cases recovered at the scene can be used to reconstruct, indirectly, the approximate speeds of a vehicle (Haag, 1988) and its position in the roadway. Generally, these reconstructive estimates are made by conducting controlled experiments to create ejection patterns on the same or similar surfaces as the shooting scene with a known firearm in a known orientation and height, using the same ammunition. The resulting distribution of cartridge cases on the test surface is then compared to the distribution of cartridge cases recovered from the scene to estimate the speed of the vehicle. From reported studies (Garrison, 1993; Haag, 1988), it is generally known that increasing the speed of the vehicle increases the scatter of the cartridge cases as they continue to move to their final resting places from the launch or ejection point. Ideally, these patterns represent longer and wider ovals as vehicle speed increases (Garrison, 1993).

Garrison (1993) suggests a general rule for estimating vehicle speed (p. 20): “ten miles-per-hour means that a car or cartridge case is moving at roughly 15 ft per second, or about an average car-length per second. Twenty MPH translates to two car-lengths per second, 30 MPH to three, 40 to four and so on.” This is based on cartridge cases dropped from a moving vehicle. Although these data do not simulate cartridge cases actually ejected from a vehicle that has the added effects of the speed and direction of the ejection forces from the firearm itself, it can be helpful for conservative estimations of vehicle speed.

If the direction and approximate speed of the vehicle can be determined with some degree of confidence, the measured bullet path azimuth angles in the vehicle, and the use of trigonometry to estimate the change in azimuth angle to the speed of the vehicle, can assist in estimating the approximate direction from which shots were fired. Conversely, if the shooter position outside the vehicle can be established at a fixed location, then the azimuth angles in the vehicle and trigonometry can be used to calculate the change in azimuth angle to the speed of the vehicle.

The reader is cautioned that these are estimates solely dependent on the reliability of data being used to make such calculations. Such parameters in making these estimates should be well qualified and included in any conclusions made from these estimates.

SHOTGUN EVIDENCE: RECONSTRUCTION CONSIDERATIONS

An extensive descriptive treatment of shotgun design and shotshell construction is beyond the scope of this chapter; however, certain reconstructive considerations related to their design and ammunition deserve our attention.

Shotgun Bore

Shotguns were originally developed for hunting small game animals and birds by discharging numerous spherical balls, referred to as *shot*. They differ from rifled long arms and handguns in that they are equipped most commonly with a smooth bore rather than a rifled bore. The size of a shotgun's bore (barrel diameter) is expressed in terms of **gauge**. The most common gauges in modern-day shotgun design are 12 gauge [0.730 in. (18.5 mm)], 20 gauge [0.615 in. (15.6 mm)], and 410 gauge [0.410 in. (10.4 mm)]. Less common gauges include 10 gauge [0.775 in. (19.6 mm)], 16 gauge [0.670 in. (17.0 mm)], and 28 gauge [0.550 in. (14.0 mm)].

The bore may contain a constriction at the muzzle end called **choke**, designed purposely to control the spread of the shot when it leaves the barrel. Choke has a direct bearing on shot dispersal patterns. The amount of constriction, in increasing order, is referred to as cylinder, improved cylinder, modified choke, and full choke. This is typically designated on the shotgun and should be noted.

Some shotguns are equipped with a polychoke mechanism on the end of the barrel that allows for adjustment of the choke. It acts like the nozzle of a hose, increasing and decreasing shot spread at the will of the shooter. The position of this mechanism should be documented by photography and noted at the scene before the weapon is touched.

Shotgun Ammunition

Standard cartridges are composed of a cartridge case, primer, gunpowder charge, and, in most cases, a single projectile. However, shotgun shells present a much more complex arrangement of components. These includes various sizes and compositions of shot, shot wads, shot cups, shot collars, and buffering materials. Additionally, these components are produced in an extensive variety of configurations and various materials. However, because of the endless variety of shotshell designs, and the physical dynamics of how these materials interact with the shooting scene environment, much can be gleaned that is helpful for reconstructing events.

Dynamics of Shotgun Evidence at Shooting Scenes

A load of shot fired from a shotgun, due to its aerodynamic qualities, loses velocity rapidly and spreads outward over the distance traveled. Relatively speaking, the maximum range of shot is measured in yards. This is true even when the largest of buckshot loads are fired, whereas single bullets from a rifled firearm can travel several miles in some cases. The rate of shot spread and the resulting size of the shot pattern are controlled predominantly by the distance shot pellets travel and choke. Gauge is generally not a factor in determining the spread size.

In addition to the expulsion of shot, numerous wads and buffer material are also propelled from the muzzle, along with the burned and partially burned propellant powder products. These materials travel considerably shorter distances than shot or slugs. Propellant powder may expel only a few inches or feet, whereas buffer material may expel from 75 to 100 feet (in the author's experience) depending on wad/shot cup designs. It is the relatively shorter range "exterior ballistics" exhibited by shotshell components that are of greatest value in shooting incident reconstruction. Furthermore, if the gun and ammunition are available, these components can be studied, measured, and used to answer specific questions developed in the reconstructive process.

A progression of general observations concerning the ballistic characteristics of these components, with approximate distance traveled (when the surface struck is perpendicular to the direction of component travel), are described as follows.

Contact

Contact with a head will result in significant blast damage, causing extensive tearing of the skin and fracture of bone. Contact wounds to the trunk, however, are relatively nontraumatic in appearance (Di Maio, 1999). The entire contents of the shotshell enter the wound tract in skin and

tissue or objects struck, causing a single hole. The majority of any soot and powder particles is deposited on the interior surface of the object and/or driven into the wound along with the wads and shot. Some heat searing and blackening from the hot gasses may be present around the edges of the entrance hole. An imprint of the muzzle may also be registered on the surface of the skin around the periphery of the hole.

Close Range (>0–12 Inches)

At near contact to distances of a few inches, the contents of the shotshell enter the wound tract or object struck. Dark, dense to light gray sooting with deposits of unburned and partially burned powder particles (along with buffer material, if present) are present around the single entrance hole.

Blast destruction (still prominent in the skull area) (Di Maio, 1999) on skin in some cases, as well as powder tattooing and/or heat damage on clothing (including melting of synthetic fabrics), occurs around the immediate region of the entrance hole.

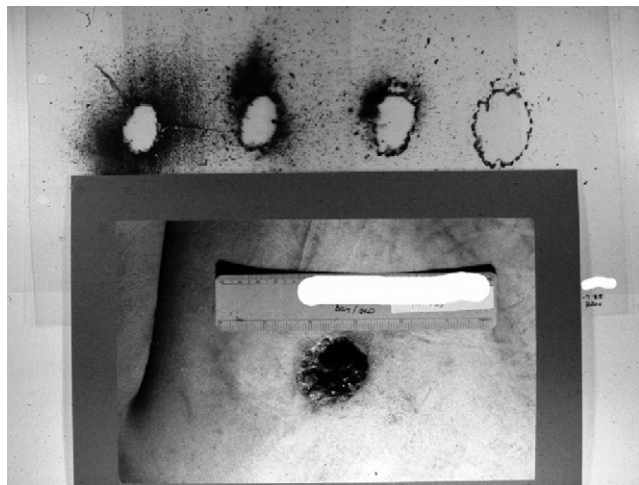
Intermediate Range Zone I (1–2 Feet)

At intermediate range distances of 1–2 feet, the contents of the shotshell are still very likely to enter the wound tract or object struck. Sooting is likely to be diminished greatly or undetectable at this distance; however, the heavier unburned powder particles and buffer material (if present) will be deposited in a roughly circular pattern around the periphery of a single entrance hole. These particles may be embedded in the weave or adhered loosely to the fabric surface.

Intermediate Range Zone II (2–3 Feet)

At intermediate range distances of 2–3 feet, the contents of the shotshell are still very likely to enter the wound tract or object struck. The single entrance hole may begin to exhibit scalloping around the edges as the pellets begin to spread outward, but this is insufficient to create individual pellet holes (Di Maio, 1999) (Figure 14.64). Sooting is no longer present, and heavier, more aerodynamic unburned gunpowder particles, as well as buffer material (if present), are likely to

FIGURE 14.64 The single entrance hole created by this shotgun wound exhibits indications of the beginning of individual pellet holes at the margins. This is generally typical at distances of approximately 2–3 feet. In this case, the author concluded that the muzzle-to-wound distance was approximately 2 feet after comparing the morphology of the wound pattern to test patterns produced at known distances and angle using the responsible shotgun and ammunition.



be deposited in an increasingly less detectable and roughly circular pattern around the periphery of the entrance hole. These heavier particles, if present, are likely to be adhering loosely to fabric. At this distance, it is significant to note the following observations reported by [Haag and Haag \(2004\)](#) and observed by the author.

Combination wads equipped with petaled shot cups (commonly manufactured in the United States) will open as they are subjected to wind resistance. Then, due to their very lightweight and rear-end center of gravity, they will travel rear-end forward. Combination wads of this design will consistently cycle in this manner within the first 3–4 feet of travel after leaving the shotgun muzzle and therefore have significant reconstructive value. For example, the configuration of impact marks on these one-piece wads is quite characteristic and can resolve muzzle-to-target distance questions of 1 foot versus 2 or 3 feet. These telltale rectangular “slap” marks, when they appear on skin or clothing items, strongly suggest this restricted 2- or 3-foot range of distance. At less than 1 foot, the petals have not opened, and at 3–4 feet there will be an absence of a slap mark because the wad is now fully rotated to its side and then turned on end ([Figures 14.65–14.67](#)).

Intermediate Range Zone III (3–6 Feet)

At this distance, the shot pellets are still traveling in a tight group; however, a few pellets begin to separate to form individual pellet holes. Additionally, wads or shot cups with the least aerodynamic qualities begin to veer off from the shot column and strike the target surface, creating a variety of patterns depending on the design of the wad or shot cup and the angle at which they impact. These strike marks can often be observed readily with the unaided eye or, if associated with lead shot, can be visualized using the sodium rhodizinate reagent ([Figure 14.68](#)).

Distant Range Zone I (6–100 Feet)

At more distant ranges, the column of shot pellets will elongate as well as spread in a predictable manner with increased distance traveled. The rate of spread will be affected by the choke restriction of the **shotgun bore**. A general guide to these rates of spread is summarized in [Table 14.1](#). Depending on their aerodynamic qualities, shot wads or shot cups are capable of

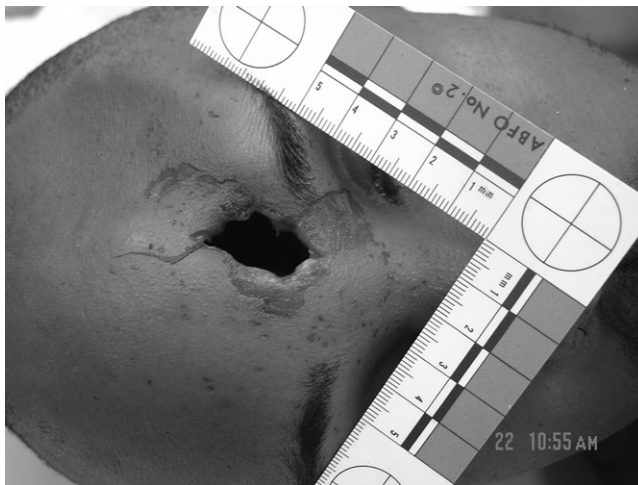


FIGURE 14.65 Telltale slap marks were observed around the periphery of an entrance wound to the decedent’s forehead involving a .410-gauge shotgun loaded with a shotshell containing #4 shot and a plastic tripetal combination wad. Powder stippling/powder tattooing can also be observed around the entrance wound. Photo printed with permission of Faye Springer.

FIGURE 14.66 A plastic tripetal combination was used in shotshells fired in suspect shotgun. Photo printed with permission of Faye Springer.

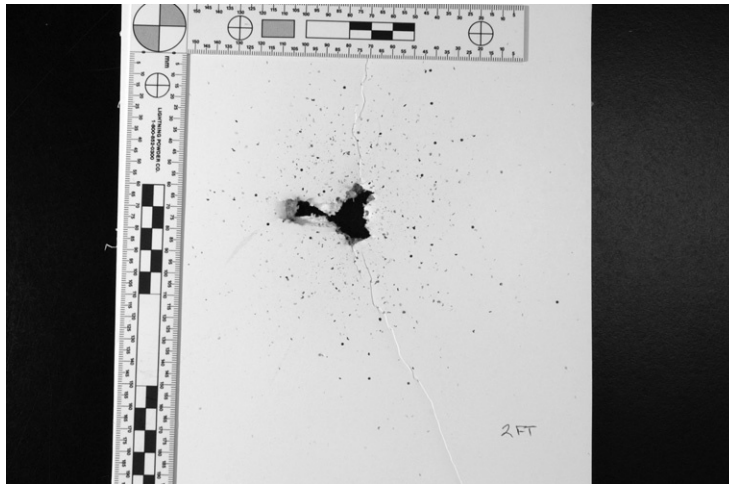
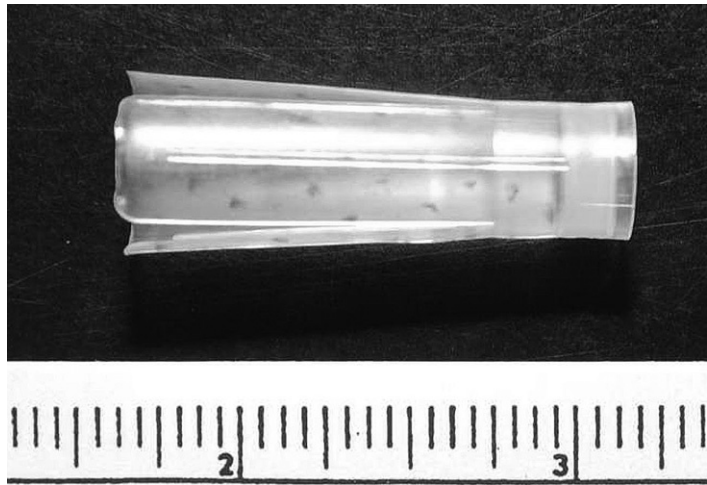


FIGURE 14.67 Using the suspect shotgun and the same ammunition, test patterns were produced with very similar slaps marks and gunpowder patterns at distances between 18 and 32 inches and were used as a basis to estimate the muzzle distance of the shotgun from the decedent's head at the instant the fatal shot was fired. This pattern was produced at a 24-inch distance. Photo printed with permission of Faye Springer.

traveling approximately 100 feet. At these distances, however, the chances of detectable strike marks are increasingly diminished. Additionally, they will often significantly veer from the path of the shot pellets and fall with little consequence to the ground.

Distant Range Zone II (>100 Feet)

Pellets will continue to spread at rates generally indicated in [Table 14.1](#). At distances greater than 120 feet, however, the patterns become increasingly diffuse and undecipherable and do not provide reliable reconstructive information. Eventually, depending on the size and composition

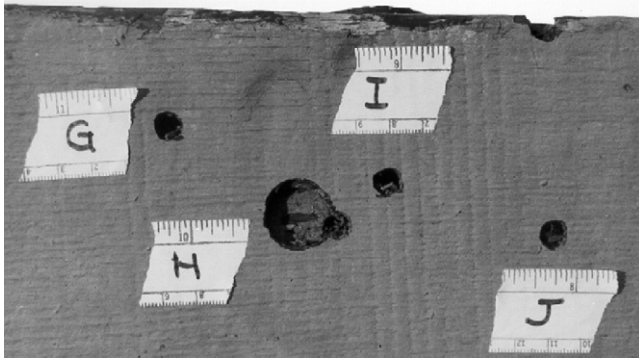


FIGURE 14.68 Note the impression of a plastic wad in this wooden sign among several buck-shot holes. Such impressions can be an indicator of distance traveled in addition to the pattern of the shot pellets.

TABLE 14.1 Nominal Shot Pattern Diameters (Inches)

Choke	Amount of constriction	Common name	Range in yards							
			10	15	20	25	30	35	40	
Cylinder bore	None	Cylinder bore	19	26	32	38	44	51	57	
Quarter choke	.010"	Improved cylinder	15	20	26	32	38	44	51	
Half choke	.020"	Modified	12	16	20	26	32	38	46	
Three-quarter choke	.030"	Improved-modified	10	14	18	23	29	35	43	
Full choke	.040"	Full choke	9	12	16	21	26	32	40	

of the shot pellets, gravity and wind resistance overcome their forward movement and they reach a maximum distance of travel. A summary of maximum range for various sizes of shot calculated from Journee's formula is provided in [Table 14.2](#).

Maximum distance traveled, as suggested by [Haag and Haag \(2004\)](#), has reconstructive value in cases where the potential for cause of injury from shot pellets striking victims is in dispute, for example, when a shooter claims to have fired in the direction of another person or persons, but the pellets failed to strike them. Tests can be conducted with the shotgun in question and the same ammunition involved to determine the maximum range. If the maximum range is less than the reported distance between complainant and defendant, then there may be merit to the defendant's claim.

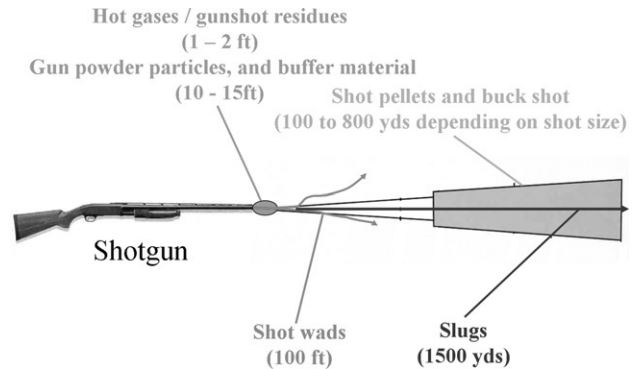
Note that the previous observations are approximate and should be used only as a general guideline in estimating muzzle-to-target distances (see [Figure 14.69](#) for a graphic representation of maximum distances of fired shotshell components). Additionally, these observations are only applicable for patterns produced with smooth bore shotguns. Shotguns equipped with rifled bores (designed for use with rifled slugs) produce dramatically different patterns from smooth bores when shotshells are fired. [Besant-Mathews and colleagues \(1992\)](#) characterize these patterns as unconventional in their appearance and significantly larger than those for smooth bore shotguns given the same ammunition and distance. Patterns formed generally resemble "hollow circle," "double doughnut," or "circle-and-central" configurations. It is theorized that the shot

TABLE 14.2 Maximum Ranges for Various Sizes of Shot (Calculated from Journee's Formula^a)

Shot size	Diameter (inches)	Maximum range (yards)	Shot size	Diameter (inches)	Maximum range (yards)
12	.05	110	2	.15	330
11	.06	132	Air rifle	.175	385
9	.08	176	BB	.18	396
8.5	.085	187	#4 Buck	.24	528
8	.09	198	#3 Buck	.25	550
7.5	.095	209	#1 Buck	.30	660
6	.11	242	#0 Buck	.32	704
5	.12	264	#00 Buck	.33	726
4	.13	286	#000 Buck	.36	792
Rifled slugs	All gauges	≈1500 yards			

^a Calculated from Journee's formula, which gives the maximum range (in yards) as the product of the shot diameter (in inches) multiplied by 2200 ($r = 2200d$, where r is the range and d is the diameter of shot).

FIGURE 14.69 This illustration provides a general guideline of maximum distances that shotshell components can travel. These distances will vary to some extent depending on the type of shotgun, the length of the barrel, and the type of ammunition used. The reader is cautioned that these distances are approximate in nature and should be used only as a general guideline in estimating muzzle-to-target distances in the field. Testing with the responsible shotgun and ammunition used, if available, should be conducted whenever possible to ensure the most reliable estimate of muzzle-to-target distance.



load engages the rifling, creating a rotation and thereby imparting a centrifugal (tangential) force on the pellets, causing them to spread outward more rapidly than when fired from smooth bore shotguns (Figure 14.70).

Estimating muzzle-to-target distance is most useful when an entire load of pellets/buckshot has struck a surface of interest. However, this will not always occur in a shooting incident. Even with partial patterns, it is possible to estimate range of fire by studying the distances among individual pellets. Studies have demonstrated that such separations between individual pellets with distance traveled are predictable (Haag, 2002).

Some interesting characteristics of double aught (#00) buckshot patterning are also useful in estimating muzzle-to-target distances when partial patterns are encountered. Double aught

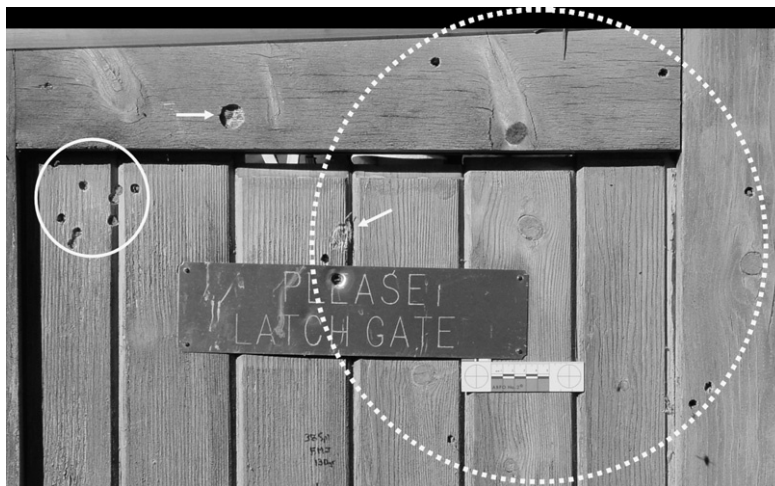


FIGURE 14.70 Shotshells containing shot pellets fired from rifled shotgun bores (normally designed to fire slugs) produce dramatically different patterns from those fired from smooth bores. The patterns formed resemble “hollow circle” or “doughnut”-like patterns with significantly more spread (right) at the same given distance as patterns from smooth bores (left), as seen in this example of buckshot fired into a wooden gate. Also, note the impact of shot wads (arrows).

buckshot is typically contained within the shotshell in stacked sets of three. The buckshot produces a series of triangular configurations within an overall circular pattern. Distances among these triangles are also repetitive and predictable with distance. Even partial patterns exhibiting these triangular “subpatterns” can be used as a basis for estimating distance by direct comparison of test patterns.

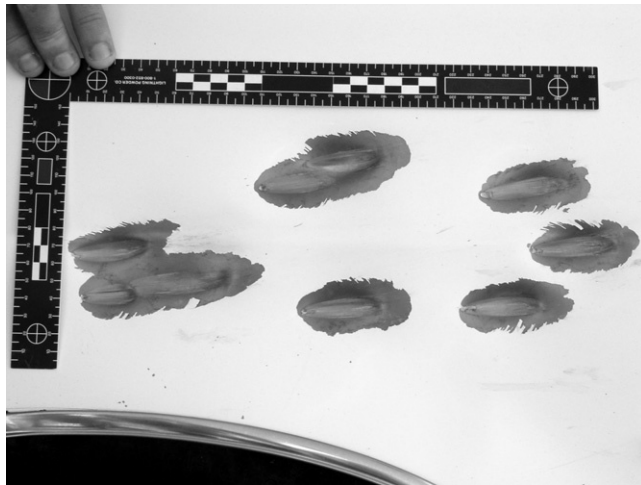
Shotgun loads fired at flat surfaces at angles other than perpendicular will produce an elliptical pattern that can be used as a basis for estimating the angle of impact by dividing the oval width by the length and calculating the arc sin value of this ratio (Figure 14.71). The same approach can be used to calculate the impact angle from entrance holes produced by individual shot pellets when dealing with incomplete shot patterns. Probing pellet/buckshot holes to empirically estimate impact angle can be used as a cross-check to the calculated estimate derived from the overall pattern shape.

DIAGRAMS AND ILLUSTRATIONS

Field sketches are an important supplement to photographic documentation in accurately locating items of evidence, the direction of projectile paths, establishing the relationship of items to each other, and other significant observations. The degree of attention given to this form of documentation will often dictate the degree of success when considering reconstruction issues in shooting incidents.

Field sketches and illustrations documenting bullet path directions do not have to be works of art, but they should be adequate enough to ensure that the reviewer of the diagram will be able to clearly determine the location of projectile defects and the direction of the responsible

FIGURE 14.71 Shotgun loads fired at flat surfaces other than perpendicular angles will produce an elliptical pattern that can be used as a basis for estimating angle of impact by dividing the oval width by the length and calculating the arc sin value of this ratio. Note the characteristic pinch points on the left edges of the defects produced by nine buckshot balls and boat-wave-fractured edges of the paint surrounding them, indicating a left-to-right direction of travel at a low incident angle.



projectile(s) that created those defects. Documentation should be adequate to facilitate the preparation of formal crime scene diagrams, computer-aided design (CAD) scale diagrams, and, in some cases, 3D computer-drawn reconstructions (see [Figure 14.61](#)). Diagrams drawn to scale can be used effectively for illustrating the potential location of a shooter along plotted bullet paths as a function of the shooter's height.

Two types of sketches are especially useful for documenting shooting scenes and facilitating CAD and 3D reconstruction diagrams.

Overhead Projection Diagram

The overhead projection diagram provides a bird's-eye view of evidence item locations and projectile paths ([Figures 14.72](#) and [14.73](#)). These diagrams are useful in depicting not only the location of firearm-related physical evidence items, such as firearms, fired bullets and cartridge cases, bullet holes, and other projectile impact sites, but also their positional relationship to each other. Just as important, they illustrate the relationship of firearm-related evidence to other forms of physical evidence that contribute to the overall reconstruction of a shooting incident.

The location and position of objects at the scene that have bearing on the circumstances of the shooting incident, such as furniture, doorways and windows, and areas of disturbance in indoor scenes, are easily observed in the overhead projection diagram. This view is also conducive to plotting of the azimuth directions of bullet paths and for providing reconstructive information related to the location of shooters and participants receiving gunshot wounds. The diagram is also very useful in orienting the reconstructionist to the overall layout of the scene and facilitating the correlation of crime scene photographs to specific locations and perspective views.

Elevation Diagram

Elevation diagrams provide height perspective views of a shooting scene ([Figure 14.74](#)). These views provide valuable elevation information, such as the height of bullet holes and bullet impact sites relative to objects they have struck and their relation to the height of other objects at

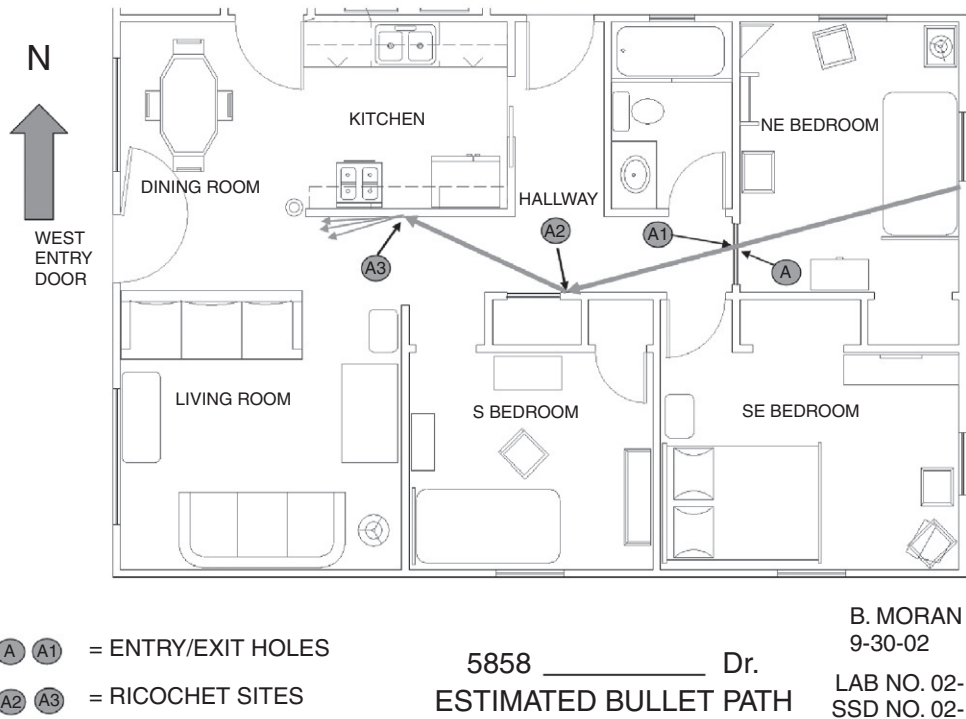


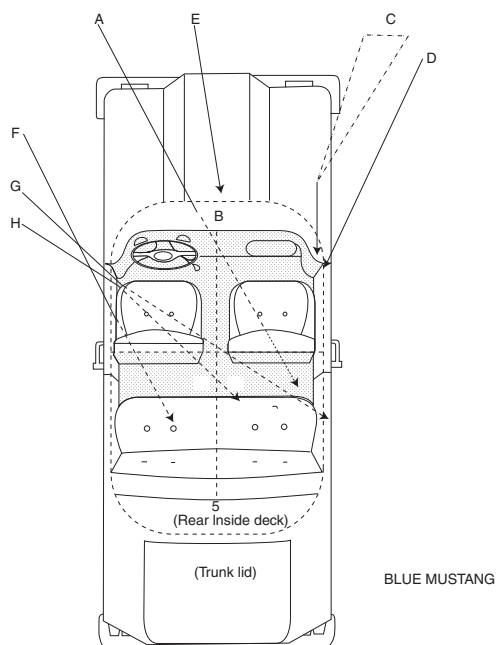
FIGURE 14.72 Finished drawings such as the illustrated bullet path in this residence can be prepared from a hand-drawn sketch but are not essential to the successful outcome of the shooting scene investigation. They can, however, be quite useful for informing a jury in court. The author prepared this projection diagram for this purpose with an easy-to-use Broderbund Home Architect 3D drawing program and then annotated it using PowerPoint.

the scene. Moreover, this diagram is useful for plotting the inclinational direction of bullet paths in the scene, as well as any relative ground slopes or contours that could potentially play a significant role in resolving reconstructive issues.

Three-dimensional diagrams prepared with the aid of computer drawing programs are effective tools for illustrating aspects of a shooting scene from any perspective. A variety of CAD and 3D drawing programs are available that allow the reconstructionist to prepare illustrations that can then be manipulated in real time to view a scene from any vantage point (Figure 14.75). Additionally, programs are also available to construct anatomically accurate human figures in any position. Bullet paths can also be plotted through these models as well. Some of these programs allow for importation of these figures into 2D and 3D reconstructed crime scenes and preparation of 3D models from 2D photographs (Figure 14.76).

This author has used some of these programs to great effect when illustrating reconstructed events in shooting incidents (Figures 14.77 and 14.78). Computer animations have also been used with increasing frequency to illustrate both prosecution and defense theories as this technology has advanced in its sophistication, as well as affordability.

FIGURE 14.73 This finished diagram illustrates various bullet paths in a vehicle prepared by scanning a generic vehicle diagram into PowerPoint and using the simple drawing tools of this software program to annotate it.



BULLET PATH DIAGRAM
(NOT TO SCALE)
Drawn by: B. MORAN, 9-24-99
Lab No.

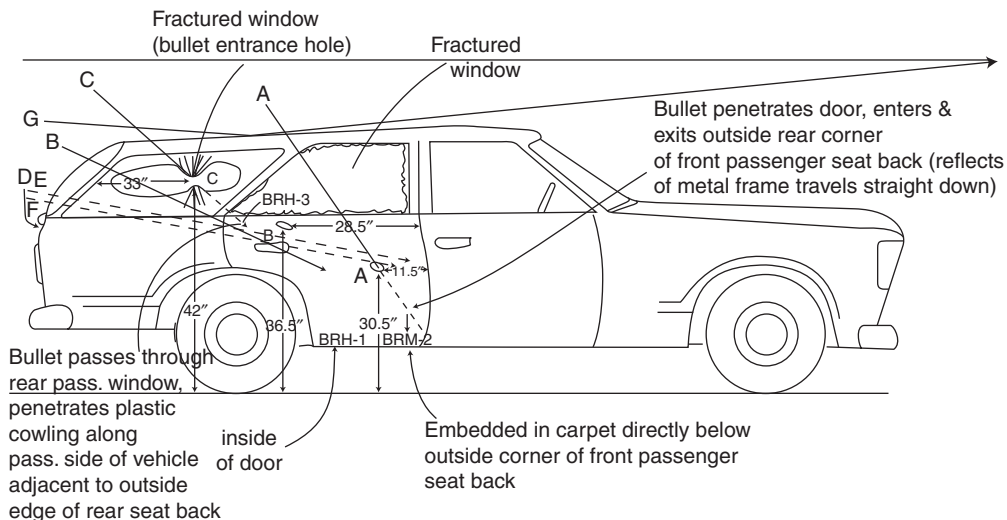


FIGURE 14.74 Elevation diagrams provide height perspective views of a shooting scene and are an essential form of documentation for reconstructing bullet paths. This example depicts several bullets that have entered at the rear and right rear of a station wagon and one bullet that has deflected off the roof of the vehicle.

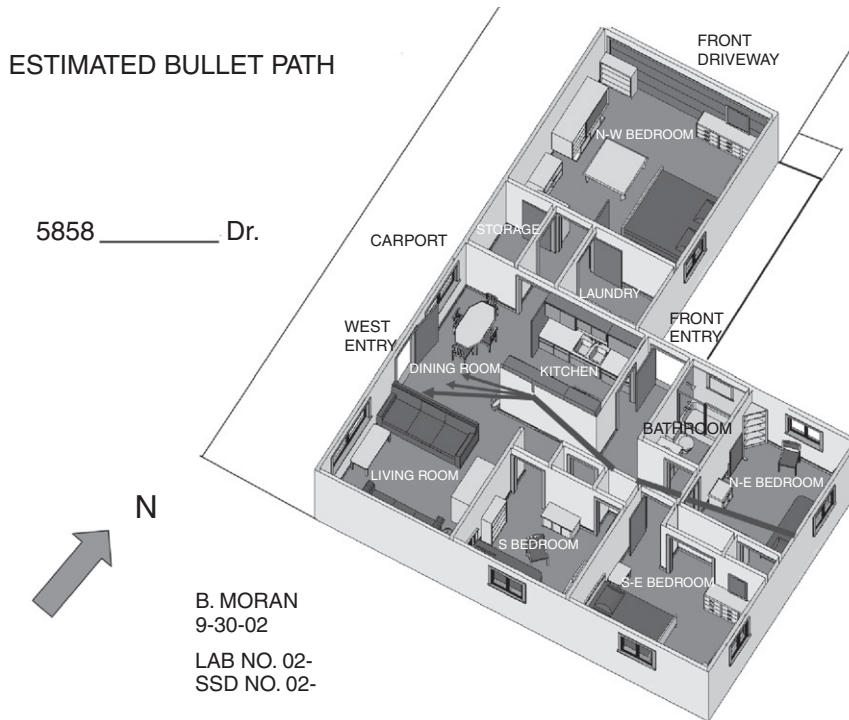


FIGURE 14.75 This 3D perspective diagram of the bullet path in a shooting scene was prepared with the Broderbund Home Architect 3D drawing program and then annotated in PowerPoint. Three-dimensional drawing programs allow the reconstructionist to view the crime scene in any perspective.

CLOTHING OF PARTICIPANTS

Clothing of the participants involved in a shooting incident offers a receptacle for a variety of useful information because it retains evidence such as projectile holes that may exhibit sufficient morphology/trace evidence to decipher entrance from exit, gunshot residue patterns, blood patterns, and damage that can provide significant clues with regard to specific events that have taken place in a shooting incident. Thorough photographic documentation of any blood or gunshot residue patterns is mandatory prior to packaging and transport.

These patterns and their relationship to other items in the scene are significant observations that can be lost easily without such documentation prior to collection and transport of the garment. It is also recommended that permission from the coroner or medical examiner be obtained to remove clothing items from any deceased victims to prevent contamination of pattern evidence. In certain cases, bullets will have sufficient energy to perforate the body but insufficient energy to perforate the clothing and may be found inside clothing.

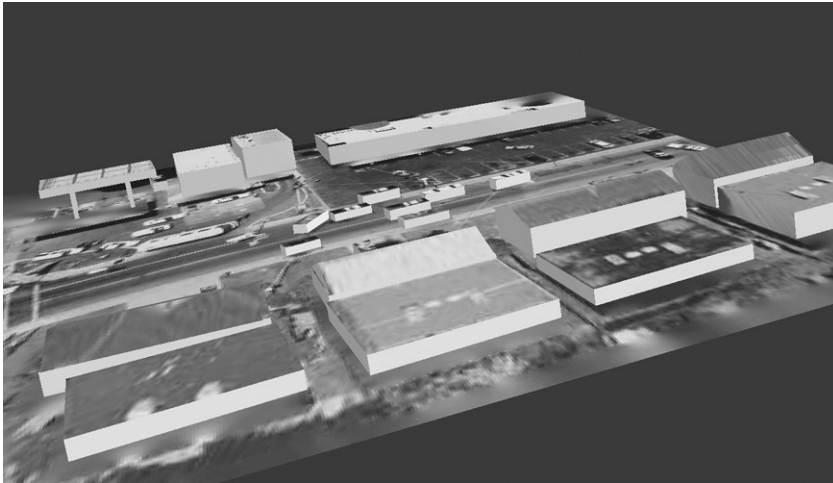


FIGURE 14.76 This three-dimensional rendering from an aerial photo taken over the scene of a shooting incident was produced using the Canoma software program. This software allows the reconstructionist to create a 3D model of a shooting scene from a 2D photograph. The model can then be manipulated into any viewpoint and zoomed in and out to any distance. An animated “fly-through” of the 3D scene can also be produced using this software. These models can also be helpful for reconstructing specific viewpoints of key witnesses/participants involved in a shooting incident to either corroborate or refute their statements.

FIGURE 14.77 This photo depicts a patio area just outside of a kitchen doorway where a fatal shooting occurred with the use of a shotgun. Critical to the case were the position and orientation of the victim and shooter at the moment the fatal shot was fired. The male victim’s dress jacket and personal items are observed in the foreground. An expended shotgun shell is just inside the doorway. Spattered, dripped, and trailed bloodstains are also evident.



REVIEW OF THE AUTOPSY REPORT

A review of the postmortem examination report and photographs is a valuable source of information for integration with other observations made at the shooting scene for reconstructive purposes. The pathologist’s findings in regard to (1) the locations and direction of projectiles

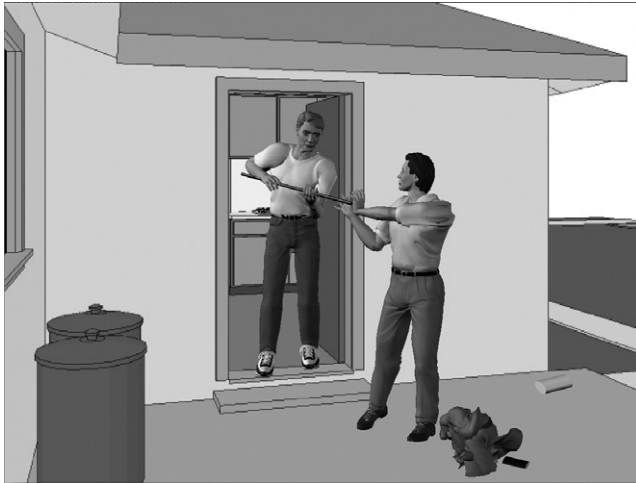


FIGURE 14.78 The author prepared this perspective view of the most probable position/orientation of the shooter and victim at the instant the fatal shot was fired after (1) investigating/processing the original shooting scene, (2) examining numerous items of evidence, (3) reviewing the autopsy report, (4) conducting numerous tests with the shotgun and ammunition used, (5) interpreting numerous bloodstains, and (6) considering statements made by witnesses. The shooter and victim were created using Poser superimposed over this perspective view of the patio area created with the Broderbund Home Architect 3D drawing program.

that have penetrated or perforated the deceased; (2) distance estimations of muzzle to entrance wound(s); (3) the nature of the projectile associated with each wound tract, if any; (4) the presence of any significant pattern evidence in the form of wounds, marks from wads or sabots, tattooing, or cylinder gap patterns; and (5) opinions as to the effect of incapacitation from wounds received can add important information to facts established from examination of the shooting scene. The reconstructionist often incorporates gunshot wounds and their respective paths into or through the victim with bullet path information gathered at the shooting scene (Figure 14.79).

However, the reader is cautioned that there are some inherent limitations and uncertainties associated with wound paths through the human body. Generally, projectiles penetrating or perforating human bodies travel over very short distances prior to striking the victims. Additionally, bullets striking the body may follow straight paths but may deviate as they pass through tissue, organs, and, most notably, bone. High-powered rifle bullets, due to their length and rearward center of gravity, are more prone to deviation from their initial path when penetrating tissue than short pistol bullets that more closely approach a sphere. Consequently, pistol bullets tend to follow straight paths in tissue unless destabilized previously by contact with an intermediary target prior to striking the body or deformed unevenly during penetration of the tissue (Haag and Haag, 2004).

Also, the recipient of a gunshot wound may likely be in some contorted position at the moment the wound is received and then placed in the standard anatomical position on the autopsy table. For a general understanding of wound profiles, the reader is referred to Fackler (2001), who provide a good general background pertaining to the dynamics involved in wounding effects and incapacitation, as well as a variety of diagrammatic examples of wound profiles for various rifle, pistol, and shotgun projectiles.

With these considerations in mind, Haag and Haag (2004, pp. 80–82) emphasize four general sources of information for estimating bullet paths in a gunshot victim: the forensic pathologist's descriptive narrative of the wound path; autopsy photographs; the forensic pathologist's description of bullet entry, exit, recovery site, and organs perforated by the projectile; and additional information, such as X-ray films (radiographs).

FIGURE 14.79 A portion of jacketing recovered from the perforating leg wound of a participant during a postmortem examination was matched physically to the bullet recovered in the floorboard of a vehicle after having passed through the driver's seat cushion. This combined information made it possible to position the gunshot victim in the vehicle at the time the wound was received.



Descriptive Narrative of the Wound Path

Descriptive narratives of the wound path are typically provided in the main body of the forensic pathologist's postmortem report. Some pathologists will include angle references relative to the vertical and horizontal planes of the body, such as "the projectile enters the lower right back directed back to front, upward 30°, right to left 10°, and exiting at the anterior midline of the sternum." These descriptors can be extremely useful for integrating with bullet paths established within the shooting scene to assist in locating/orienting the victim at the moment the gunshot wound was received.

Autopsy Photographs

Obtaining a set of photographs of the postmortem examination is recommended in addition to obtaining the forensic pathologist's report. The photographs should be examined carefully in general and referenced to all observations described by the pathologist. Autopsy photographs depicting probes inserted into the wound track can also be used to estimate the horizontal and vertical angles, provided that the photographs have been taken from the proper perspectives (Figure 14.80). In the event that inappropriate views of the probes are the only photos available, it may be difficult, if not completely unreliable, to make estimates of such angular components of the bullet path in the decedent. If this is the case, the reconstructionist should consult the forensic pathologist who performed the postmortem examination to solicit concurrence with any

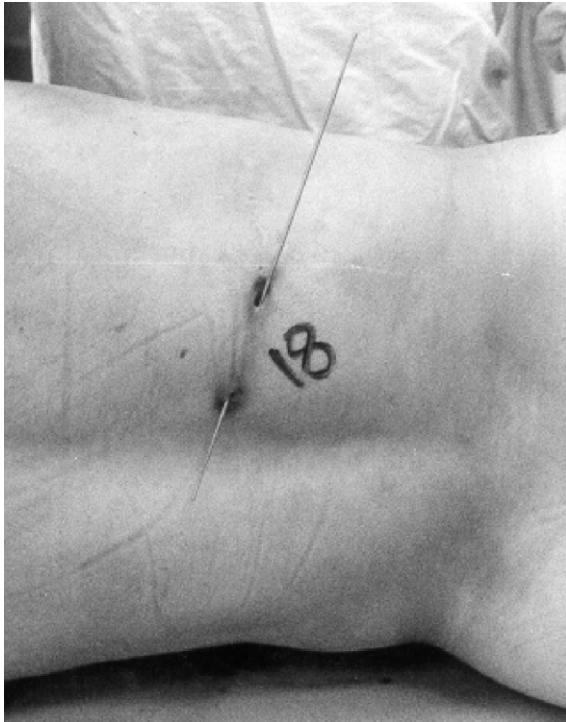


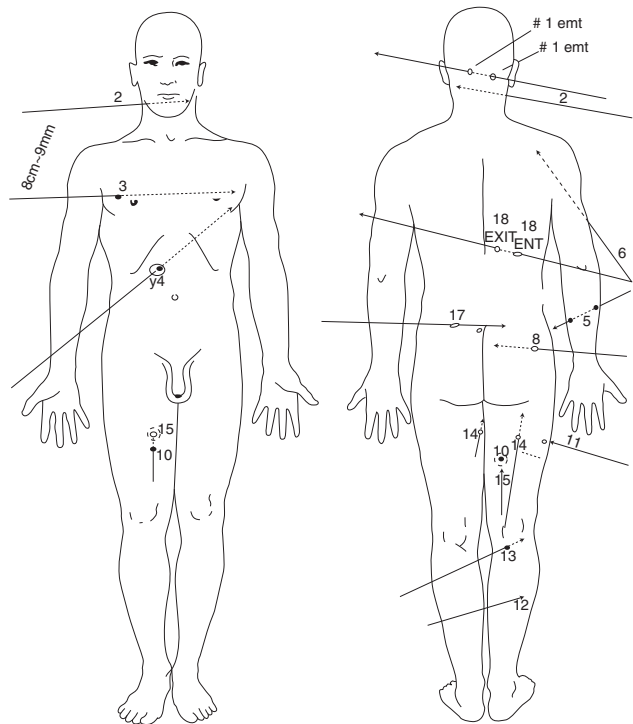
FIGURE 14.80 Autopsy photographs depicting probes inserted into the wound track can be used to estimate the horizontal and vertical angles, provided that they have been taken from the proper perspective. The perspective of this photo is taken at eye level and is perpendicular to the plane of the decedent's back, making it possible to estimate the angle of the bullet path.

estimates made (Figure 14.81). It should also be kept in mind that the wound path represented by the probe may not be a true representation of the actual bullet path if the decedent was in some position other than the supine position on the autopsy table.

Description of Bullet Entry, Exit, Recovery Site, and Organs Perforated

With rare exception, forensic pathologists will document the location of bullet entry wounds, exit wounds, and recovery locations of any projectiles found in the body. These locations are typically referenced with measurements to a common point such as the top of the head and direction of the anterior or posterior midline of the body. Using the length of the bullet track and the measured locations of the entry and exit wounds, it is possible to calculate the vertical and horizontal angles of the bullet path trigonometrically. The measured bullet entry and exit wound locations can be plotted on an anatomical diagram or within a computer model depicting a human body of similar size and weight. The author has had success producing such anatomical computer models and then viewing the model from various viewpoints and/or importing such models into photographs or 3D diagrams of the scene (Figure 14.82).

FIGURE 14.81 In this case, the pathologist narratively described the bullet paths but did not provide any illustrations or photos of the bullet paths. In order to obtain a clearer understanding of the various bullet paths, the author plotted the bullet paths using this anatomical diagram based on the pathologist's narrative descriptions of the wounds received by the decedent. The author then presented the diagram to the pathologist to verify the accuracy of the represented bullet paths before drawing reconstructive conclusions from this source of information.



X-Ray Films (Radiographs)

X-rays of the body can provide useful information, such as a visual trail of small bullet fragments (most commonly lead fragments) along the bullet track and any projectiles. Bones that have been struck or fractured can also be revealed. Additionally, it is possible to identify/characterize projectiles and other ammunition components in X-rays of surviving victims who have not had them removed surgically (Figures 14.83 and 14.84).

Just as a fired bullet that passes through a shooting scene records a snapshot of time within a sequence of events, including the instant a victim is struck, in some cases this momentary recording may indicate the posture of the decedent and/or the orientation of body parts to each other at the time the gunshot wound(s) was received. Additional information obtained from the autopsy report may include the number and types of firearms responsible for striking the decedent with projectiles and the distance of the decedent to the shooter or shooters.

It is advisable to consult the pathologist who performed the examination to confirm, clarify, or expound on the conclusions stated in his or her report if any of the previously discussed possibilities become apparent from this source of information. This author routinely asks pathologists about the ability of the victim to perform tasks before expiring and the length of time required for the victim to perform tasks before expiring. This subtle but important information may have a bearing on the feasibility of certain theories that may be brought forward during the investigation.



FIGURE 14.82 This anatomical model, produced by the author using Poser, depicts a decedent who suffered three gunshot wounds. The model can be viewed from any viewpoint using the software program and images can be exported for illustration and study. In this case, the left arm of the victim was raised at the instant a bullet passed through the triceps muscle and into the left chest (black probe depicted). When the decedent is lying on the autopsy table, this observation is not apparent, but it can be illustrated effectively using such models.

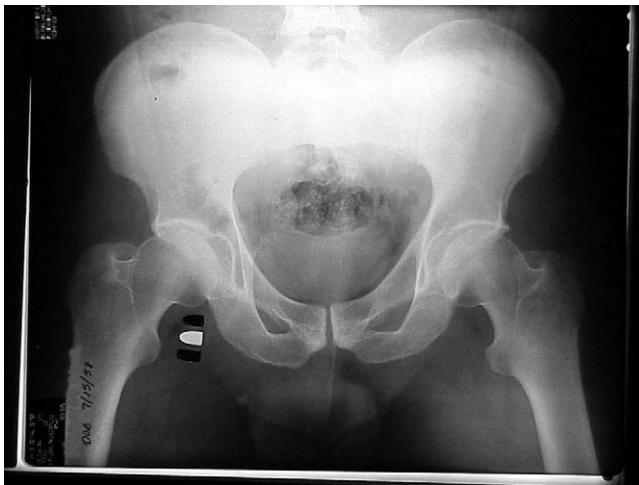
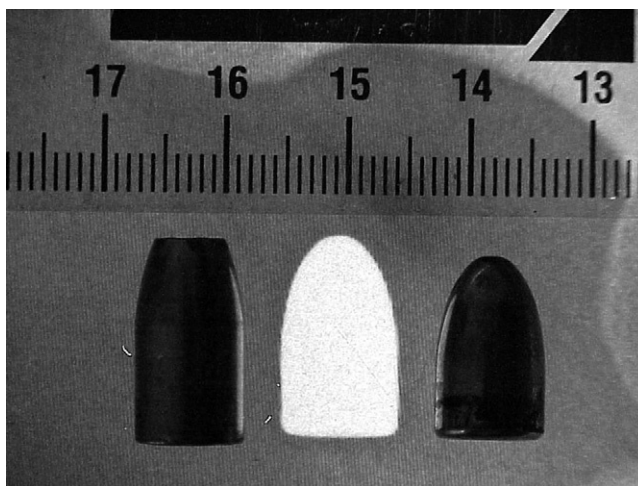


FIGURE 14.83 A police officer was shot through the pelvic region while attempting to apprehend a suspect wanted for several murders. The bullet was not removed from the officer for medical reasons, and it became important to know if the officer was shot by the suspect or a fellow officer during the incident. This X-ray depicts a bullet that transversed the hips of the wounded officer and lodged in the right hip area. The X-ray was taken in such an orientation that a clear profile of the bullet shape could be seen.

FIGURE 14.84 Side profiles of the bullets associated with ammunition used in the suspect's gun and police officer's service weapons were compared. The suspect was using ammunition with full metal jacketed round-nose bullets, whereas the police officers were using jacketed hollow-point bullets. The profiles of sample bullets from these two sources of ammunition were compared directly to the profile of the shadow created by the bullet in the X-ray. The author was able to eliminate the police officers' ammunition but not the suspect's ammunition.



MEDICAL RECORDS AND PHYSICIAN REPORTS

To a much lesser degree, it is possible to obtain useful information from doctors' reports made during medical intervention of shooting incident participants. However, typically physicians are not trained to make forensic observations. Furthermore, the goal of the physician is to save lives, and any observations made concerning the detailed nature of wounds, projectile paths, and distances are secondary to that goal. Reports are often sparse, vague, and confusing. If potential significant observations can be made from medical reports, it is strongly suggested that the physician who prepared the report be consulted for confirmation and/or clarification of conclusions.

REVIEW OF INVESTIGATIVE CRIME SCENE PROTOCOLS

In many cases, the reconstructionist will be consulted well after the shooting incident has occurred. When there is no opportunity to examine the original shooting scene, any visual data recorded at the scene therefore become the next best alternative to the visual walk-through. It is paramount that a thorough review of all crime scene photographs (including Polaroid photos and snapshots taken by responding officers), crime scene video, crime scene diagrams, and crime scene investigative reports be conducted.

Ultimately, the degree of the reconstructionist's success will be directly dependent on the quality and thoroughness of crime scene documentation.

Scene Photos and Video

It is the author's practice to first organize the photographs into a logical order by specific locations within the overall scene and correlate them with any available crime scene sketches and/or diagrams. The photos are then inserted into clear plastic photo album pocket organizer

pages and assembled in a three-ring binder. This facilitates the ability to scan through the photographs as many times and in as much detail as required to gather as much information as possible to assist in resolving whatever questions have been posed or will be posed as the review process develops. The clear plastic protecting the photographs allows the ability to make notations using an assortment of colored fine-tipped indelible marking pens without damaging the original photographs.

Emulsion-based photographs of special interest are typically scanned and/or imported into various media programs, such as Adobe Photoshop, PowerPoint, and Microsoft Word, allowing for enhancement of certain details in the photographs and/or preparation or annotation of notes or observations and/or court exhibits that can be reviewed more readily by any interested party.

With the significant advancements in digital photography, a rapidly increasing percentage of crime scene and evidence documentation is being conducted with this media. Digital images captured with equipment available today are approaching the resolution of emulsion-based photos and are a viable means of crime scene documentation. These images may be screened rapidly on the computer and/or printed out in catalogue form and reviewed in the same manner as described for emulsion-based photographs. Additionally, digital images are very conducive for import into word processing program documents for purposes of annotation, note taking, supporting conclusions, and report writing. The images may also be used with a presentation program for presenting observations to others. Caution should be taken when relying on such photographs for estimating distances or relationships of items to each other.

The value of photographic evidence is maximized when photographs taken at the scene include overall orientation views, medium-view/approach views, and close-up view photographs that include some sort of scale. The reconstructionist can make detailed observations about the appearance and condition of individual items of evidence (with close-up photos), relate the position and orientation of specific items to the environment immediately surrounding them (with medium or approach views), and locate the items in the overall shooting scene (overall views).

The review of any videotape recordings of the crime scene is also highly recommended because it offers an excellent supplement to still photographs. Often, shooting scene videotapes recorded in a systematic fashion with good use of the overall, medium view, and close-up view approach provide an excellent perspective of the scene second only to examining the original scene firsthand. Additionally, videotapes may be the only visual source for filling in the photographic gaps created by failure to record coordinated overall, medium view, and close-up still photos.

Although, in general, the resolution of videotape is inferior to still photos, this visual source of information often records details either purposely or coincidentally that can be of great significance in providing important clues to the investigation. If such observations are significant, these frames may be captured and converted into still photos.

Sketches and Diagrams

As discussed previously, field sketches and diagrams are of great importance in supplementing crime scene photographs because they aid greatly in locating items of evidence accurately, establishing their spatial relationship to other items in the scene, documenting the specific

location of bullet holes and impact defects that can later be used to ascertain the direction of projectile paths, and so on. Additionally, crime scene sketches or diagrams are very useful in correlating item and/or photographic reference numbers depicted in specific photographs when organizing the crime scene photo review binder and orienting the reconstructionist to the shooting scene.

Review of First Responding Police Officer Reports

A review of police reports can provide significant findings, most notably observations made by first responding officers to a shooting incident. Observations made by such personnel are often the only source of information detailing the original condition of the shooting scene.

It is inevitable that any postincident activity will alter any crime scene, no matter how diligent efforts are to protect it. As a result, subtle but significant conditions are changed prior to their documentation that may have significance in resolving reconstructive issues. Examples include lighting conditions; the position of doors, windows, and furniture; the status of appliances (on, off, settings, etc.); and the position of small items, such as fired cartridge cases, that can be moved. In some cases, lighting conditions and the positions of doors and windows may only be recalled by first responding officers and/or emergency medical personnel. If such issues become significant and are not recorded in official reports, it may be necessary to interview first responding officers, firefighters, and emergency medical personnel.

Polaroid photographs, 35-mm film, or digital snapshots taken by first responding officers can be very important in establishing original conditions of shooting scenes. This includes positions of wounded or deceased participants, bloodstain patterns, and locations of firearms and fired cartridge cases. All of these are vulnerable to inadvertent change (a.k.a. evidence dynamics) during the course of the crime scene investigation.

Also, officers assigned to accompany the transport of shooting victims to the hospital for emergency medical treatment may occasionally take photos of the victims during transport and treatment as well and thereby record the appearance of wounds and clothing items that will likely be altered significantly during such treatment.

Crime Scene Reports

This author carefully reviews reports of crime scene personnel and investigators who have specifically described the condition of the crime scene. These sources of information typically bring attention to significant observations relative to the reconstructive problems at hand as well as direct the reconstructionist to conditions of the scene that may or may not be obvious in the photographs, such as lighting conditions, locked and unlocked doors, settings on appliances, room/atmospheric temperatures, and wet stains.

The author also purposely reviews lists and descriptions of specific items collected at the scene that provide details about items not described in the narrative crime scene report or depicted in photographs. These lists can also be correlated against any evidential examination conducted in the laboratory.

CORROBORATING WITNESS ACCOUNTS WITH THE PHYSICAL EVIDENCE

Statements made by victims, suspects, and witnesses and conclusions rendered in investigative reports by investigative personnel can provide information as the basis for the development and testing of scenarios and theories. Observations by these participants and witnesses can also direct significance to certain items of physical evidence that might not otherwise be apparent to investigators at the time the statements are made. However, the reader is cautioned that such statements should be considered only for this purpose, and they should not be relied on as fact. Consequently, physical evidence and observations made at the shooting scene should be consciously correlated with participant statements to either support or refute them.

It is this author's experience that eyewitness information in many instances is incomplete or falls short of the truth, even when offered in good faith. Witness recollections can fade with time, be altered due to stressful conditions, be made deceitful for personal benefit, and conflict with other statements. For example, descriptions of firearms observed during a shooting incident are often vague at best and totally inaccurate at worst. So too are statements about the location or posture of shooting scene participants.

Notorious for inaccuracy are "earwitness" statements regarding the number of shots fired or the caliber of the firearm by the sound heard. It is more the exception than the rule that physical evidence fully supports the accounts of such recollections. Physical evidence, however, when documented and interpreted properly, does not fade in memory and can serve to clarify these ambiguities created by witness statements.

Investigative reports may also offer theories of how incidents occurred based on observations made at the scene and witness accounts. These theories, as suggested previously, should neither be believed nor disbelieved but, rather, considered as possibilities that can later be included or excluded when cross-referenced with all sources of physical evidence and crime scene documentation.

In this spirit, the reconstructionist should maintain an objective and unemotional demeanor regardless of how far-fetched some theories may seem. It may well be the case that what seems outlandish as a possibility cannot be proven wrong and may therefore be the correct reconstruction of the events being studied.

REVIEW OF PHYSICAL EVIDENCE REPORTS

Physical evidence examination reports prepared by forensic scientists are invaluable tools that can be used to attach additional significance to observations and determinations from firearm-related evidence in the shooting scene. It adds greatly to the big picture approach necessary to shooting scene reconstruction. The reconstructionist is at a great advantage if he or she has at minimum a generalist background in as many of the forensic disciplines as possible to take advantage of these additional sources of information.

Consultation with forensic scientists who have conducted such examinations is often fruitful in gaining additional insight from the perspective of the analyst that might not be apparent in the written report. Additionally, a review of photographs and notes prepared by the analyst during

such consultations may also provide significant observations that would otherwise go unnoticed. The following are examples.

- Tool mark evidence may assist in establishing location and modes of entry and exit within a shooting scene. Additionally, tool marks caused by unconventional items that come into contact with each other, such as impressed damage to a wall by the corner of a sliding table, can provide associative information relating items or events to each other.
- Footwear impression evidence may assist in establishing movements made by participants during the course of a shooting incident.
- Tire track impression evidence may assist in establishing movements of vehicles used by participants in a shooting incident.
- Blood patterns may assist in establishing the location and specific activities of victims wounded or killed during a shooting incident or postshooting activities of surviving participants who have come into contact with sources of blood.
- Fingerprint evidence may assist in establishing locations of participants in a shooting incident and establish certain associations with the shooting scene or the manner in which items were handled during the course of a shooting incident.
- Trace evidence may assist in establishing contact between participants, location of participants within the scene, and association of participants to the shooting incident. Additionally, trace evidence on fired components and firearms may serve to associate these items with other important surfaces they may have come into contact with during the course of the shooting incident. For example, fibers collected from a firearm that can be associated with the pocket lining of a suspect's jacket may serve to suggest this person as the most likely possessor of the firearm in situations in which multiple shooters are involved or blue paint transfers on the side of a fired bullet might strongly suggest the bullet to be the source of a bullet ricochet observed on a blue vehicle present at the shooting scene.
- Serological/DNA evidence may be valuable for associating participants with a shooting incident, associating specific projectiles with through-and-through wounds received by participants, or identifying individuals who may have operated a firearm or handled certain ammunition components.
- Toxicological findings may provide a better indication of the ability of surviving participants as well as decedents to perform certain tasks prior to, during, and after a shooting incident.

REVISITING THE SHOOTING SCENE

A visit to the shooting scene even well after the fact, when feasible, is highly recommended if for no other reason than to gain a real-life perspective for the layout of the shooting scene environment. On numerous occasions, the author has visited the scenes of shooting incidents for this purpose and/or to conduct follow-up examinations that have become necessary to address specific questions that have developed during the reconstruction process. Additionally, the author has returned to the scene to reconstruct parts of the shooting scene for the purpose of testing various theories that have been developed during the case review.

Typical revisits to the scene have been for purposes as simple as the recovery of fired projectiles that have been left inside walls or inaccessible objects. A return to the shooting scene may

also be for the purpose of locating bullet holes and impact sites documented previously and using this information to reconstruct the paths of bullets responsible for creating these defects.

More involved revisits to the scene have been done for the placement of items damaged by gunfire, such as vehicles examined in the laboratory, back into their original positions at the shooting scene using crime scene photographs and measurements obtained during the original investigation. Bullet paths that have been predetermined by such laboratory examinations can be extrapolated throughout the extent of the overall shooting scene, taking advantage of the original crime scene environment/terrain. Subsequent documentation of shooter position possibilities along extrapolated paths is then demonstrated and documented with photos and additional crime scene diagrams. This new information may be used to either support or refute current and future theories.

RECONSTRUCTION THROUGH ROLE-PLAYING

Ultimately, the gathering of information results in the ability to test proposed scenarios offered by participants and witnesses or theories offered by police officers, investigators, and attorneys. The author suggests that the reconstructionist take a methodical approach to developing and testing these offerings. A "brain storm"-oriented model is recommended: the reconstructionist should formulate as many scenarios and variations to explain the available evidence as possible. All theories should be considered regardless of how absurd some may seem.

However, working laboriously without the benefit of input from others, it inevitably becomes difficult to view the problems at hand with the imaginative thinking necessary for maximum success. Therefore, the practice of discussions and active role-playing with other investigative and forensic science professionals is encouraged. On more than one occasion, the power of multiple thinking that emerges in role-playing exercises has proven effective in eliminating all but a few, or even one, scenario that is fully supported by the physical evidence.

This will more rapidly develop any alternate theories that might be feasible and help with attempts to disprove as many of the proposed theories as possible.

CLOSING COMMENTS

In 1991, Bell offered a rather concise definition for reconstruction as a "process of utilizing information derived from physical evidence at the scene, from analyses of physical evidence, and from inferences drawn from such analyses to test various theories of the occurrences of prior events" and that "the above definition indicates that reconstruction is neither an art nor a science, but a process" (p. 741). Reconstruction is indeed a process of elimination conducted with the information available.

Critiques of the reconstruction process may suggest that it is not possible to reconstruct events in a particular case because changes had been made subsequent to the crime and prior to the crime scene preservation by investigative personnel or due to a lack of physical evidence at the crime scene. Under the previous definition, such a suggestion would not necessarily be true. Due to the lack of information available, reconstruction will simply be less refined than otherwise. Even in such cases, it may be possible to answer questions to a certain point. For example,

it may not be possible to reconstruct the exact position of a shooter, but there may be sufficient information to indicate a general direction such that all but one participant may be excluded as having been in the area suggested.

Given sufficient information, more definitive conclusions can be drawn. For example, in a shooting involving two shooters and a decedent who has received a single perforating wound, the question may be who was responsible for firing the fatal shot. Several bullets recovered from an adjacent wall near the decedent are identified as having been fired by the shooters' two guns. The information gathered so far is insufficient to answer the question; however, the presence of blood and tissue containing the decedent's DNA profile on one of the identified bullets provides strong support to implicate the suspect in possession of the firearm responsible for firing the bullet as the responsible party for delivering the fatal shot.

This chapter and the one before it have been offered as an introduction to the subject of shooting scene reconstruction. Any party involved in a shooting incident investigation can better utilize physical evidence when he or she understands that physical evidence can do more than simply place a person at the scene. To stop at this point and not utilize physical evidence to help establish a record of the events that occurred during the course of the shooting incident is missing a valuable aid.

The advantage of physical evidence at shooting scenes is that it can be used to support or refute witness statements and provide undisputable evidence of certain events, as well as associate participants with the shooting incident. The stories offered by participants can be cross-checked, compared, and contrasted with the position or condition of items at the scene or patterns produced by actions of physical activities. This is where the process of shooting incident reconstruction makes its greatest contribution.

A comprehensive approach to the evaluation of physical evidence, investigative information, and witness statements from a multidisciplinary standpoint is highly recommended in resolving issues in shooting incidents. Following a logical, methodical, and thorough approach to shooting scene investigation with big picture thinking and grounded in the application of the scientific method will maximize the chances of a successful investigative outcome and be well worth the effort.

Finally, it is hoped that those experienced in this area, having read the information in this discussion, will view their next shooting incident with a different eye and see it from a new perspective that will enhance their ability to both identify reconstructive questions and resolve them effectively. For those who have little or no experience, it is hoped that they will be inspired to pursue the tools necessary to perform such work.

SUMMARY

This chapter discussed advanced applied concepts of shooting incident reconstruction, focusing on shooting incident reconstruction in consideration of gunfire involving vehicles and reconstructive issues associated with shotguns.

Gunfire involving vehicles, because of their mobility, confronts the reconstructionist with additional considerations. To orient reconstruction of the events within a vehicle, the examiner must create artificial coordinate reference points to plot the location of bullet defects and

associated bullet paths. The examiner must also be aware of vehicle orientation, or its position relative to the bullet path and the ground, and how it can be influenced by various factors.

Reconstruction considerations related to shotgun design and ammunition also deserve our attention. If the gun and ammunition are available, these components can be studied, measured, and used to answer specific questions developed in the reconstructive process.

QUESTIONS

1. There are no true coordinate reference points available for measurement of projectile defect locations or projectile paths in a vehicle. True or false?
2. List the four sources of information that should be used to estimate bullet paths in a gunshot victim.
3. Explain why is it important for a reconstructionist to visit the shooting scene after the fact.
4. Provide two examples of evidence that can be gained from the clothing of participants involved in a shooting incident.
5. Explain why reconstructionists should not rely solely on eyewitness information.

Acknowledgments

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15

Fire Scene Reconstruction

John D. DeHaan

Key Terms

Accelerant; Anoxia; Arson; Autoignition; Explosion; Fire; Flaming combustion; Flashover; Glowing (smoldering) combustion; Rollover (or flameover)

THE CHALLENGE OF FIRE SCENE RECONSTRUCTION

The reconstruction of fire scenes is considerably more difficult than the reconstruction of a typical homicide scene because of the changes and destruction wrought by the event being investigated. Imagine taking a homicide scene with its myriad evidence and ripping portions of the walls and ceiling down, flooding the room with water, and then spraying every visible surface with gray or black tempera paint (Figure 15.1). Heat alone causes surfaces to discolor,

FIGURE 15.1 Typical room fire scene. Fire damage patterns on the wall paneling, ceiling, and furniture are all used to recreate the movement of the fire (from left to right in this fire) and intensity (more damage to the sofa in the left rear corner). *Photo courtesy of Jamie Novak (Novak Investigations, Lindstrom, MN).*



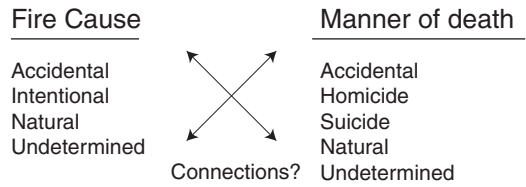
melt, or char. Smoke or pyrolysis products coat most exposed surfaces, especially at higher levels in a room. **Fire** chars or consumes furnishings, bodies, and wall and floor coverings, sometimes to the point of structural collapse; however, the processes of combustion, ventilation, and heat transfer produce much of the evidence on which the reconstruction depends. Those processes must be understood before their effects can be interpreted correctly. Water is used in great abundance in the extinguishment of most fires, diluting, moving, obscuring, or even washing away critical evidence. Exposure to the elements (rain, wind, heat, and sun), sometimes prolonged, adds to the destruction. Yet, despite all the difficulties, by applying appropriate protocols in a thoughtful analytical process, gathering appropriate data, and using knowledge of the fire processes and fire engineering principles, a great deal can be accomplished in reconstructing fire events accurately and defending those conclusions in courts of law. Due to the complexity of the topic, this chapter focuses on the reconstruction of fires in residences and small businesses. Explosions and fires in manufacturing or industrial premises, aircraft, vehicles, or wildlands require extensive specialist information and are not discussed in this chapter. The interested reader is referred to the specialist literature for information on such fires [Cole, 1992; DeHaan, 2002; National Fire Protection Association (NFPA), 2004].

The objective of a fire scene reconstruction is to provide reliable and defensible answers to the following questions:

1. Where did the fire begin, that is, where was the origin of the fire?
2. What was the first fuel involved in the fire (and what fuels supported its spread)?
3. What was the cause of the fire, that is, what circumstances brought an ignition source into contact with the first fuel such that a fire resulted?
4. Who, if anyone, was responsible for the fire occurring?
5. What factors contributed to the ignition and growth of the fire?
6. What other events occurred (and in what order) in connection with the fire—death, injury, forced entry, or burglary?

Fires can be accidental in origin. Although accidental events are not a primary focus of this text, fires are nearly unique as investigation targets because each requires at least some investigation before it can be determined that the fire was accidental or intentional in causation. In fact, sometimes extensive investigation and analysis have to be carried out before that call can be made with any authority. Because all fires must be “investigated” and a cause “established” by the responding fire agency in many U.S. jurisdictions, a superficial examination and summary judgment may result. Once a fire is established to be accidental, the public agencies need only secure the building and turn it over to the owner or his or her insurance representative. If a fire is thought to be deliberately set, a criminal investigation must be carried out by a police agency (or fire marshal) having investigative and arrest powers. Some agencies are reluctant to become involved in the more complex police investigations and will write off as many fires as accidents as they can. This is a dangerous and pernicious practice because many fires that at first appear to be simple accidents are, in fact, deliberately set. The common “fat fire on the stove” may be set to meet the perceived needs of the “cook”—whether that is to justify a remodeled kitchen, to call attention to household or personal crises, or attempt to intimidate or kill another person in the house. Once a fire is thought to be accidental, a more relaxed and less thorough investigation takes place, evidence is overlooked, and less documentation is carried out. If later information suggests the fire was set, critical evidence may be lost forever. Every fire

FIGURE 15.2 Accurate reconstruction of a fatal fire requires determination of the cause of fire, the cause of death, and connections between those two events, as an incendiary fire can cause an accidental death, as can an accidental fire.



deserves a systematic examination, but pressures of insufficient resources and excessive demand mean many do not receive proper attention from public authorities. Fire scenes should be secured, access controlled, and documented as would any possible crime scene, at least until reliable evidence demonstrates an accidental causation. This practice must be balanced against the danger of assuming that a crime has definitely occurred and developing a bias to exclude accidental causes. It is more important for the fire scene examiner to keep an open mind as to all the possibilities of both accident and crime while conducting the initial examination and developing the evidence to prove one or the other.

Fires can be intentionally set for their own purposes—to kill someone, to destroy property, or to gain a monetary or psychological end. The crime of **arson** requires three basic elements of proof:

1. There had to be some physical destruction by the fire.
2. The fire had to be deliberately set.
3. The fire had to be set with some specific intent.

That specific intent can be murder, monetary gain, or psychological advantage or to fulfill a need identifiable only to the perpetrator. The existence of a “firebug” who sets fires in response to an uncontrollable need has been largely discredited by recent research. Fires can also be set as part of another crime—to conceal or destroy evidence (of murder, burglary, or fraud) or as part of a ritual or fantasy (particularly in sexually driven homicides). The reader is referred to other texts for additional information on motives (Icove and DeHaan, 2004; Sapp et al., 1995).

When there has been a death associated with a fire, the investigation must be three-pronged: what caused the fire, what caused the death, and what circumstances connected those two events? Fires can be the result of accidental, natural, or deliberate events. Deaths can occur by natural, accidental, suicidal, or homicidal means. Either may be undetermined, as seen in Figure 15.2.

Connections between the fire and the death may not be obvious. A death caused by a heart attack may be triggered by the stress of a response to an accidental fire or an intentional one. A suicide victim may trigger an accidental fire by actions taken to end his or her life. A natural death may trigger an accidental fire. A homicide may be accompanied by a deliberate fire or by an accidental one. The cause and manner of death must be established reliably by a full forensic postmortem, and then the circumstances of the fire and death must be examined together in a critical manner.

SCIENTIFIC METHOD

Although the “scientific method” is familiar to all of us who have had an education in one of the physical sciences, it is only recently that many fire investigators have been faced by judicial decisions to employ it and defend it as the basis for a properly conducted fire investigation. The “steps” of the scientific method are well known, as shown in Figure 15.3.

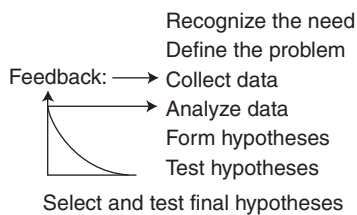


FIGURE 15.3 The scientific method is a system of logical analysis and interpretation that is the best basis for any scientific inquiry or fire investigation.

The scientific method has really been the basis for all successful approaches to fire investigation for more than 50 years, but its practitioners simply did not recognize it as such. Recently, fire investigators have been forced to explain and defend their decision-making process, and the scientific method is now widely cited in investigation protocols. Obviously, it forms the basis for forensic fire scene reconstruction as well, as it relies on data collection, analysis, hypothesis testing, and the feedback loop for more data.

THE BASIC INVESTIGATION

Investigative approaches to fire scenes are described in nationally recognized protocols such as those in the *Guide to Fire and Arson Scene Evidence* (National Institute of Justice, 2000), *NFPA 921: Guide for Fire and Explosion Investigation* (NFPA, 2004), and *Kirk's Fire Investigation* (DeHaan, 2002). Every good scene investigation begins with an initial noninvasive survey of the immediate scene and its surroundings. This hands-in-pockets walk-through allows the investigator to

1. Establish the nature and extent of fire damage versus the extent of the structure itself
2. Evaluate possible means/routes of entry/exit
3. Establish sight lines to adjoining properties (to aid in canvassing for witnesses and evaluating witness statement reliability)
4. Conduct a preliminary search for evidence outside the fire scene—items discarded or left at some distance from the target property, including fuel cans, shoe prints, or stolen property
5. Evaluate the size and location of a security perimeter to control access to the scene and what type of barrier is going to be needed—barrier tape, rope, barricades, or manned checkpoints

The scene perimeter is secured according to the results of the survey and available resources. Every fire scene deserves protection from unauthorized persons entering, moving, destroying, or removing evidence, however inadvertently.

A forensic fire scene reconstruction proceeds in the following six general steps, which may overlap and, depending on scene circumstances, may not occur in the same sequence in every investigation:

- Document the fire scene and its processing
- Establish the starting conditions
- Evaluate the heat transfer damage observed
- Conduct a fire engineering analysis
- Correlate human observations and factors
- Formulate and test hypotheses about the fire

DOCUMENTATION

Documentation is the most critical step of investigation and reconstruction. The more complete the documentation, the more accurate and defensible the reconstruction can be. Photography is the most critical tool. Photos should be taken of the overall site and then of the exterior of the building (from all available directions). Photos should also be taken looking outward toward nearby roads or buildings from where someone could have seen events. External photos must include undamaged portions of the building. Aerial views are often helpful (pre- and postfire). Exterior photo documentation can begin even while the fire is still in progress before safe entry can be made or while smoke and steam are clearing from the interior. Some fire and police units have point-and-shoot cameras in their vehicles so that they can capture events early on in the response.

Once conditions are suitable for entry, interior photographic documentation takes place. Photos should be taken of all rooms in a structure, even those not damaged by the fire. At least six photos are needed of each room, area, or corridor—one from each corner plus ceiling and floor views. The condition of walls and ceilings can change after a fire, as water-logged plaster or drywall collapses, so every effort should be made to take interior photos as soon as possible. Rekindles sometime occur and subsequent damage may obscure or destroy patterns that survived the initial fire and suppression.

Photos must include patterns of heat and smoke damage on interior and exterior surfaces and visible indicators of intensity and direction of movement. Localized areas protected from heat or smoke may also be useful for putting fuel packages or furniture back into their prefire locations and should also be photographed.

Specialized photographic techniques such as panoramic photography may be needed to capture fire patterns on large surfaces. The human visual field is nearly 180 degrees, but that of a standard 50-mm camera lens is approximately 80 degrees, so multiple overlapping photos are needed to capture wall-sized patterns. These photos can be merged using PC programs such as Roxio Photosuite (Roxio Corporation, www.roxio.com) or PTGui (www.ptgui.com).

Photos must be taken of the undisturbed scene, as layers of debris are removed revealing buried or concealed evidence and patterns. All photographs must be accompanied by notes in the form of a photographic log listing photo number, object description, location, and direction of camera. This log can be supplemented with a floor plan or plan view diagram of the scene with numbered arrows showing the location and direction of each photo. Scales should be included if size is a critical feature of the evidence.

Notes are important documentation because they help record descriptions of position and condition that may not be discerned from photos alone. Observations such as temperature, wind, weather conditions, odors, and information from responding firefighters or police can only be captured by written notes.

Accurate dimensions of all rooms, including length, width, and ceiling height and size, sill and soffit height of all windows, doors, or other ventilation openings are essential for fire engineering calculations or modeling to be accurate and relevant to the scene. Such dimensions can be captured on simple elevation or plan view drawings or diagrams, as shown in [Figure 15.4](#).

Diagrams must be accompanied by a compass orientation and designation of side A, B, C, and so on. Proper documentation should also include notes of observations of police and fire

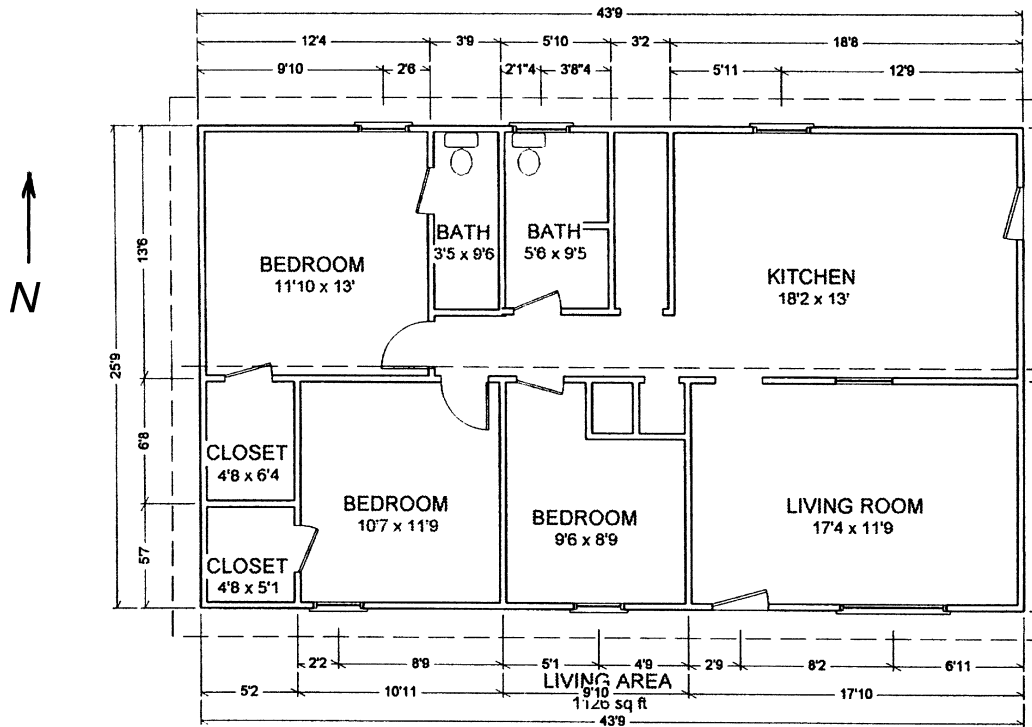


FIGURE 15.4 A simple plan (overhead) view of a structure fire scene is the best way of capturing room dimensions, window and door locations, and connections between adjoining rooms. All of these data are critical to a proper reconstruction. *Courtesy of Dr. David Icove, Knoxville, Tennessee.*

personnel and other witnesses; the nature, condition, and response of alarm or fire protection systems; the actions of firefighting crews; the nature and locations of contents, particularly major fuel packages; and weather conditions (temperature, wind, and precipitation) at the time of the fire. Many alarm system panels can be “queried” (on-site or at a remote monitoring location) to establish recent activations.

Interviews with firefighters should include their observations as to fire, smoke, and ventilation conditions upon their arrival (and time estimate); where fire and smoke were visible; and which windows and doors were open, closed, or broken prior to or during suppression. They should also be asked what tactics were used to attack the fire, from where, and what effects were observed.

ESTABLISH STARTING CONDITIONS

Documentation of the interior of the structure for later analysis or modeling may be aided by a form for each room involved in the fire, such as that shown in [Figure 15.5](#) (NFPA, 2004, pp. 232–233). Note that it includes wall, floor, and ceiling structural materials as well as

ROOM FIRE DATA

Room _____

Room # _____

Length _____

Width _____

Height _____

Note ceiling height changes _____

Floor Plan

Walls: Structure/material _____ Thickness _____ Covering _____ Sample? Y/N

Structure/material _____ Thickness _____ Covering _____ Sample? Y/N

Ceiling: Structure/material _____ Thickness _____ Covering _____ Sample? Y/N

Floor: Structure/material _____ Thickness _____ Covering _____ Sample? Y/N

Openings (door, window, other vents) into room (number on plan above):

Height (bottom to top of opening)	Sill Height	Soffit Depth (above opening)	Width	Open or Closed? Changes During Fire?
1.				
2.				
3.				
4.				
5.				
6.				
7.				

HVAC System:

Description _____

On/off prior to/during fire? _____

Furnishings (descriptions of major fuel items, including floor and wall coverings, draperies):

FIGURE 15.5 A form such as this reminds the investigator to record all information needed to conduct an accurate fire engineering analysis and reconstruction.

coverings and also fuel package assessment. The ignition, growth, and contributions of any fuel package are the combined result of that fuel's chemical composition, its geometry, physical state, and mass. To ensure accurate identification, a comparison sample of the combustible portions of any major fuel package or suspected first fuel ignited should be collected and preserved. This includes carpet and pad, wall paneling or other covering, ceiling covering, and upholstery and padding (fabric, liner, and padding). A sample 4–12 inches square (10–30 cm square) would be ample for laboratory identification of material, detection of flame retardants, and simple fire tests, if needed later. Prefire photographs and videos can often be of great help in establishing the starting conditions—structural, furnishings, and decorations—that may play a role in fire ignition, spread, and pattern formation. These may come from family, owners, tenants, or public authorities. Aerial photos are often used by agencies for property tax assessments on both residential and commercial properties.

BASIC FIRE CHEMISTRY

Before proceeding to the evaluation of thermal damage patterns and fire engineering analysis, we must discuss basic fire chemistry and fire dynamics. Fire can be defined as a sustained exothermic oxidation (combustion) of a fuel sufficient to produce readily detectable heat and light. Combustion can occur either as a gaseous flame in which gases or vapors mix with air and then are ignited or as **glowing (smoldering) combustion** where oxygen combines directly with the solid surface of the fuel, producing little or no flame. The heat from this combustion is, in part, absorbed by nearby fuel, causing it to pyrolyze or evaporate to continue the process. Very few solid or liquid fuels can burn without pyrolytic action to break down their molecular structure to support combustion (reactive or combustible metals, such as sodium, potassium, iron powder, or magnesium, are the most common exceptions). Heat applied to a surface (by convective, radiative, or conductive heat transfer mechanisms) causes the temperature of that surface to rise [the rate of rise being controlled by the thermal conductivity (k), heat capacity (c), and density (ρ) of the material or by the multiplicand of all three, called thermal inertia ($k\rho c$)].

Modest heating (to cause surface temperatures up to 100°C) causes no visible or permanent changes to the material. More rapid heat transfer (higher heat flux) causes higher surface temperatures. Temperatures between 100 and 150°C will cause many thermoplastics to soften, shrink, or melt but will not affect most natural fibers or materials (cotton, wool, paper, or wood, unless very prolonged). Higher temperatures will cause many materials to start to degrade or pyrolyze, which is evidenced by permanent discoloration of the surface as the fuel is degraded (scorched). Further heating to higher temperatures will cause charring or carbonization. Eventually, the surface or the gases generated by the pyrolysis can be ignited by the external heat being applied. This is called **autoignition**. If a preexisting flame is nearby, ignition of the pyrolytic vapors can occur at a lower temperature, called the piloted ignition temperature. Flames then spread across the surface of the fuel depending on its flammability, thermal inertia, and orientation. Downward vertical flame spread does occur in most solid fuels, but at a rate 1/100 to 1/1000 the upward vertical spread (Quintiere, 1997, pp. 88–91). Outward horizontal spread occurs at a rate in between (but closer to the downward rate).

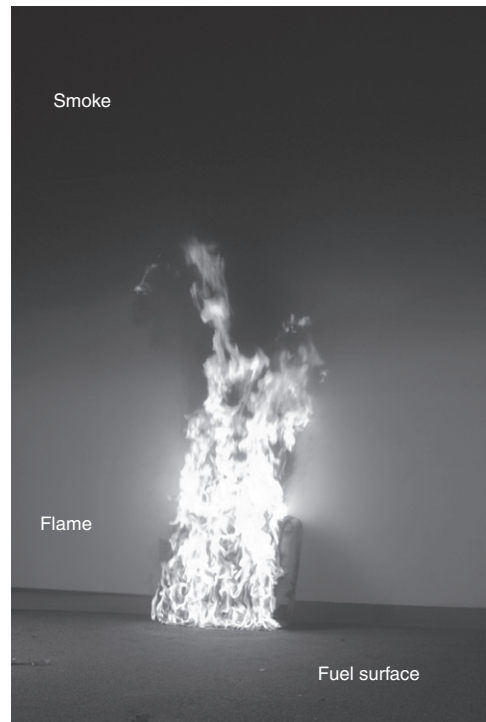
BASIC FIRE DYNAMICS

The predominant driving forces that produce fire patterns are heat transfer and the buoyancy of the hot combustion gases. The buoyant hot gases rise and form a vertical fire plume. This plume is visible to the unaided eye when it is hot enough to be luminescent (more than $\sim 500^{\circ}\text{C}/1000^{\circ}\text{F}$). This is the flame plume. The gases and products that rise above the flame plume are the smoke plume, as shown in Figure 15.6. The movement of gases causes the entrainment of air that brings oxygen into the combustion zone and cools, dilutes, and diffuses the fire plume, as shown in Figure 15.7. Heat is lost from all portions of the plume by convective transfer to the surrounding air (aided by entrainment) and radiative losses mostly from solid carbonaceous soot particles or aerosols (droplets) of pyrolysis products. A fuel that burns very cleanly with little or no soot or intermediate pyrolysis products (e.g., methanol) produces very little radiant heat. Very sooty fires (e.g., a crude oil pool fire) produce so much soot that much of the heat is absorbed by the plume. The effect of either circumstance is to reduce the radiant heat effect on target materials while maintaining very high combustion temperatures in the plume.

The intensity of heat radiating from a source at temperature T is a function of temperature, namely,

$$I = \varepsilon\sigma T^4,$$

FIGURE 15.6 A burning chair cushion displays three major components of the fire plume: the continuous flame plume (of constant flame temperature), the intermittent flame plume (where the buoyant gases are cooling but still hot enough to support some flame), and the smoke plume above that. Smoke has also accumulated to form a ceiling layer. *Photo courtesy of Jamie Novak (Novak Investigations Lindstrom, MN).*



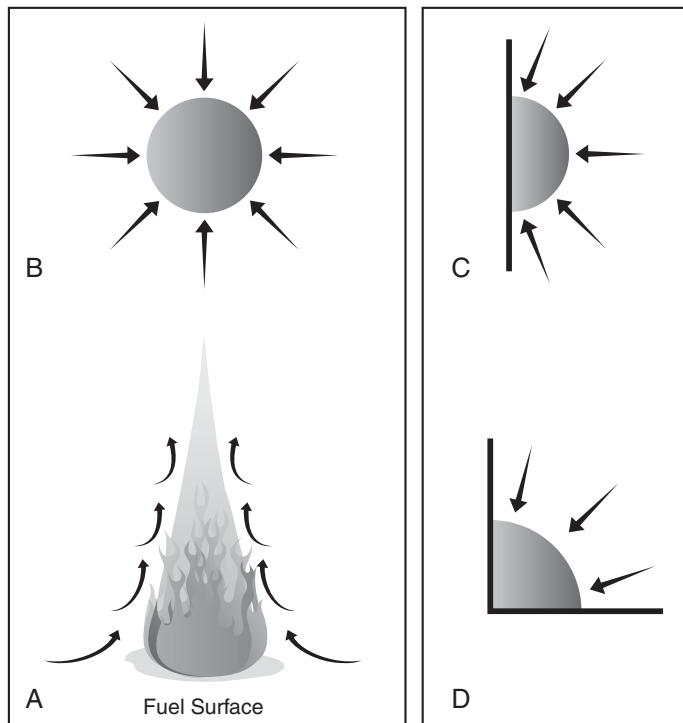


FIGURE 15.7 Entrainment of room air into a fire away from any walls forming an axisymmetric plume. (A) Side view. (B) Overhead view. Entrainment of room air. (C) Fire near wall and (D) fire in corner.

where ε is the emissivity of the surface and σ is the Stefan–Boltzmann constant. Note that intensity is a function of T (in Kelvin) to the fourth power. The nature of the source determines ε , but most sources (e.g., wood flames) are approximately 0.4–0.6.

Convective heat transfer from a gas to solid surfaces plays a much smaller role, in general. The heat flux via convective transfer is expressed as

$$\dot{q}'' = h(T - T_a)/A,$$

where h is the convective heat transfer coefficient, T is the temperature of the gas ($^{\circ}\text{C}$), T_a is the ambient temperature, and A is the area over which transfer occurs (m^2). For most materials, h is a function of the gas flow and the nature of the solid surface. For a raw wood surface with a buoyant hot gas flow, h is on the order of $5 \text{ W}/\text{m}^2 \cdot ^{\circ}\text{C}$.

Radiative heat flux can be expressed as

$$\dot{q}'' = X_r \sigma T^4 F_{12},$$

where F_{12} is the view factor between the source and the target surface, as shown in [Figure 15.8](#), and X_r is the radiative function (0.4–0.6 for most fires).

If the source can be treated as a point source (relatively far away from the target), the relationship can be simplified to

$$\dot{q}'' = X_r \dot{Q} / 4r^2$$

where r is the distance and \dot{Q} is the total heat release rate (HRR) of the source. Note that \dot{q}'' falls as the inverse square of the distance.

FIGURE 15.8 (A) Estimating radiant heat flux (\dot{q}'') onto a surface some distance from a small (point) source ($r \gg a$ or b) $\dot{q}'' = X_r \dot{Q} / 4\pi r^2$, where \dot{Q} is the heat release rate of source, X_r is the radiant heat fraction, and r is the distance. (B) Radiant heat flux \dot{q}'' on a surface close to a large radiant heat source ($r \leq a$ or b) depends on the view factor F_{12} related to the geometry of the exposure. In general, $\dot{q}'' = \epsilon \sigma T_1^4 F_{12}$, where ϵ is the emissivity of the hot surface, σ is the Stefan-Boltzmann constant, T_1 is the temperature of the hot surface, and F_{12} is the view factor.

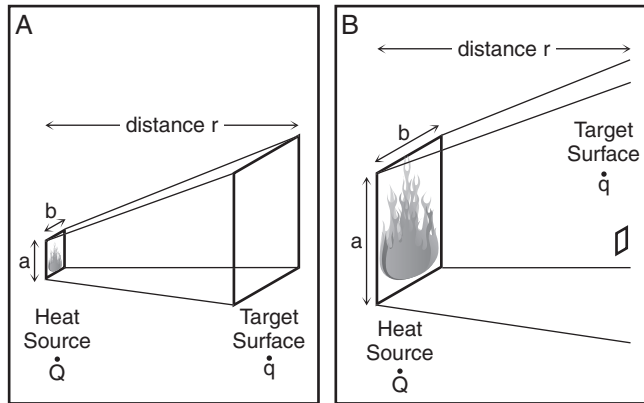


TABLE 15.1 Radiant Heat Fluxes and Effects on Common Nonmetallic Materials

Total	Source heat flux (kW/m ²)	Surface	Effect temperature (°C)
1	Sunny summer day	40	Warm sensation to skin
2–4	1.0 m from bonfire	50	Pain after 30 seconds
4–6	0.5 m from bonfire	60–80	Skin blisters after 8 seconds
10	0.2 m from bonfire	100–200	Thermoplastics melt; some scorching of cellulotics
20	0.1 m from bonfire	200–400	Scorching, charring, many materials autoignite
50	Contact with flames	500	Rapid onset of charring and ignition
150	Post-flashover room fire	>700	Almost immediate ignition

We can relate heat flux to physical damage to a target surface (if we assume a $k\rho c$ of 0.4, typical of polystyrene plastic, wood, gypsum board, or human skin) by the examples shown in [Table 15.1](#).

EVALUATE HEAT TRANSFER PATTERNS

Some of the effects observed (and the time of onset) are controlled by the thickness of the material. Thin materials (<1 or 2 mm in thickness) are affected in a shorter exposure time than thermally thick materials. Loose sheets of paper (wall calendar pages), thin draperies, wallpaper blistered or separated from plaster, and the like are affected more than thicker (or firmly attached) materials. Thermoplastics will soften, distort, and melt long before thermosetting materials will start to decompose. If we calculate the convective heat transfer from a buoyant flame at 800°C in room air, we find that the flux $\dot{q}'' = (5 \text{ W/m}^2 \cdot \text{°C})(800 - 20^\circ\text{C}) = 3.9 \text{ kW/m}^2$. The radiant heat from a similar flame adjacent to a surface is on the order of 50 kW/m², so we

can see that radiant heat normally plays a dominant role in affecting nearby materials. If a line fire is small, however, such as a match flame or a flame in a small wastebasket, the radiant heat effects are much less pronounced and most of the energy is in the buoyant flame plume. (It is much easier to scorch paper by holding it above a match flame than holding it alongside it.)

Direct contact between a flame and a surface maximizes the heat transfer by both convection and radiation, so fuels in direct contact (direct flame impingement) rise quickly to their maximum surface temperatures, char, and ignite (if sufficient oxygen is available and the piloted ignition temperature of the fuel is exceeded long enough to establish a self-sustaining combustion).

As a general rule, the longer the duration of exposure to heat, the deeper the resulting damage will be. To a limited extent, the more intense the heat flux, the faster the penetration will be. All materials, even good thermal conductors, have a finite thermal penetration time. Application of heat to one side of a slab of material always produces a temperature curve that reflects a high temperature on the exposed side and a much lower temperature on the opposite side, as shown in [Figure 15.9](#). If the heat is applied to an edge or corner, there is less material behind the heated surface, and the temperature of the heated edge is higher than would be observed if the same heat were applied to a flat surface, which is why it is always easier to ignite the edge of a piece of fuel (or very finely divided fuel) than a solid surface of the same fuel. One will observe greater damage to such corners and edges than to the flat surfaces adjacent. The demarcation between damaged and undamaged areas of a flat surface denotes the area where the heat flux was enough to induce thermal damage to the surface. These demarcations record the locations of hot gas layers or fire plumes.

Because **flaming combustion** (and, to a large extent, smoldering combustion) is a surface phenomenon, conditions induced on the surface of a fuel are what drive the combustion. The rate at which a fuel burns away from a surface (called the mass flux, measured in $\text{g}/\text{m}^2 \cdot \text{sec}$) is dependent on the nature of the fuel and on the radiant heat flux that is falling on the burning surface. If a piece of wood burns in isolation, the radiant heat falling onto the wood is from the flames being generated and so reaches an equilibrium, as shown in [Figure 15.10](#).

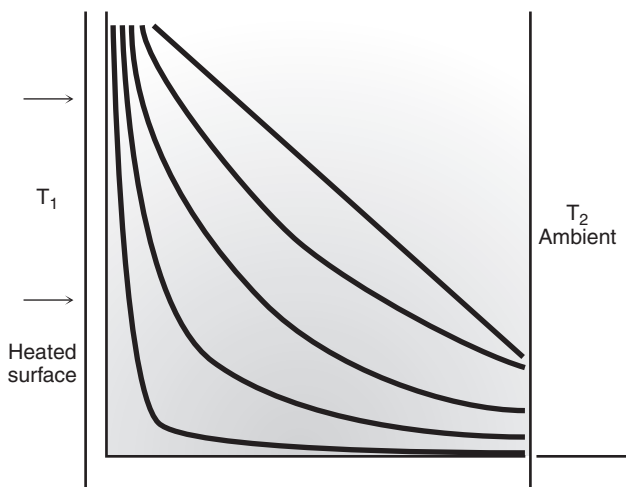


FIGURE 15.9 Temperature of a solid as a function of depth from the heated surface is a function of time. Note that for short exposure times, elevated temperatures occur only near the heated surface. After a long time, there is a linear gradient from surface to surface.

FIGURE 15.10 In an isolated fire, radiant heat from the flames produces a steady radiant heat flux onto the surface of the fuel below, which is dependent on the fuel being burned.

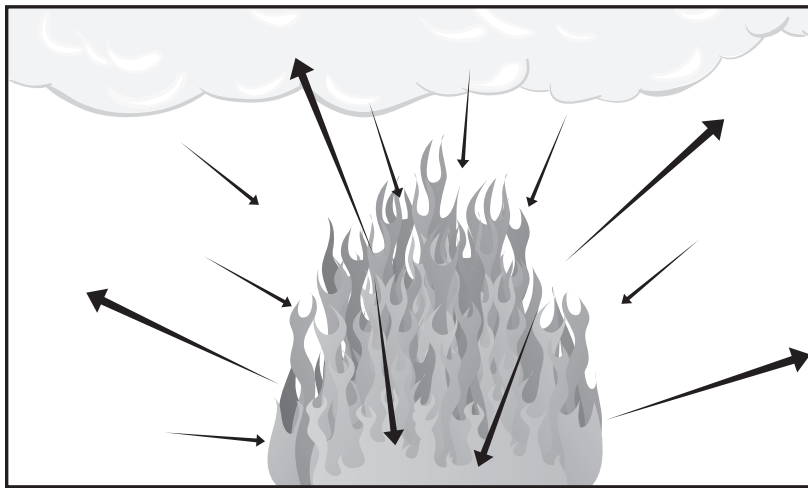
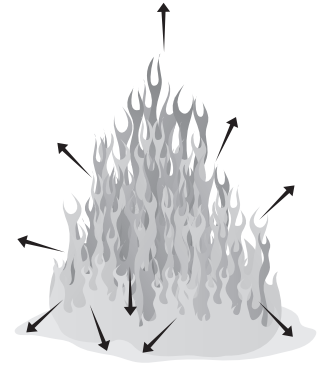


FIGURE 15.11 In a fire in an enclosure, the surface of the fuel is receiving radiant heat from the flames, from the ceiling layer, and reflected from nearby walls. These fluxes are additive and increase the burning rate of the fuel.

If a piece of wood burns in a compartment, the radiant heat reflected from wall and ceiling surfaces can usually reach the burning surface and add to the total heat flux, increasing the combustion rate (as long as there is enough air getting in to support the burning), as shown in [Figure 15.11](#).

If a hot smoke layer forms in the room, or if there are other fuel packages burning in the room nearby, the radiant heat created adds further to the radiant heat impacting the fuel surface. The effects of such additional heat sources must be considered when evaluating thermal effects.

A fire developing in a room produces a quantity of buoyant hot gases (at a rate controlled by the heat release rate, \dot{Q} , of the fire). If these gases cannot escape, they form a layer at the ceiling of the room, deepening as the fire burns. The temperature of this layer is determined by the size of the room (especially ceiling height) and the heat release rate of the fire. The larger the fire, the taller the flame plume and the greater the volume of gases being produced. If a fire is located away from walls, the height of the visible flame plume is approximated by the relationship

$$Z_f = 0.23\dot{Q}^{2/5} - 1.02D,$$

where Z_f is the height of flame plume, \dot{Q} is the heat release rate of the fire (in kilowatts), and D is the equivalent diameter of the fire, by the Heskestad equation (Drysdale, 1985, p. 133).

When Z_f approaches the ceiling height of the room, the fire gases have not had a sufficient opportunity to cool off and still have a temperature in the range of 500–600°C. If a fire is built against a wall, the entrainment of cooling air is limited and some heat is reflected from the wall toward the fuel. As a result, the flames are taller for a fire of the same heat release rate. If built in a corner, the effects are more pronounced and the result is even taller flames from a fire of the same heat release rate. This effect is reflected in the relationship

$$Z_f = 0.17(kQ)^{2/5}$$

where “ $z >$ height of flame plume (m), \dot{Q} is the heat release rate of the fire,” and where $k = 1$ for an axisymmetric fire away from walls, $k = 2$ for a fire against a noncombustible wall, and $k = 4$ for a fire built in a 90-degree corner (NFPA, 2004, p. 29).

As the temperature of the ceiling layer increases, the intensity of radiant heat originating from it increases (as a function of T^4). Experimental results have shown the relationship between the temperature of the ceiling (hot smoke) layer and the heat flux impacting the floor of the compartment (Figure 15.12). Because a radiant heat flux of approximately 20 kW/m² is enough to ignite many common materials, it is considered a critical threshold. As seen in Figure 15.12, smoke layer temperatures of approximately 600°C produce radiant heat fluxes of approximately 20 kW/m² on the floor of a compartment with a 2.5-m ceiling height. Because this condition can trigger full room involvement (flashover), it is a critical threshold. Until flashover occurs, the atmosphere in a fire room is divided into two zones, the hot smoke (ceiling) layer overlying a layer of normal room air, as shown in Figure 15.13. As the fire continues, this layer deepens, balanced against losses through the tops of window or door openings and ceiling vents. If the fire increases in size, the temperature of the layer increases and transfers more heat to the upper walls and ceilings. Soot, water vapor, and pyrolysis products in this layer condense out on the cooler ceiling, walls, and windows, producing a visible surface effect. In a typical accidental fire, there is usually very little mixing between the layers. These processes give rise to a heat or smoke horizon. As hot gases spill from door openings, the hot buoyant gases begin to fill adjacent rooms, giving a stair-step effect (Figure 15.14), with the room of origin having the deepest layer (i.e., closest to the floor). Hot gases flowing horizontally have a characteristic acute angle to the “front” of the wave, as shown in Figure 15.15. If flowing hot gases strike a vertical surface, their momentum causes a piling-up effect (like waves against a breakwater or seawall). Flow over an object causes eddies and protected areas on the downstream side.

The most intense heat effects are in the vicinity of the highest temperatures (i.e., near the fuel packages ignited), and the fire progresses from one fuel package in the room to the next by direct flame contact or by radiant heat to nearby surfaces. The damage observed may be limited to a few items, and the logical progression from one item to the next can be deduced. (See Figure 15.16 for an example of item-to-item growth.) If a fire in a room becomes large enough, the radiant heat from the ceiling layer causes ignition of all the exposed fuel surfaces in the room, leading to full room involvement. This transition is called **flashover**. It is usually (but not always) preceded by flaming ignition of the combustible gases (mostly CO), soot, and pyrolysis products in the smoke layer. This flaming ignition of the smoke layer is referred to as **rollover** or

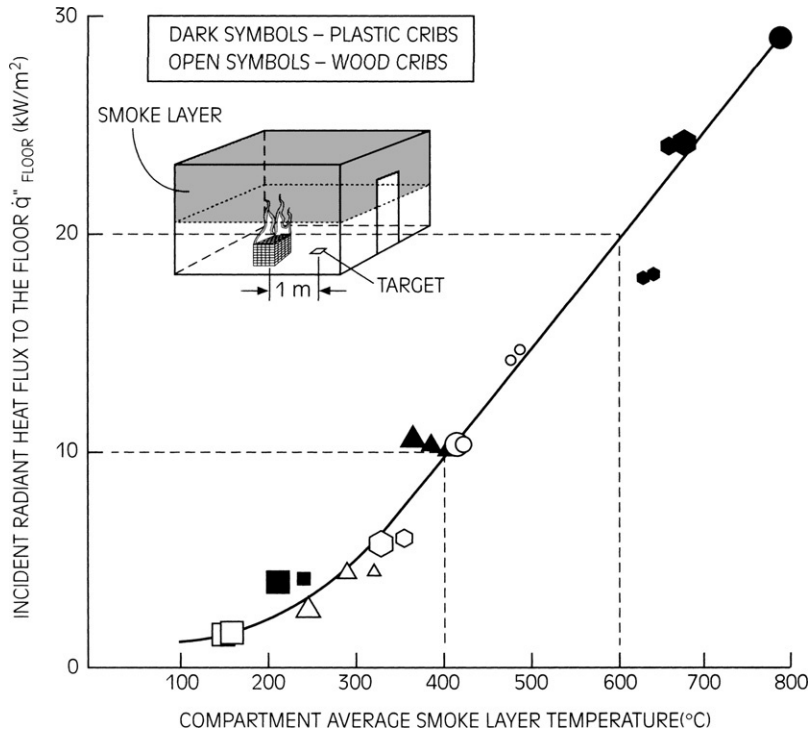


FIGURE 15.12 These data demonstrate the relationship between the temperature of a ceiling layer in a room fire and radiant heat flux onto the floor. Because a radiant heat flux of 20 kW/m^2 is considered sufficient to ignite most floor coverings and furnishings, the corresponding layer temperature of 600°C is considered critical to triggering flashover. Reproduced from [Quintiere and McCaffrey \(1980\)](#).

flameover and produces very high temperatures that accelerate the radiant ignition of fuels throughout the room ([Figure 15.17A](#)).

After flashover, there are extremely high temperatures ($800\text{--}1000+^\circ\text{C}$) and very high heat fluxes ($120\text{--}150 \text{ kW/m}^2$) everywhere throughout the room ([Figure 15.17B](#)). All fuel packages are burning as quickly as air can reach them. The areas of most intense burning are no longer the vicinity of fuel packages but the areas nearest ventilation points where oxygen can best reach the fuels involved. In a postflashover room, the maximum total heat release rate may be limited by the size of the ventilation openings. Assuming 100% efficiency, the maximum fire size will be controlled by the relationship

$$\dot{Q}_{\max} = 1500(A_o \sqrt{h_o})$$

where A_o is the area of a ventilation opening (m^2) and h_o is the height of that opening ([DeHaan, 2002](#), p. 47). Because these relationships are roughly additive, the areas and heights of individual openings can be added together. Each room has a minimum heat release rate necessary to produce flashover in that room. This rate can be calculated by several different relationships that estimate the effects of heat losses through walls, floors, ceilings, doors, and other openings. Using three of the most common relationships, one may calculate a range of 2–4 megawatts (MW)—typical for



FIGURE 15.13 Chair fire producing a hot smoke (ceiling) layer in a room. Depending on the size of the room and size of vent openings (doors and windows) that can lose heat, the minimum size of the fire needed to trigger flashover can be calculated. *Photo courtesy of Jamie Novak (Novak Investigations, Lindstrom, MN).*

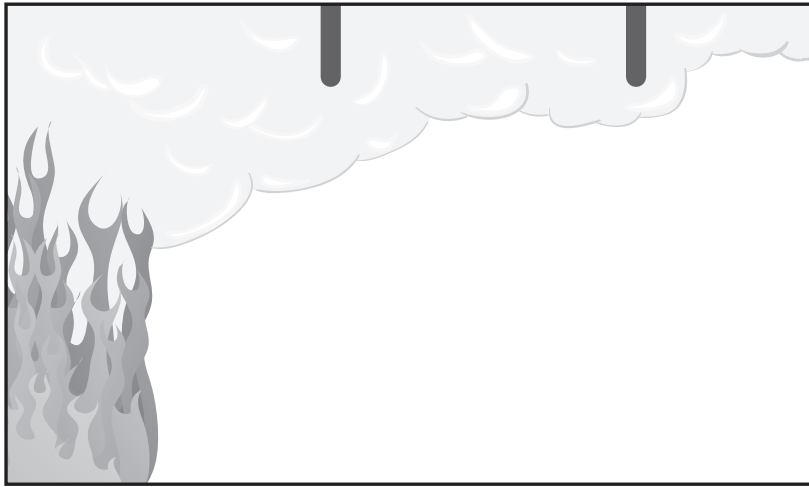
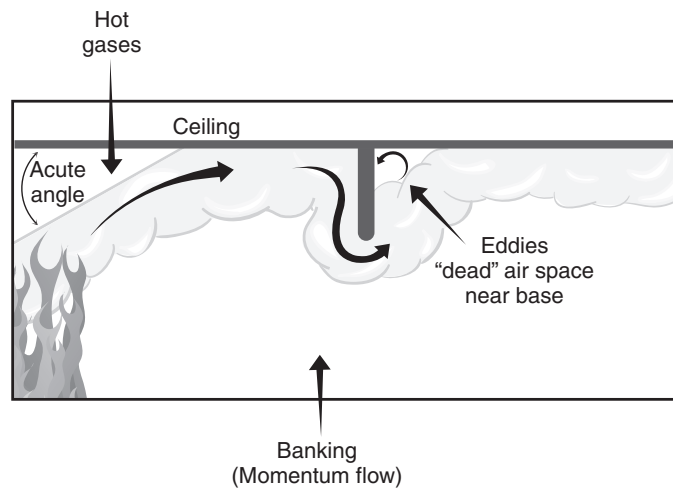


FIGURE 15.14 Typical buoyant flow of smoke from room to room produces a stair-step pattern to smoke horizons. The lowest horizon usually corresponds to the room of origin.

FIGURE 15.15 Buoyant flow along a ceiling produces an acute angle to the heat pattern on adjacent walls. Momentum flow produces a piling effect (sometimes called mushrooming) against vertical barriers on the upstream side and eddy flow (reduced flow or dead airspace) near the base of the downstream header above the opening.



large 4×5 -m rooms with two doors and a 2.5-m ceiling. If the size(s) of the opening(s) cannot accommodate a fire of that size (e.g., a single 1×1 -m window opening will permit a maximum of a 1-MW fire in a typical real-world room), then flashover could not have occurred by normal fire progression. It is possible to induce temporary full room involvement without forming a hot gas layer. If a quantity of gasoline is spread throughout a room and ignited, enough heat and direct flame can be produced to ignite all ordinary combustibles before the oxygen in the room is depleted. Under these conditions, full room involvement can be produced in less than 20 seconds as the oxygen in the room is consumed, but it will only be sustained by whatever air can get in through window and door openings once that supply is exhausted.

Postflashover fires produce charring of all exposed surfaces (floors, ceilings, walls, and furnishings) as a result of the extremely high combustion temperatures, high heat fluxes, and turbulent mixing that occur in such a room. The combustion of all surfaces is not a uniform process, however, because complex materials melt, shrink, and decompose. The resulting postfire patterns can be highly irregular in outline and depth. Some irregular floor patterns induced by postflashover burning of floors, carpets, and pads have been identified mistakenly as “flammable liquid patterns,” as shown in [Figure 15.18](#). The investigator must be careful to test hypothesized “flammable liquid” involvement against other possible explanations.

FIRE SCENE RECONSTRUCTION

Forensic fire scene reconstruction, when applied properly, can aid in the hypothesis testing that is so critical to defending conclusions in court. This goes far beyond the physical reconstruction of putting furniture back in its prefire location based on burn patterns and protection patterns. This reconstruction involves a fire engineering analysis of the elements of the fire (fuels, ventilation, and heat sources) to evaluate direction of fire spread, intensity of fire exposure, duration of exposure, effects on materials, effects on people in the fire environment, and timelines of events. The fire engineering analysis can be carried out by “thought” experiments,



FIGURE 15.16 Vertical fire growth on bedding and draperies (from wastebasket) is very rapid. The depth and temperature of the hot smoke layer will both increase rapidly. *Photo courtesy of Jamie Novak (Novak Investigations, Lindstrom, MN).*

mathematical relationships, laboratory analysis, simple or complex computer models, or empirical “live-burn” tests in either full scale or reduced scale. Sometimes, several different analyses are required to validate conclusions reached or inferred. In fact, the best solutions are those that can be shown to be correct from several different independent avenues of testing.

AREA OF ORIGIN

The observations of witnesses to early stages of the fire; surveillance camera recordings; or fire, smoke, or burglar alarm activations may give indications of the area within the room or building where the fire began. More commonly, assessment of the fire patterns will yield sufficient indications of the direction of fire spread to make at least a preliminary determination. Sometimes called vector analysis, the process relies on the physics of flow of buoyant gases, smoke and heat layering, heat transfer, and heat effects to develop a set or pattern of directional indicators: hot gases losing heat to a surface and doing less thermal damage in the direction of spread; layers being deeper in the room of origin (lower heat/smoke horizons) than in subsequent rooms; edges and corners being “beveled off” or faces being charred deeper by thermal effects on the side facing the oncoming fire; and smoke being deposited on the eddy (downwind) side of projections into the flow. Like a movie being run backward, these indicators pointing in the direction of propagation are used to point “back” toward the source. The documentation described previously (supported by interviews of occupants, staff, or owners, when necessary)



FIGURE 15.17 (A) Nonaccelerated fire in a furnished cubicle approaches flameover or rollover as the smoke layer begins to ignite into open flame. (B) Same fire 1 minute later: Radiant heat has ignited all furnishings and carpet throughout, completing the flashover transition. Postflashover fire is burning most intensely where ventilation (fresh air) supply is best. Note intense fire in the doorway.



FIGURE 15.18 The exposed carpet and 1/2-inch plywood floor of this test cubicle were consumed by exposure to a postflashover fire of duration of less than 6 minutes.

should establish the appearance and function of structural elements of the building as it existed at the time the fire started; doors, windows, transoms, vents, and HVAC system operations can all affect the buoyant flow of hot gases and smoke. Firefighters need to be interviewed regarding the tactics used to fight the fire and the effects those tactics produced. Opening ceilings or roof vents, positive pressure ventilation, or even hose streams can change the flow of hot gases inside a building.

Heat transfer patterns to walls and (often) ceilings can reveal the location of burning fuel packages, with the most intense damage (both temperature and penetration) revealing the hottest part of the flame plumes. Fire patterns can be classified conveniently as surface deposits (no chemical change to actual surface, smoke or soot condensates), surface changes (paint or wall-paper blistered or scorched, plastic coatings melted), penetration (physical and chemical changes within the matrix), and consumption (or destruction). Physical effects such as calcination (dehydration of plaster or gypsum drywall), spalling (differential thermal expansion causing loss of surface material) on concrete or brick, or crazing of glass (complex partial fracture patterns caused by sudden cooling of hot glass) can also be used as indicators of heat transfer.

As a starting premise, the area with the deepest or most widespread thermal damage is likely to be an area of origin. However, the investigator must be aware of fuel load and ventilation considerations (either of which can affect the heat release rate generated in that room dramatically). A well-fueled, well-ventilated fire can do a lot of damage in a shorter period of time than a poorly fueled or inadequately ventilated fire in an adjacent room. Suppression may be successful in one room and not in another. In such cases, the premise that the fire always burns longest, and therefore does the most damage, in the area of origin does not hold up. Alternative hypotheses must be tested even for the simplest cases if later problems are to be avoided.

CAUSATION

Once a suspected area of origin is established, examination can proceed toward locating a point of origin where the heat source came into contact with the first fuel ignited. Identification of first fuel and heat source (and the circumstances in which the contact occurred) constitutes the establishment of the cause of a fire. Ignition sources can range from appliances (matches, lighters, candles, stoves, ovens, etc.) that are designed to produce heat to items that produce heat as a by-product of normal use (current-carrying wires, incandescent lamps, and motors) and items that produce heat as a result of misuse or failure. Circumstances of the heat production and how the heat ignited the first fuel are the bases for establishing responsibility for the fire. The time factors involved are also part of the reconstruction. These include time to develop the heat, time required for that heat to ignite the first fuel, time for that first fuel to become fully involved, and time for the fire to grow to the point at which it was detected or observed (time to be extinguished). Very few of these times will be “hard” times (i.e., have an accurate clock time recorded). Alarm activation, 911 call time, and on-scene arrival of fire department may be the only hard times. Others will be based on data from a variety of sources, including live-burn tests or heat release curves of test fires in laboratories (and available through published or Web site sources), as shown in [Figures 15.19–15.22](#).

As a general rule, the weaker the initial heat source (the lower its heat release rate), the longer it will take for that source to ignite a fuel (and the closer the proximity of the source to fuel).

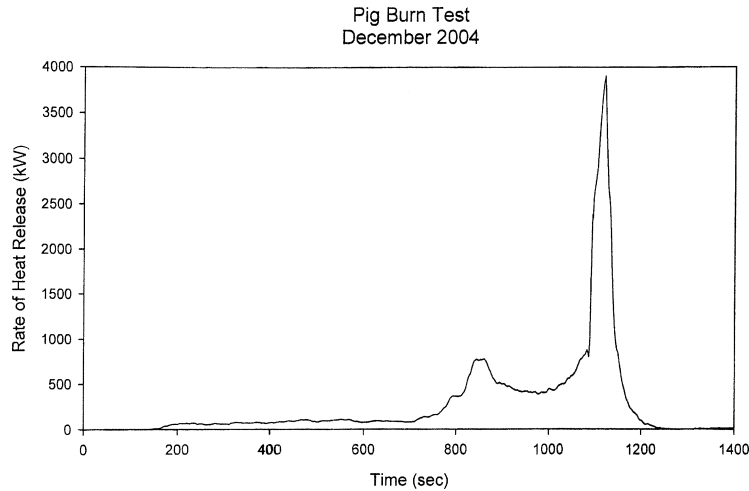
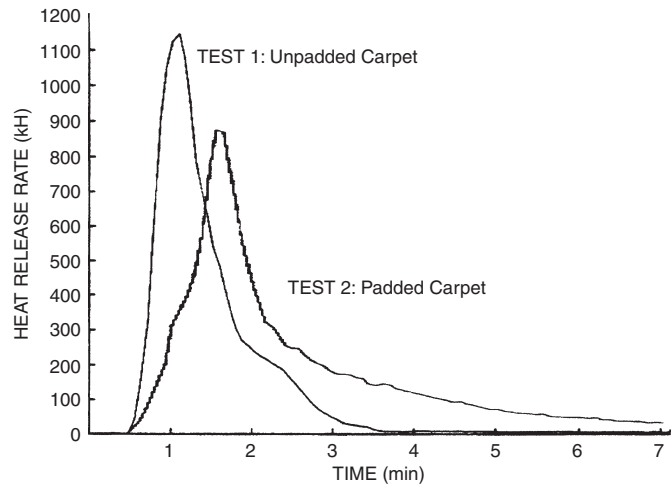


FIGURE 15.19 Heat release rate signature of bedroom fire with bedclothes ignited by match (at $t = 0$). Flashover at ~ 1100 seconds triggered by involvement of “boxspring” under mattress igniting adjacent dresser. Figure courtesy of the Bureau of Home Furnishings & Thermal Insulation, California Department of Consumer Affairs.

FIGURE 15.20 Heat release rate curves of 2 liters of camping fuel on carpet (padded and unpadded). Note the rapid growth after ignition at 30 seconds (ultrafast t^2 fire) and rapid decay with a duration of the major fire of less than 1.5 minutes. Appeared originally in [DeHaan \(1996\)](#). Reprinted with permission from [Lippincott Williams & Wilkins](#).



A glowing cigarette has a very hot central “coal” ($800\text{--}900^\circ\text{C}$), but is only a 5-W fire. It has to be in contact with a suitable fuel to cause ignition. A wooden match or a candle may have a portion of its laminar flame with a temperature of 1200°C , but it is still only a 50-W fire that must be very close (2–4 cm) to even a susceptible solid fuel. A wastebasket fire of 150 kW can be considerably farther from a target fuel and still cause ignition. A Christmas tree fire of 3 or 4 MW can cause radiant ignition of materials more than 1 m from the outer margin of the tree. The relationship between heat output of a source, radiative fraction, distance, and radiative heat flux was explored previously, and it plays an important role in analyzing the competence of ignition sources.

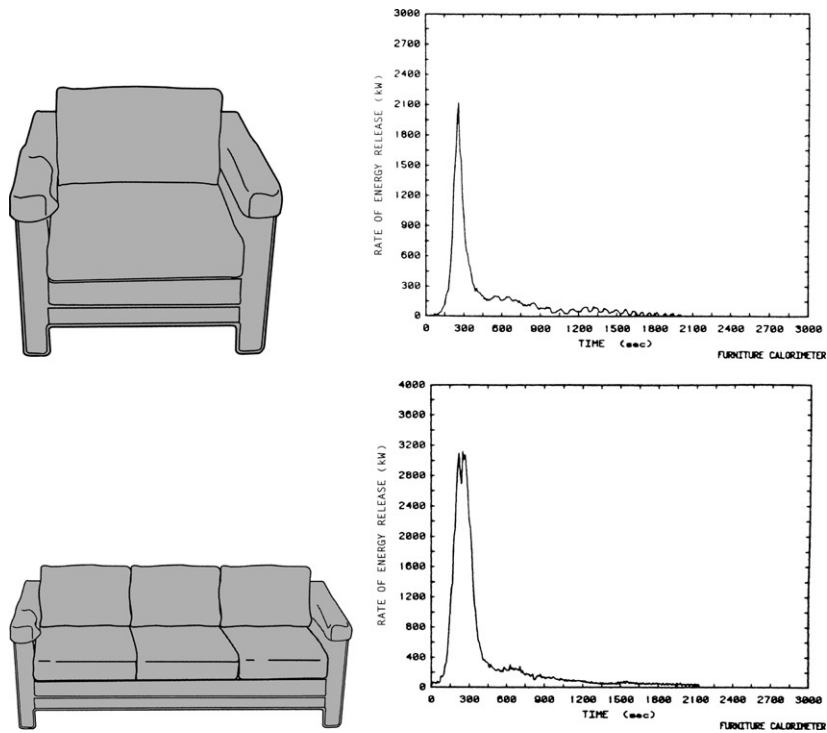


FIGURE 15.21 Heat release rates of typical modern chair and sofa with flame ignition. Note the rapid growth (ultrafast t^2 fire), rapid decay, and short duration. *Figure courtesy of the National Institute of Standards and Technology.*

If the first fuel ignited is a flammable gas or vapor, even a weak source of energy (the minimum ignition energy of most flammable gases or vapors is less than 0.3 mJ) can be adequate, but the source must be in direct contact with the fuel, the fuel must be in its flammable range, and the contact has to be prolonged enough to allow enough energy to transfer. Vapors produced by the evaporation of any flammable liquid are significantly heavier than air and will form a discrete layer at floor level, with only slow diffusion occurring unless there is mechanical stirring (fans, vehicles, or people moving about) or thermal currents mixing the vapors and air. Only methane, carbon monoxide (CO), and acetylene are lighter than air (and only methane will rise perceptibly when released in still air).

Every fire, whether it is a single match, a wastebasket of paper, a sofa, a pool of gasoline, or an entire room, will develop along a characteristic HRR/time curve called its fire signature, as shown in [Figure 15.19](#), with four phases—incipient, growth, fully developed, and decay.

A gasoline pool fire will have a very short incipient phase, a very rapid growth phase (often called ultrafast), and a fully developed phase (with HRR controlled by the size of the pool, the maximum mass flux for gasoline, and, possibly, a ventilation limit). As the gasoline pool is exhausted, the onset of decay is very rapid and there is no decay phase smoldering, seen in [Figure 15.20](#). Modern furnishings are ignited easily by open flame and will support extremely large and fast-growing fires (as shown in [Figure 15.21](#)) that behave very much like accelerated fires.

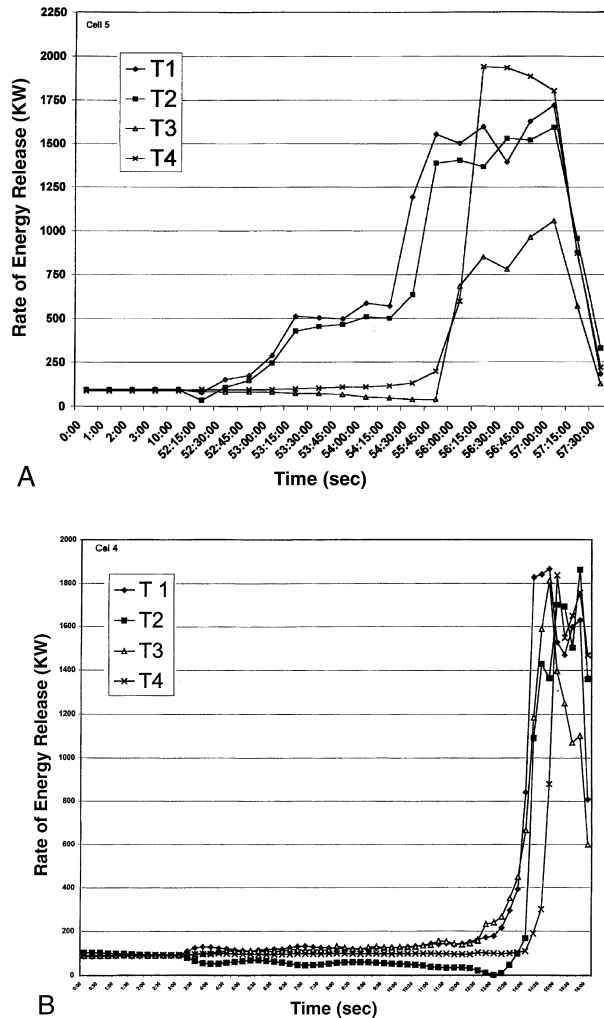


FIGURE 15.22 (A) Temperature curve of test fire started in traditional chair with a cigarette. Note the prolonged initiation phase (incipient fire) of 52 minutes and minimal change in ceiling temperature ($T1$ and $T2$) until then. After the onset of flaming fire, fire growth is very rapid. The apparent decrease in floor temperature ($T3$) is due to faulty electrical connection to thermocouple. (B) Temperature data for a fire started with a flame in a wastebasket under a desk (at $t = 0$). $T1$ and $T2$ were ceiling (upper layer) thermocouples, and $T3$ and $T4$ were floor-level thermocouples. Note the minimal change in upper layer temperature until the desk ignited at 13:30, followed by extremely rapid onset of flashover. Postflashover temperatures ranged from 1400 to 1850°F (700–900°C). Figures courtesy of Washington State Patrol, Region 8, fire investigation team.

A smoldering ignition in a traditional chair will look very different, as shown in Figure 15.22A. It will have a long incipient phase, a much slower growth phase with a transition to flame, and a prolonged decay phase with considerable smoldering. Timescales vary for the

transition to flame, sometimes occurring in as little as 22 minutes from cigarette contact to as long as 3 or 4 hours, or it may never occur.

The flame height above a given fuel package is useful for evaluating fire patterns. The two most common formulas for calculating such values were discussed previously. With a large, rectangular fuel package such as a sofa, the “diameter” correction of the Heskestad formula is useful. The equivalent diameter [D_{eq}] of any noncircular fuel surface of area A is calculated by estimating or measuring the horizontal surface area and solving for r using the formula

$$A = \pi r^2 \quad D_{eq} = 2(A/\pi)^{1/2}$$

Flame height will be revealed by thermal effects on vertical walls adjacent to the flames (keeping in mind the wall effect). If a flame appears to have been much larger than it should have been based on the estimated HRR of the fuel package thought to have been present, then the investigator should evaluate the possible causes. Was it a stack of chairs and not just one, was it an upholstered armchair and not a simple desk chair, or was there an **accelerant** placed on the chair (Styrofoam packing, a urethane cushion, or a flammable liquid)?

Radiant heat ignition or thermal damage will occur when the radiant heat flux striking a surface causes the temperature of that surface to reach a critical point (to cause it to soften, melt, scorch, char, or ignite). If a fire can be treated as a point source (i.e., its distance, d , from the target surface is much greater than its height or width), the simple relationship

$$\dot{q}'' = X_r \dot{Q} / 4r^2$$

can be applied to test hypotheses about fire progression. Knowing what the “target” surface is (thermoplastic, cellulosic, wool, thermosetting resin, etc.) allows us to predict the effects of various fire sizes (\dot{Q}) at various distances. If the critical radiant heat flux needed to ignite a surface is 20 kW/m^2 , a fire of at least 500 kW is going to be needed to ignite a surface just 1 m away (and this assumes full frontal exposure). If the first fire is a chair, the geometry of the chair and where the fire is burning on it will affect the lateral ignition greatly. In his extensive furniture tests, Babrauskas observed that a modern armchair has to be less than 1 m away from a similar burning chair (with a typical \dot{Q}_{max} of 1000 kW) if it is to be ignited by direct radiant heat (Krasny et al., 2001). The larger the vertical burning surface in proportion to the distance, the easier it is for distant radiant ignition to occur as the intensity no longer falls off with $1/d^2$ (see Figure 15.8). Anyone who has attempted to stand in front of a burning wooden wall or tall wooden cabinet can attest to the intensity of radiant heat even 2 or 3 m away.

Fire engineering analysis is carried out to test hypotheses and confirm the reliability of data and predictions in a fire scene reconstruction. In the past, fire investigators relied on experience (often as line firefighters or as postfire investigators who rarely saw the actual fire in progress) as the basis for predictions. These cause-and-effect pronouncements were sometimes based on limited (or no) data, erroneous information, or so-called “common sense” and led to wrongful conclusions. Using fire engineering analysis, the investigator can look to enormous bodies of data gathered and tested under controlled conditions by such fire researchers as the National Institute of Standards and Technology (NIST), the University of Maryland, Fire Research Station, Factory Mutual, and others in the public and private sectors. For instance, data show that the heat release rate from a modern sofa can easily exceed that produced by a 1-m^2 pool of gasoline burning in the same room and can reach that rate in only 2 or 3 minutes after ignition by open

flame. So, short of overpressure (**explosion**) effects, the end result in a room can look identical (and nearly equal in growth rate). Further testing shows that neither the gasoline nor the modern synthetic-upholstered sofa can be ignited directly with a discarded cigarette. Either first fuel requires an open flame (or an electric arc) to ignite, so the “witness” information that a cigarette was left burning in the room just before the fire can be excluded as unreliable. Fire engineering analysis can help solve puzzles of fire behavior, growth, and effects on humans exposed to it.

CASE STUDY

An elderly man was found unconscious in his upstairs bedroom when firefighters were ventilating smoke and steam from his apartment after extinguishing a large paper and cardboard trash fire on the stairs leading to his bedroom hallway (Figure 15.23). The fire never extended past the stairs but did damage the adjacent walls and had spread to clothing and other household furnishings adjacent to the stairs. The man, who suffered from emphysema and a heart condition, also had a blood alcohol content of 0.12% (he was a “moderate” alcoholic). He had first- and second-degree burns (blisters) on his face, upper chest, and arms. The door to his room at the end of the upstairs hallway was found partly open, and his room was charged with steam and smoke (to the point the firefighter did not see the victim in bed until the windows were opened and he heard labored breathing). The man was removed from the apartment and recovered consciousness briefly as he was put on oxygen by the rescue unit, but he lapsed into unconsciousness and died the next day. Upon admission, the victim had carboxyhemoglobin (COHb) saturation in the hospital of 23% (after approximately 40 minutes on oxygen). He was seen to have soot in his nostrils on admission. Heat effects in his room were limited to softening of a plastic wall clock and lampshade. Smoke levels in the room were estimated to have been 1.5–1.8 m from the floor (by staining on walls). He was found in bed in his underwear at a height estimated to be 0.5 or 0.6 m from the floor. There were unmelted plastic trash bags of clothing on the floor of the room. The issue here was how did the victim sustain his injuries when the fire never extended past the landing of the stairs? Using the pattern of thermal damage on the stairwell walls [showing flame damage to approximately 2.7 m from the foyer floor (base of the stairs)], the maximum heat release rate was calculated from the relationship

$$H_f = 0.174(k\dot{Q})^{2/5},$$

where $k = 2$ (walls). Solving for \dot{Q} , using $H_f = 2.7$ m, $\dot{Q} = 500$ kW. Using the Zukowski method for smoke production rate,

$$\dot{m}_p = 0.065\dot{Q}^{1/3}Y^{5/3},$$

where \dot{m}_p is the rate of smoke production in kilograms per second and Y is the height from the point source of fire to the bottom of the smoke layer. Since the fire’s source was at the bottom of the stairs, the height to the ceiling was 5 m at the start of the fire (dropping to ~2.5 m as the hall filled with smoke).

Solving for \dot{m} , the rate ranges from 7.5 kg/sec at the start to 2.4 kg/sec at the end. Assuming an average smoke temperature of approximately 200°C (based on experimental data and thermal

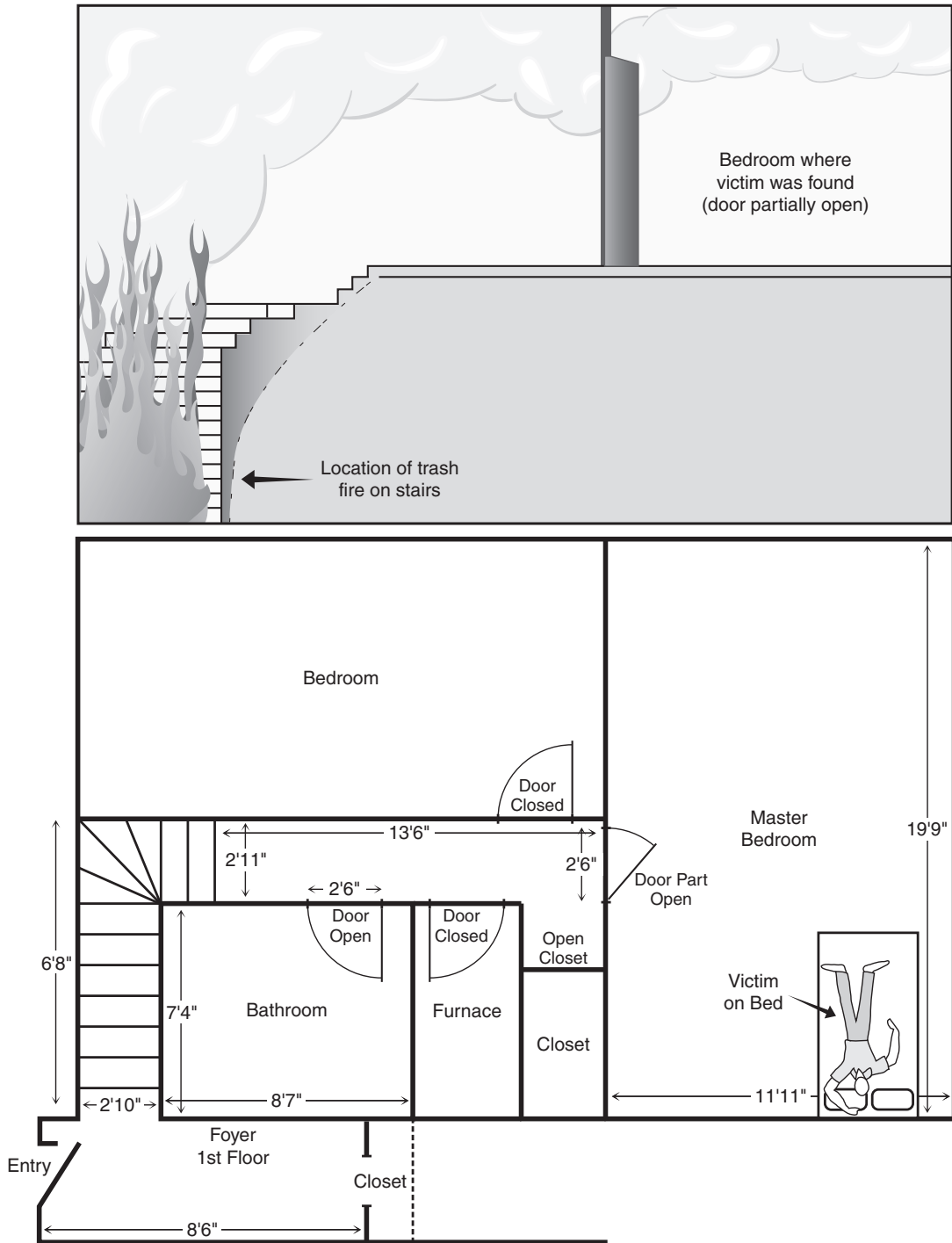


FIGURE 15.23 Plan and elevation diagrams of fatal fire where localized fire on stairs created enough heat and smoke to cause the death of an elderly man in the bedroom at the far right. Courtesy of Halton Regional Police, Ontario, Canada.

effects observed at the scene), the density of the hot gases would be approximately 0.7 kg/m^3 (vs 1.2 kg/m^3 at 20°C). The filling rate would then be between 10 and $3 \text{ m}^3/\text{sec}$. Based on the dimensions of the hallway [and adjoining bathroom with an open door (total volume, 27 m^3)], the hallway would be filled with smoke in less than 5 seconds after the fire reaches 500 kW. Given the heat release curves of trash fires in tests, this would occur within 2 or 3 minutes after open flame ignition. It was suggested that the victim's burns were produced when he started the fire on the stairs. The absence of burns to his legs suggested that he did not have close contact with a trash fire burning on the stairs below him (close enough for radiant heat to affect his legs). Human tenability data show that direct contact with gases hotter than $50\text{--}60^\circ\text{C}$ is sufficient to induce second-degree burns, as is exposure to radiant heat of approximately 4 kW/m^2 . The buoyancy of the hot gases filling the hallway would push hot gases and smoke into the room through the narrow opening of the partly opened door observed by the firefighter. Given the room size and the smoke-filling rate calculated previously, it was calculated that his room could be filled with a ceiling layer 0.6–0.9 m deep within a few minutes of ignition (with a 500-kW fire on the stairs). Data from Quintiere and McCaffrey (see [Figure 15.12](#)) showed that a ceiling layer with temperatures between 200 and 300°C would produce floor-level radiant heat flames of $3\text{--}5 \text{ kW/m}^2$. Even if the ceiling layer temperature never exceeded 200°C , as indicated by the melted plastic clock, there would be enough radiant heat from a hot ceiling layer alone to induce burns to exposed skin. In addition, smoke and steam venting into the room during suppression could easily charge the room completely (floor to ceiling) with hot gases with temperatures in excess of 50°C , causing burns by prolonged convective heat transfer from immersion in the hot steam. His moderate COHb saturation and observed soot in the nostrils (but no singed hair) are also consistent with immersion into, and inhalation of, hot gases and smoke. In this case, his elderly roommate (landlady) was convicted of starting the fatal trash fire deliberately in an attempt to convince her tenant to move elsewhere.

CRIMINALISTICS ASPECTS

Fire investigators tend to focus on the origin and cause of the fire and may overlook the kinds of physical evidence that are discussed in great detail elsewhere in this text. We all realize the contributions that analysis and interpretation of evidence can make toward connecting a victim and a perpetrator, a perpetrator to a scene, or a victim to a scene; establishing sequences of events; or establishing timelines of events. As a reminder, the following sections discuss some of the types of criminalistics evidence that have played a critical role in reconstructing both intentional and accidental fires.

Shoe Impressions

Often compromised inside a fire scene by structural collapse or water or outside a scene by vehicle or foot traffic, shoe prints have been recovered as three-dimensional impressions in soil away from the fire and its suppression. They have been found on doors (as mud or dust transfers) or on glass or windowsills where entry was forced. They have also been found (as patent or latent impressions) on papers scattered on floors during vandalism, burglary, or fraud

concealment prior to the fire. The footwear worn by firefighters is often distinctive and can be eliminated easily by direct observation at the scene. Photography (with appropriate scales) followed by recovery whenever possible is the correct preservation.

Fingerprints

Investigators are prone to completely dismiss the possibility of fingerprints at fire scenes due to heat, water, soot, ash, and physical destruction of the fire. Tests have shown that fingerprints can and do survive fires at a reasonable rate. Patent impressions in mud, blood, or paint may well survive a fire even when the underlying substrate has begun to scorch or char (some patent prints may actually be enhanced by the action of heat on the medium or on the substrate). Due to the large number of chemical, optical, and photographic methods for developing latent prints today, recovery is much more likely. "Plastic" (molded, three-dimensional) impressions have been recovered from window putty after a fire, and plastic containers softened by petroleum liquid accelerants have been known to record the molded prints of the person using the container. Lasers and light sources can be used to detect prints even in the presence of some fire contaminants. Soot deposits can actually preserve or even enhance print detail. Heat and moisture can cause skin oils to darken (and become patent prints) or cause metal surfaces (e.g., zinc galvanizing) to corrode where skin secretions are left. A physical developer can be used on light-colored porous surfaces that have become wet. A small-particle reagent (or its commercial variants) can be used on nonporous surfaces (metal and plastics) that have been wet and are still wet (with metal objects kept immersed in water to prevent oxidation prior to processing). Leucocrystal violet has been used to recover prints in blood or blood spatter evidence on surfaces that have been covered with soot.

The bottom line is that until the substrate chars and disintegrates, there is some chance for prints to be developed. Far too many investigators claim they have never found any fingerprint evidence at fire scenes, when in truth they have never looked for it. With today's powerful automated fingerprint identification systems and interconnected databases, fingerprints are much more useful to fire investigators than ever before.

Blood

With the dramatic increase in sophisticated and sensitive DNA systems, blood evidence is more important than ever before to fire investigators. Tests have shown that unless the tissue is cooked completely or the bone is exposed long enough to heat all the way through, DNA typable material can survive. Investigators must be aware that heat penetration into deep tissues requires a long time, even when the exterior is exposed to direct flame. The water in the tissue must evaporate before the temperature of the tissue can rise to the point where DNA is compromised. This evaporation slows heat penetration. Blood spatter, even when the DNA is not typable, can help reconstruct events involving injuries and physical violence. Again, careful documentation and minimal postfire overhaul are essential if such evidence is to be recovered.

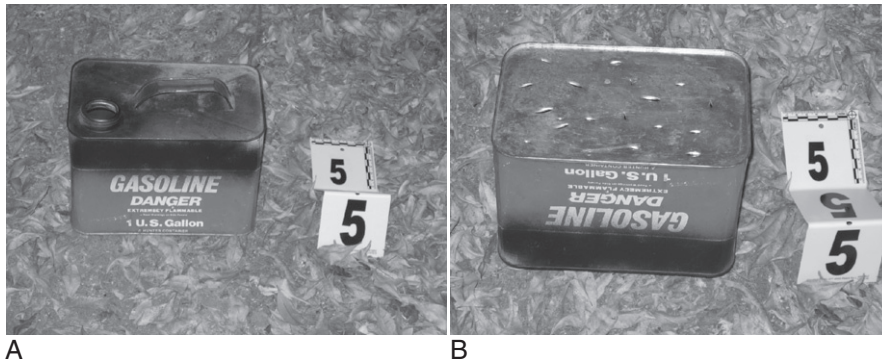


FIGURE 15.24 (A) A scorched and smoked gas can appears normal from above, but careful examination shows repeated punctures from a knife blade (B), proving that the can was used to distribute the liquid fuel in an intentional fire.

Tool Impressions

Tool impressions in all but the softest metals (aluminum, zinc, or lead will all be melted by fire exposure) will not be affected by most fire exposure and will only require cleaning to be comparable. Preparations for setting a fire, such as puncturing a metal can to aid in dispersal of its contents (Figure 15.24), will also leave identifiable tool marks.

Physical Match

Glass, concrete, tape, cloth, and upholstery fabric have all played a role in reconstructing the events of a fire. Glass can be broken by thermal or mechanical shock, and distinguishing between the two by examination of the fracture pattern and margins may be useful in establishing the sequence of events. The direction and relative speed of mechanical force may also be determined. These reconstructions are most useful when all (or at least a large majority) of the fragments can be recovered and the interior/exterior sides of a window glass can be identified and documented.

Trace Evidence

Glass, soil, construction materials, fibers, paint, and hairs can all serve to aid the reconstruction of events preceding a fire (and sometimes during it). Fire investigators, however, tend to overlook such trace evidence and need to be reminded of its potential value, particularly early in an investigation before tools, shoes, clothing, or vehicles can be changed or cleaned.

FIRE DEATHS AND INJURIES

Problems and Pitfalls

Several problem areas can complicate fatal fire investigations and compromise the accuracy and reliability of the conclusions reached.

1. Prejudging the fire and its attendant death as an accident, and automatically treating the scene investigation accordingly, is a major problem. Fires can be intentional, natural, or accidental in their cause, and deaths can be accidental, homicidal, suicidal, or natural. The linkage between the two events can be direct, indirect, or simple coincidence. The responsibility of the investigation team in fatal fire cases is to establish the cause of both the fire and the death and to determine the connection (if any) between the two.
2. Sudden violent deaths are assumed to be instantaneous exposure to insult followed by immediate collapse and death (a shot is fired and the victim collapses to die shortly afterward), and many forensic investigations are considered (and successfully concluded) in this light. Fires, however, occur over a period of time, creating dangerous environments that vary greatly with time and can kill by a variety of mechanisms. A person may be killed nearly instantaneously by exposure to a flash fire or only after many hours of exposure to toxic gases. Investigators must have an appreciation of the nature of fire and its lethal products and not treat the event as a single exposure to a single set of conditions at a precise moment in time that results in instant collapse.
3. There is little accurate information available to detectives and pathologists about the temperatures and intensities of heat exposure that occur in a fire as it develops.
4. In most violent deaths, the victim offers a fight-or-flight response to the threat, suffers an injury, and collapses and dies. In fires, in addition to flight or attempting to fight the fire, potential responses include going to investigate; simply observing; failing to notice or appreciate the danger; failing to respond due to infirmity or incapacitation from drugs or alcohol; and returning or delaying escape to rescue pets, family, or purses. This variability of response can vastly complicate answering the critical question: Why did this person fail to escape the fire (and perhaps others escaped)?
5. Fires can kill in seconds or death can occur minutes, hours, days, or even months after the victim is removed from the scene. The longer the time interval between the fire and the death, the more difficult it is to keep track of the actual cause (the fire) and the result (the death). Evidence is lost when a living victim is removed from a scene, and when the victim dies later, away from the scene, it may be too late to recover or document that evidence.
6. There can be conflicts between perceived or mandated responsibilities of police, fire, medicolegal, and forensic personnel who are often involved in fire death scenes.
7. After death, there can be severe postmortem effects on the body that can vastly complicate the investigation by obliteration of evidence. The body can bear fire patterns of heat effects and smoke deposits that can be masked by exposure to fire after death. The body can be incinerated by exposure to flames, such that evidence of prefire wounds or even clinical evidence such as blood samples is destroyed. There can be structural collapse and the effects of firefighting hose streams and overhaul that induce additional damage.
8. A major problem is the premature removal of a deceased victim from the fire scene. The compulsion to rescue and remove every fire victim is a very strong one, particularly among dedicated firefighters. However, once the fire is under control and unable to inflict further damage to the body of a confirmed deceased, there is nothing to be gained and much to be lost in the way of burn pattern analysis, body fragments (especially dental evidence), projectiles, clothing and associated artifacts (keys, flashlight, dog leash, etc.), and even trace evidence by the undocumented and hurried removal of the remains.

What Kills People in Fires?

Structural fires can achieve their deadly result in a number of ways—heat, smoke, flames, soot, and others—but fire conditions change continually as a fire grows and evolves, and the conditions of exposure of a would-be victim can vary from “no threat or injury” to almost instantly lethal. We can isolate the major lethal agents as follows.

Heat

The human body is capable of surviving exposure to external heat as long as it can moderate its temperature by radiant cooling of the blood through the skin and, more important, by evaporative cooling. This occurs internally via evaporation of water from the mucosal linings of the mouth, nose, throat, and lungs and sweat from the skin. If the body temperature exceeds 109°F (43°C), death will occur. Prolonged exposure to high external temperatures (175–250°F, 80–120°C) with low humidity can trigger fatal hyperthermia. Exposure to lower temperatures accompanied by high humidity (which reduces the cooling evaporation rate of the water from the skin or mucosa) can also be lethal. Fire victims can die of exposure to heat alone, even if they are protected from carbon monoxide, smoke, and flames. This may result in victims with minimal postmortem changes, although skin blistering and sloughing (“sleeving” or “gloving”) may occur after death.

Inhalation of Hot Gases

Inhalation of very hot gases causes edema (swelling and inflammation) of mucosal tissues. This edema can be severe enough to cause blockage of the trachea and asphyxia. Inhalation of hot gases may also trigger “laryngospasm,” in which the larynx closes up involuntarily to prevent entry of foreign material, or “vagal inhibition,” in which breathing stops and the heart rate drops.

Rapid cooling of inhaled hot gases occurs as the water evaporates from mucosal tissues, so thermal damage usually does not extend below the larynx. If the hot gases include steam or are otherwise water saturated, evaporative cooling is minimized and burns/edema can extend to the major bronchi.

If inhaled gases are hot enough to damage the trachea, they will usually be hot enough to burn facial skin and singe facial or nasal hair.

Smoke

Soot is agglomerations of carbon from incomplete combustion to produce solid particles. Because these particles may be very hot and are not cooled readily as they are inhaled, they may induce edema and burns where they lodge in the mucosal tissue of the respiratory system. Soot particles are active absorbents, so they may carry toxic chemicals and permit their ingestion or inhalation (with direct absorption by the mucosal tissues). Soot can be inhaled in sufficient quantities to physically block airways and cause mechanical asphyxiation. Soot in smoke can also obscure the vision of victims and prevent their escape.

Toxic Gases and Chemicals

Products of combustion can include a wide variety of chemicals depending on what is burning and how efficiently it is burning (temperature, mixing, and oxygen concentration are all important variables in determining what species are created). Materials can be classified generally into three basic categories: acidic, toxic, or irritant.

Acidic: HCl, H₂SO₃, H₂SO₄—cause edema and chemical burns when inhaled and absorbed into the water of the mucosal tissues.

Toxic: CO, HCN (hydrogen cyanide), and free radicals (reactive chemical “fragments” that occur at high temperatures)—all have a deleterious effect on tissues, nerves, or biological processes.

Irritants: HCl and acrolein (2-propenal, C₃H₄O) (produced by combustion of wood)—cause tearing of eyes and coughing (possibly to incapacitation).

Carbon Monoxide

Carbon monoxide is produced in fires by the incomplete combustion of any carbon-containing fuel. It is not produced at the same rate in all fires. In free-burning (well-ventilated) fires, it can be as little as 0.02% (200 ppm) of the total gaseous product. In smoldering, postflashover, or underventilated fires, CO concentration ranges from 1 to 10% in the smoke stream (Golovina and Khaustovich, 1960, p. 784).

When inhaled and absorbed into the bloodstream, it forms a complex (COHb) with the hemoglobin that is approximately 200 times more stable than the hemoglobin complex formed with either oxygen or CO₂. (There is no measurable diffusion from an external atmosphere rich in CO into the blood or tissues of a dead body.)

The stability of the COHb means that it replaces the O₂-carrying capacity of the blood with a virtually inert complex. CO has both an asphyxiant effect (by starving cells of O₂) and an anesthetic effect as it interferes with energy production in cell functions (Feld, 2002).

Although COHb saturation (the percentage of blood that is “tied up” with CO) is considered lethal by itself at 50%, the actual “lethal” concentration varies widely from as low as 20% in some extreme cases to 80% or higher. Controlling variables are health and age of victim, the presence of other toxic materials, concentration of CO in the air being breathed, and especially physical activity. If no demands are being made on the voluntary muscles (e.g., if the person is asleep), higher concentrations can be accumulated before death occurs. If a person is in good health, with good heart and lung function, higher concentrations can be tolerated. The very old and the very young are most susceptible to death at relatively low concentrations (<40%). Respiratory or cardiac illnesses can compromise oxygen exchange and cardiac function to the point at which saturations of 20–25% can be lethal.

The mere presence of CO in the blood is not a sign of breathing fire gases. The normal body has COHb saturations of 0.5–1% as a result of degradation of heme in the blood (Penney, 2000). Higher concentrations (up to 3%) may be found in nonfire victims with anemia or other blood disorders. Smokers can have levels of 4–10%, as tobacco smoke contains a high concentration of CO coming from a smoldering fire. People in confined spaces with emergency generators, pumps, and compressors can have elevated, sometimes dangerous, COHb concentrations.

When a victim is removed from a CO-rich environment of fresh air, the CO is eliminated gradually (Penney, 2000). The higher the partial pressure of O₂, the faster the elimination:

In fresh air: Initial concentration will be reduced by 50% in 250–320 minutes (approximately 4 or 5 hr).

In O₂ via mask: 50% reduction in 65–85 minutes (approximately 1¼ hr).

In O₂ at hyperbaric pressures (3 or 4 atm): 50% reduction in 20 minutes.

The time at which a blood sample is drawn from a subject must be noted as well as the nature of any medical treatment (e.g., O₂). The COHb saturation of blood in a dead body is very stable, even after decomposition is progressing. CO poisoning kills many fire victims before they are ever exposed to fire. It can kill victims even some distance from a fire when they are not exposed to any heat or flames, but it is not the only factor in many fire deaths. CO is not absorbed by a dead body, only by inhalation.

Anoxia

Anoxia is the condition of inadequate oxygen to support life. This can occur when air is displaced by another inert gas such as nitrogen or carbon dioxide, by a fuel gas such as methane, or even by benign products of combustion (e.g., CO₂ and water vapor). Normal air contains 21% O₂. At concentrations down to 15% O₂, there are no readily observable effects. At concentrations between 10 and 15%, disorientation (similar to intoxication) occurs and judgment is affected. At levels below 10%, unconsciousness and death will occur. Hypoxia is aggravated by high levels of CO₂, which accelerate breathing rates.

Flames (Incineration)

When heat is applied to a surface, the rate at which it penetrates that surface is determined by the thermal inertia of the material (the numerical product of thermal capacity, density, and thermal conductivity). The thermal inertia of skin is not much different from that of a block of wood or polyethylene plastic. The pain sensors for human skin are in the dermis, approximately 2 mm (1/10 inch) below the surface. If heat is applied very briefly, there may not be any sensation of discomfort or pain. The longer the heat is applied, the deeper it will penetrate. The higher the intensity the heat applied, the faster it will penetrate. Pain is triggered when skin cells reach a temperature of approximately 120°F (48°C), and cells are damaged if their temperature exceeds 130°F (54°C) (Besant-Matthews, 1993; Stoll and Greene, 1959).

Exposing skin to 2–4 kW/m² radiant heat for 30 seconds will cause pain.

Exposing skin to 4–6 kW/m² radiant heat for 8 seconds produces blisters (second-degree burns).

Exposing skin to 10 kW/m² radiant heat for 5 seconds causes deeper injuries.

Exposing skin to 50–60 kW/m² radiant heat for 5 seconds produces third-degree burns.

Burns

Even in the absence of fire or flames, prolonged exposure of body parts that raise their temperature over 130°F (54°C) will cause desiccation, sloughing, and blistering (which can also be caused by exposure to caustic chemicals). Even in the absence of fire, prolonged exposure to higher temperatures causes desiccation and shrinkage of muscle tissue and tendons, which causes flexion of joints (“pugilistic posturing”). Exposure to flames can cause combustion of muscle and fracturing of major limb bones where the bone is exposed.

Blunt Trauma

Blunt force trauma can also cause or contribute to the death of fire victims. Structural collapse or explosions can produce direct impact of solid materials onto victims. Falls or impact with stationary surfaces (furniture or door frames) during escape attempts can induce blunt trauma that only careful examination can distinguish from the result of an assault. Wound patterns, bloodstains, or even trace evidence can be used to interpret blunt trauma injuries and establish whether they resulted from assault or were inflicted as a result of the fire.

Time Intervals

One of the problems outlined previously is the time interval between exposure to a fire and its fatal aftermath. Death can occur nearly instantaneously or minutes or hours later. Under these conditions, it is not difficult to connect the death to its actual cause. When a person dies weeks or even months after a fire, the cause can still be the fire, but the linkage can be obscured by the extensive medical events in between.

Instantaneous death:

- Vagal inhibition of laryngospasm upon inhalation of flames and hot gases, causing cessation of breathing

- Explosion trauma

- Incineration by exposure to a fully developed fire as a result of structural collapse

Seconds to minutes:

- Hyperthermia—exposure to very hot but nonlethal gases or steam

- Anoxia—lack of oxygen

- Toxic gases—hydrogen cyanide or pyrolysis products (free radicals)

- Asphyxia—inhaling of carbon monoxide or blockage of airways by soot

- Exposure to flames (shock)

- Physical trauma—loss of blood, internal injuries, brain injuries

Hours:

- Carbon monoxide

- Edema from inhalation of hot gases

- Burns (shock)

- Brain or other internal injuries

Days:

- Burns—dehydration, shock

- Infections

Weeks or months:

- Infections

- Organ failure

It should be remembered that the cause of death can be defined as the injury or disease that initiates the sequence of events leading to death. In a fire, the cause may be inhalation of hot gases, CO, or other toxic gases; heat; burns; anoxia (hypoxia); asphyxia; structural collapse; or blunt trauma. The mechanism of death is the biological or biochemical derangement incompatible with life. Mechanisms can be respiratory failure, exsanguination, or cardiac arrest.

The manner of death is an assessment of the circumstances under which the cause was brought about. In the United States, these are most often homicide, suicide, accident, natural, or undetermined. (Some jurisdictions recognize death by misadventure and by medical intervention.)

As one can appreciate, the longer the interval between the cause (the fire) and the onset of the mechanism of death (organ failure, septicemia, etc.), the more likely it is that the connection will be lost. This is especially true when the victim has been moved from trauma care hospitals to long-term care facilities, sometimes in other geographical areas. The investigator must be diligent to ensure that the cause of death is not listed on the final death certificate as some generic mechanism, such as respiratory failure, cardiac arrest, or septicemia.

Summary of Postmortem Tests Desirable in Fire Death Cases

Although not all of the following may be needed in all cases, it can be appreciated that once the body is released for embalming or cremation, it will be too late. The complexity of many fire death cases may necessitate finding the answers to problems or questions that were not apparent earlier. Having comprehensive samples and data is the best route to a successful and accurate investigation.

Blood (taken from a major blood vessel or chamber of the heart, not from the body cavity)

Tested for:

COHb saturation

Hydrogen cyanide

Drugs (therapeutic and abuse)

Alcohol

Tissue (brain, kidney, liver, lung)

Tested for:

Drugs

Poisons

Volatile hydrocarbons

Combustion by-products

CO (as a backup for insufficient blood)

Tissue (skin near burns)

Tested for vital chemical or cellular response to burns

Stomach contents

Tested to establish activities before death and possible time of death

Airways

Full longitudinal transection of airways from mouth to lungs to examine and document the extent and distribution of edema, scorching/dehydration, and soot

Internal body temperature

Should be measured at the scene; may be elevated due to hyperthermia antemortem or unusually low if death preceded the fire by several hours or more

X-rays

Full body (including associated debris in body bag)

Details of teeth and any unusual features discovered (fractures, implants)

Clothing

Remove and preserve all clothing remnants and associated artifacts

Photographs

General and close-up of any burns or wounds, in color, with scale

It is very useful for the fire investigator to be present when the postmortem is conducted, not only to ensure that all appropriate observations are made but also to answer any questions that arise during the examination. Because few pathologists have extensive knowledge of fire chemistry or fire dynamics, the investigator is in a good position to advise the pathologist as to the fire conditions in the vicinity of the body.

Postmortem Destruction

A body exposed to fire can support combustion, the rate and thoroughness of which depend on the nature and condition of exposure of the body to the flames. The skin, muscles, and connective tissues will shrink as they dehydrate and char (causing flexion of joints and pugilistic posturing of the body (Bohnert et al., 1998). If exposed to enough flame, they will burn and yield some heat of combustion, although quite reluctantly. The relatively water-logged tissues of the internal organs must be dried by heat exposure before they can combust, and that dehydration step increases their fire resistance and delays their consumption. Bones have moisture and a high fat content, especially in the marrow, so they will shrink, crack, and split and contribute fuel to an external fire. The subcutaneous fat of the human body provides the best fuel, having a heat of combustion on the order of 36 kJ/g. Like candle wax, however, it will not self-ignite nor smolder and will not support flaming combustion unless the rendered fat is absorbed into a suitable wick. This “wick” can be provided by charred clothing, bedding, carpet, upholstery, or wood in the vicinity (as long as it forms a porous, rigid mass). The size of the fire that can be supported by such a process is controlled by the size (surface area) of the wick. Depending on the position of the body and its available wick area, fires supported by the combustion of a body will be on the order of 20–130 kW (smaller than that of a small wastebasket fire) (DeHaan et al., 1999). The flames will be 800–900°C; if they impinge on the body surface, they can aid in the destruction of the body. The process, if unaided by an external fire, is quite slow, with a fuel consumption rate on the order of 3.6–10.8 kg/hr (7–25 lbs/hr). It is possible, given a long enough time (5–10 hr), that a great deal of the body can be reduced to bone fragments (DeHaan and Nurbakhsh, 2001). If a body is exposed to a fully developed room fire, however, the rate of destruction will be much closer to that observed in commercial crematoria. In those cases, flames of 700–900°C and 100 kW/m² heat intensity envelop the body and reduce it to ash and fragments of the larger bones in 1.5–3 hours (Bohnert et al., 1998).

Conclusions

In a fatal fire, the cause of death and the cause of the fire are independent but linked by circumstances. Each must be established, and only then can the link between them be determined.

Accidental fires can accompany deaths by accident, suicide, homicide, or even natural causes. Incendiary fires can be associated with homicide (as a direct cause of death or simply as part of

the crime event) but also with accidental or natural-cause deaths. For there to be a successful (i.e., accurate and defensible) fire death investigation, there must be the following elements.

1. Every fire with a death or major injury should be treated as a potential crime scene and not prejudged as accidental. The scene should be secured, preserved, documented, and searched by qualified personnel acting as a cooperative team.
2. Documentation is essential. This includes accurate floor plans with dimensions and major fuel packages included and comprehensive photographic coverage. Photos must include presearch survey; photos during search and layering; and all views of the body prior to removal, during removal, and during postmortem examination. This documentation is essential to proper reconstruction.
3. The body must not be moved until it has been examined properly by the fire investigator and the pathologist or coroner's representative and documented thoroughly by photos and diagrams. The debris under and within 3 feet of the body should be layered and sifted carefully. All clothing or fragments should be preserved.
4. The fire investigator has to do his or her job correctly, especially in the assessment of fuels already at the scene (structure as well as furnishings), the role fuels played in ignition, flame spread, heat release rates, time of development, and creation of flashover conditions.
5. Every fire death deserves a full forensic postmortem, including toxicology and X-rays. Toxicology samples should be tested for alcohol and drugs, as well as CO, and should include both blood and tissue. The clothing should remain with the body and be documented and evaluated in situ before removal, if possible, and then preserved properly. The internal (liver) body temperature should be taken as soon as possible (preferably at the scene).
6. Deceased pets should be X-rayed and necropsied. Injuries to living pets should be noted and documented.
7. "Nonfatal" burn victims should be photographed and blood samples taken for analysis later if needed. External clothing (pants, shoes, and shirt) should be saved and preserved properly.
8. Pathologists and homicide detectives must appreciate the fire environment—temperatures, heat and its transfer, flames, and smoke—and the distribution of fire products and the variables of human response to those conditions. In best practice, the pathologist visits the scene and sees the body in situ to appreciate its conditions of exposure (to flame, heat, and smoke), the nature of debris, and its location and position.
9. A full reconstruction may involve criminalistics evidence such as blood spatter or transfers, fingerprints, tool marks, shoe prints, and trace evidence. The criminalist should be part of the scene team along with the homicide detective, fire investigator, and pathologist.

As we have seen, a death involving fire is not a simple exposure to a static set of conditions at a single moment in time. Fire is a complex event, and a fire death investigation is even more complex and challenging. A coalition of talents and knowledge working together as a team is the only way to get the correct answers to the major questions: What killed the victim? Was the fire accidental or deliberate? How did those two events interact?

The fire engineering principles described previously also play an important role in reconstructing fire deaths and injuries. Thin materials such as hair or loose, lightweight fabrics will be affected by short-duration exposures to fire (such as the 1-sec durations of flash fires or combustion explosions) where thicker materials will not. Skin and underlying tissue have about the same thermal inertia as pine wood or polyethylene plastic and will react to heat flux in much

the same way. Very brief exposure (1 or 2 sec) to flame can induce reddening and separation of the epidermal layers (first-degree burns and peeling) but not pain (Stoll and Greene, 1959). The longer the duration of exposure, the deeper the injury. Fire injuries involving the dermal layer [where skin cells grow from the germinative (basal) layer] cause third-degree burns that usually require replacement of the skin via skin grafts. Partial-thickness or second-degree burns involve the interface between the epidermal and dermal layers, causing cell death and disintegration, fluid loss, and blisters. Such injuries leave the basal layer of the dermis intact, and the skin will grow back without grafts.

The radiant heat flux from established fires can be calculated to evaluate the likelihood of skin burns at various distances from the fire. The layering effect in a room described previously will also control exposure of a person to heat and toxic gases in the smoke layer. If a person is positioned low in a room (e.g., reclining on a bed or on the floor), he or she may be able to exist in a room with a developing fire for an extended period of time and not suffer any ill effects. If the person stands up (or the smoke layer descends to the person's level), he or she will be exposed to convective heat and inhalation injuries. The intake of CO from smoke can be estimated from the Stewart equation (Icove and DeHaan, 2004, p. 234):

$$\%COHb = (3.317 \times 10^{-5})(\text{ppm CO})^{1.036}(\text{RMV})t,$$

where ppm CO is the concentration of CO in the air being inhaled, RMV is the respiratory minute volume in liters per minute (lpm), and t is the time of exposure. The RMV, of course, varies with the sex, age, and level of physical activity of the person exposed. In the case study described previously, the time of exposure of the elderly victim could be calculated roughly as follows:

$$t = \frac{(3.015 \times 10^4)(\%COHb)}{(\text{ppm})^{1.036}(\text{RMV})}$$

The RMV for an adult at rest is 7.5 lpm. In the case study described previously, the victim's COHb at hospital admission was 23% after ~40 minutes on oxygen. We know that COHb saturation is reduced by 50% by 65–86 minutes, so in 40 minutes his COHb would have been reduced from 50 to 36% at the time of removal. If the COHb is estimated at 30% and if we estimated that CO concentration at bed level was 5000 ppm (a typical level in light smoke), the time of exposure would be approximately 17 minutes. In this case, this time fits the other information about the start of the fire, response and suppression time for the fire department, fire and smoke conditions observed by the firefighters, and time needed to search for and recover the victim. (Because the accused landlady never informed anyone that her lodger was still in the apartment, a rescue search was not conducted. The victim was discovered only during routine postfire venting operations.)

Very low COHb saturations indicate that the victim died of other causes before being exposed to the fire or succumbed to massive external burns (thermal shock), inhalation of flames that stopped further inhalations, or hypoxic conditions as a result of a flash fire. When a flammable hydrocarbon fuel burns explosively in a room, very little or no CO is produced initially, and so much of the oxygen is consumed in the room that the atmosphere is unable to support life (O_2 core below 10%) (DeHaan, 1996). If the victim is trapped, particularly in a closed room, and if he or she survives the flash of intense heat, the victim can die of hypoxia (enhanced by high concentrations of CO_2 produced by the combustion) before he or she is exposed to high

concentrations of CO produced by the combustion of other combustibles burning in the room. Death by hypoxia cannot be detected postmortem because the O₂ and CO₂ saturations are not stable after death and cannot be measured. The finding of a negligible COHb saturation (<3%) alone is not proof that the victim was dead prior to the fire. There are several other mechanisms. The entire event deserves careful reconstruction and assessment before such a conclusion is reached.

FIRE TESTING

Data to test various hypotheses and defend conclusions derive from a variety of sources. Fire tests can range from simple field tests requiring no specialized equipment to lab (bench-scale) tests involving dedicated equipment and large-scale tests with actual furnishings, scale models or full-scale recreations of a particular room, or even a building. The American Society of Testing and Materials (ASTM) offers a number of bench mark tests that can provide useful information about what contribution a fuel might make in a real fire (given that the test conditions do not duplicate real fire conditions). Some tests include:

ASTM D1230: Standard Test Method for Flammability of Apparel Textiles ([ASTM, 1994a](#))

ASTM D2859: Standard Test Method for Ignition Characteristics of Finished Textile Floor-Covering Materials (Methenamine Pill Test) ([ASTM, 1996a](#))

ASTM E1352: Standard Test Method for Cigarette Ignition Resistance of Components of Upholstered Furniture ([ASTM, 1998a](#))

ASTM E648: Standard Test Method for Critical Radiant Flux of Floor-Covering Materials ([ASTM, 1997a](#))

ASTM E659: Standard Test Method for Determining Autoignition Temperature of Liquid Chemicals ([ASTM, 1994b](#))

ASTM D1929: Standard Test Method for Determining Ignition Temperatures of Plastics ([ASTM, 1996b](#))

ASTM E84: Standard Test Method for Determining Surface Burning Characteristics of Building Materials (Steiner Tunnel Test for Horizontal Surfaces) ([ASTM, 1998b](#))

ASTM E1321: Standard Test Method for Determining Material Ignition and Flame Spread Properties (Vertical Fuel Surfaces) ([ASTM, 1997b](#))

The reader is referred to *ASTM Fire Test Standards* (2000) for a complete listing. There are also a number of standard bench mark tests for flammability of apparel as defined by the U.S. Code of Federal Regulations (CFR) ([DeHaan, 2002](#), Chapter 11). The following are examples:

16CFR1610—Flammability of Clothing Textiles

16CFR1611—Flammability of Vinyl Plastic Film

16CFR1630—Flammability of Carpets and Rugs

16CFR1632—Flammability of Mattresses and Pads

16CFR1615 and 1616—Flammability of Children's Sleepwear

Calorimetry is used (in a variety of scales) to establish the heat release rates of some fuels, fuel packages, and even entire rooms. If electronic weighing of the fuel is conducted, the mass loss rates and effective heat of combustion can also be measured. Classical bomb calorimetry is

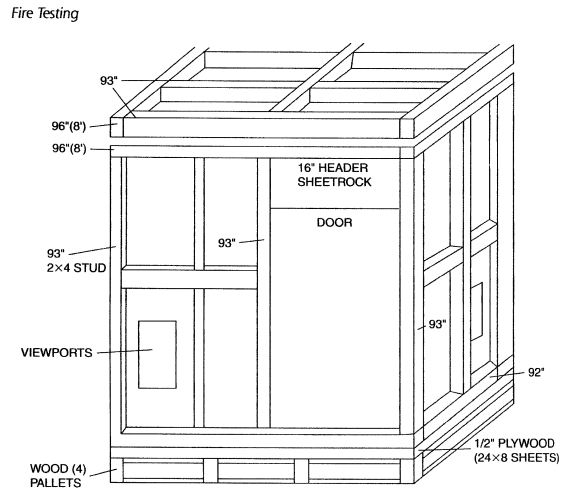
typically used for small quantities of pure fuels (described in *ASTM D240-92*; *ASTM, 1997c*). Oxygen depletion calorimetry is used more commonly for complex materials. The cone calorimeter was developed by Babrauskas at NIST (described in *ASTM E1354*; *ASTM, 1997d*). It exposes a 10×10 -cm sample to a known radiant heat flux (from a cone-shaped heater), provides a flame ignition source, and then monitors the airflow, O_2 , CO_2 , and CO concentration in the airstream of the exhaust duct from the chamber. Since combustion of almost all common fuels produces approximately 3 kJ/g of air “consumed” (~ 13 kJ/g O_2), if one knows how much oxygen is consumed, the heat released can be derived directly. The sample is weighed continuously by a sensitive load cell. This method has been shown to be widely applicable for assessing the real fire behavior of a wide range of fuels. The same principle is applied in the furniture calorimeter, in which a fume hood-sized exhaust system is used and the same data are captured by analysis of the exhaust gases and a load cell beneath the item being tested. Very large calorimeters, such as the 20-MW 30×30 -m system installed at the ATFE Fire Research Lab in Amundale, Maryland, can accommodate very large fires, such as those of vehicles or multiroom structures.

Typical test data from a room-size calorimeter at the California Department of Consumer Affairs, Bureau of Home Furnishings, showing the development of a fire in a bedroom mock-up are shown in [Figure 15.19](#). Data from such tests on a variety of household and commercial fuel packages are available in printed versions or online from NIST.

Scale models have been used to study fire, and especially smoke, development in structures. Scale models (often 1:4 scale) must allow for dynamics (ventilation, smoke velocity, etc.) that do not scale down in a linear fashion, and thermal responses of lining materials must be calibrated to the scale of the test ([Ingason et al., 2001](#)). One successful variant is constructing a clear plastic scale model of the building, inverting it in a tank of clear liquid, and using a colored liquid of higher density to replicate the fluid flow of buoyant hot gases through a structure. Scaling factors are important, and the relative densities and viscosities of the liquid have to be calibrated to replicate gaseous flows, but the technique has been used to solve some investigation problems and confirm or reject computational models or hypotheses. Full-scale tests can be based on test cubicles made of wood framing and drywall in 2.4×2.4 - to 4×5 -m sizes ([Icove and DeHaan, 2004](#), pp. 273–284). They can be constructed to include windows, doors, observation ports, and even operational electricity. They can be constructed “on demand” and use only new materials to minimize toxic hazards from paint or floor tile and injuries from floor collapse [since they are usually built on grade (concrete slab) or on wood pallets]. (See [Figure 15.25](#) for a typical design.)

The reconstruction of some fires may require an architecturally accurate recreation of the original fire scene; however, this is very uncommon and very expensive, especially if more than one hypothesis needs to be tested. More often, donated or abandoned buildings are used and modified to make them similar to the subject property ([DeHaan, 1992](#)). Such tests have been used successfully, especially if one fire can be extinguished quickly and the structure rehabilitated so that two or more tests can be completed. Special preparations have to be made to ensure the safety of attending firefighters, such as reinforcing floors, removing windows, preventing roofs and attics, limiting fuel types, and removing floor coverings (per NFPA 1403; [NFPA, 2002](#)). Some of these changes make replication of a real fire incident impossible, so alternative solutions need to be sought.

FIGURE 15.25 Typical cubicle for fire testing. They can be made in larger sizes with or without windows. View/camera ports are simple glass panes glued to the inner surface of drywall.



COMPUTER MODELING

In the past 20 years, a variety of computer-based models of fire behavior have been developed as an aid to fire research. Some are very simple and make generous assumptions about fuels, ventilation, geometry, fire growth, and other factors. Others are more complex and allow variables such as a choice of initial fire or changes in ventilation to be built in. Recent models are very sophisticated and can accommodate many variables and predict many factors. No matter how sophisticated these models may be, it must be remembered that none of them can prove how a particular fire occurred. They can best be used to test various hypotheses about a fire to demonstrate which are feasible and which are not. Because they are based on real fire data and validated for reliability in making certain predictions, they can be used to evaluate the effects of changing particular variables without the expense and difficulty of repeating full-scale fire tests.

Fire models can include calculations such as those included in FPETOOOL, developed by H.E. Nelson at NIST. It is a collection of analytical tools about fire behavior and properties with simplifications and assumptions to offer approximations rather than exact predictions (Nelson, 1990). It consists of three main elements:

Fireform (fire formulas)—a collection of fire safety calculations

Makefire—a series of procedures to produce fire input data files for use with a fire simulator

Fire simulator—an integrated set of equations (i.e., a model) designed to allow the user to create a fire case study in a Lotus format with specifications of room and vent dimensions; fuel characteristics; ceiling, wall, and floor materials; and input fire to predict layer temperature, flashover, and tenability factors

The first successful fire models were called zone models because they treated a room fire as two zones—the hot smoke (ceiling) layer overlying a normal room air layer. These models assume that no mixing occurs between the two layers and there is only one localized fire “pumping” hot gases into the ceiling layer. An input fire of known HRR and duration represents the fire (since such models are not capable of predicting fire spread). ASET-B (Available Safe Egress

Time—Version B) and CFAST (Consolidated Model of Fire Growth and Smoke Transport) are the two most commonly used zone models. DETACT-QS is a zone model developed for predicting smoke detector and sprinkler activation that has also been used frequently. As long as the user understands the limitations, underlying assumptions, and nature of data obtained, such models can be run by the average computer user using a PC or laptop.

Due to the limitations of zone models, more sophisticated models with better predictive powers and more flexibility were developed using the principles of computational fluid dynamics. Such field models break the room or building into hundreds or thousands of cells, six-sided “boxes,” and then calculate the heat energy, mass, and momentum moving into and out of each surface of each box. Such models can predict fire growth, smoke and heat movement, and concentrations of individual chemical species as the fire grows. The most widely used field model is the Fire Dynamics Simulator developed by NIST. It uses a graphical interface called Smokeview to demonstrate data regarding temperatures, smoke densities, chemical species, and gas distribution as a color-coded static or dynamic display. This model requires extensive training and familiarity with fire (and computer) processes, considerable time to set up and input data for the problem, and a moderately fast computer to accomplish its calculations. It is not unusual for a multiroom problem to require days to input data and weeks of continuous computing to conduct one “run.” Such data can be used to answer a wide variety of questions (e.g., predicting the actual CO concentration at 0.6 m height in the bedroom of the elderly fire victim) (Christensen and Icove, 2004).

Numerous guidelines are available for evaluating the applicability and reliability of computer fire models. There are ASTM guides that deal with critical modeling issues such as evaluation, validation, and documentation. These include:

ASTM E1355-97: Standard Guide for Evaluating the Predictive Capability of Deterministic Fire Models (ASTM, 1997e)

ASTM E1591-00: Standard Guide for Obtaining Data for Deterministic Fire Models (ASTM, 2000a)

ASTM E1895-97: Standard Guide for Determining Uses and Limitations of Deterministic Fire Models (ASTM, 1997f)

ASTM E1472: Guide for Documenting Computer Software for Fire Models (ASTM, 2000b)

Testing Complex Computer Models

One of the major differences between zone and field models is that field models often include routines that calculate the growing fire based on first principles of thermal response, heat flux, and flame spread. Of course, this requires that the initial fuels be identified and their physical and thermal properties defined carefully as input data.

The limitations of this text are such that detailed descriptions of complex fire models cannot be included here. The reader is referred to the references or to the firemodelsurvey.com Web site.

The following questions should be answered by an investigator when considering using a model:

Appropriateness—Is the model’s output useful and applicable?

Limitations to the model (time, ventilation, output)

Resources—Computer speed and capacity needed

Operator experience needed

Input data needed—Is there sufficient documentation to supply all of it? What default conditions apply if input data are incomplete?

Sensitivity—What happens to output when input data are changed?

Accuracy

Are the results/outputs realistic? Would they occur that way in a real fire?

Has the model been used to predict the outcome of a test burn, such as tenability, temperatures, or time to flashover? How accurately did it predict the actual fire results?

Was the model “fine-tuned” to make its predictions more accurate? (Was the program run multiple times with different data to slightly “tweak” the result?)

How were data collected in the test burn? Direct observation, thermocouple measurements, radiometers?

Where were the measurement/observation points for the test fire?

(The fire environment can be so complex that temperature or radiometric data collected in one location may not be representative of the entire room, leading to possible variations of as much as $\pm 30\%$.)

Reproducibility

If the program is run with the same data by the same person, does it give the same answer?

If the program is run with the same data by a different person, does it give the same answer?

Robustness

Is the program applicable to different situations? Has it been tested and validated (demonstrated to give accurate results) if starting conditions are very different?

Has it been shown to give reliable results for

Small fire in a large room vs large fire in a small room?

Adequate ventilation vs underventilated?

“Ultrafast” t^2 fire vs “medium” t^2 fire?

Analysis

What features of fuel, starting conditions, and initial fire size are input data and what assumptions have been made by the analyst based on personal judgment or “bias”?

One of the primary considerations before relying on computer model results is verification that the model is appropriate for the situation being modeled. Its documentation must include “real fire” data against which the model was tested. Before using a model in a fire reconstruction, the investigator must carefully evaluate the following:

Accuracy—The accuracy of input data (initial fire HRR and growth rate) is critical to the accuracy of the final result. “Garbage in—gospel out” is the risk with computer models. Are data arbitrary? Are they correct for the scenario in question?

Assumptions—What assumptions were made by the user to fill the gaps? Incompleteness of data from the scene is the major reason for most failed computer model attempts. What default values does the model insert if data are not available? Will those default values make a difference (i.e., what is the model’s sensitivity to those values)?

Impression—How are data presented? Is it in the form of reviewable printed output or a single dramatic action cartoon? Smokeview will show “movement” of flames and smoke that is a stop-action representation of a “temperature” surface or smoke concentration.

Other models (or users) refrain from showing smoke or flame movement because it is, to some extent, too complex and too random to show accurately.

Correctness—Is it the right model for the job? What is the question the investigator wants to answer? What is the question the model was intended to answer (temperature, smoke filling, or species concentration)? What are the limitations of the model—the number of rooms, fire growth, size of fire, ventilation, and time? Will this model address those issues correctly in the problem at hand? Is information about conditions in a specific location at a specific time needed? If so, a zone model may not be able to give an appropriate answer. **Evaluation/validation**—Was the model created and validated for a particular scenario (small fire in a large room) and is it being used here for a very different scenario without proper (published) evaluation?

Fine-tuning—When a comparison to a test fire is offered, the number of model runs should be evaluated. Was the model run with changes in input data to get the model to “match” the real fire? **User qualified?**—Does the user have the correct documentation (user’s guides and technical manuals)? How much experience does the user have with this model? Were other models considered or used? What steps can the user take to make sure the model is correct and used correctly (e.g., reviewing published evaluations)?

LABORATORY TESTS

In many fire investigations, the only analysis the forensic lab is asked to do is the testing of fire debris to determine the presence and identity of ignitable liquid residues. Although this information is critical to some investigations, a proper fire reconstruction may require a much wider variety of analyses. Before many of the predictive fire engineering analyses can be carried out, the investigator must have reliable identification of the materials involved. Carpets may be nylon, acrylic, cotton, polypropylene, or wool (or mixtures of two or more). Each material has very different reactions to heat—some melt, others char, and some decompose. Some (e.g., acrylic) ignite at very low radiant heat fluxes ($<10 \text{ kW/m}^2$), whereas others (e.g., nylon or wool) require very high heat fluxes and then ignite only reluctantly (Quintiere, 1997). Upholstery fabrics represent an even wider range of possible types and reactions to heat and fire. Upholstery padding may be cotton (ignited readily by smoldering sources unless fire retardant treated) or polyester fiber-fill (not ignitable except by direct flame). Foam rubber may be polyurethane (requiring open flame to ignite), synthetic combustion modified foam (very difficult to ignite), or latex foam (ignited readily by either flame or smoldering cigarette). Melting points of a variety of materials play an important role in evaluating fire patterns.

If liquid fuels are involved, lab analysis is needed to determine their flash points, vapor density, and vapor pressure because these factors control their contribution to fire ignition or growth. These values can be determined directly (using appropriate ASTM methods) or indirectly by identifying the material by gas chromatography or infrared spectrometry and then referring to published data. Elemental analysis may be needed if an inorganic material is involved in ignition (e.g., a pyrotechnic mixture), in fire spread (via a combustible metal), or in producing toxic effects in victims (e.g., heavy metals). Organic fuels can produce highly toxic combustion gases (HCN from nylon plastics or wool, and hydrogen chloride from PVC plastics), and their

identification may involve both gas chromatography/mass spectrometry and elemental analysis. Forensic laboratory personnel must never limit their thinking or their analytical services to “just doing the GC” on fire cases.

CONCLUSIONS

Final conclusions about a fire scene reconstruction should be peer reviewed whenever possible. The analysis of data from complex scenes can be very time-consuming, and reviewers may be unwilling or unable to devote much time to review someone else’s case. The best most of us can do is to make our report as comprehensive as possible, including descriptions of data examined, a description of the steps taken in accordance with the scientific method, citation of the evidence that supported elements of the final conclusion, and descriptions of the logic and reasoning by which each of the opinions and conclusions were reached.

ASTM E620: Standard Practice for Reporting Opinions of Technical Experts (ASTM, 2004) outlines suggested practices in such technical reports. *ASTM E678: Standard Practice for the Evaluation of Technical Data (ASTM, 1998c)* offers guidance in applying the scientific method by technical experts. Because these publications are peer-reviewed, professional protocols, they are being cited more often in fire cases as the practices that a fire investigator should follow. Some of the practices described exceed the practicality (and time limits) of many investigators, but we should be aware of their existence and follow them whenever possible.

The bottom line is that the report of a fire scene reconstruction must be comprehensive, listing and describing all of the items, evidence, and materials received; what data were collected; what tests were conducted; what special sources of information the expert relied on; description and evaluation of all hypotheses; and the logic and reasoning behind the final conclusions. The more comprehensive the report, the better the guarantee that the expert has conducted his or her investigation and reconstruction thoroughly and reached reliable, defensible conclusions that will withstand rigorous cross-examination.

SUMMARY

Fire can be defined as a sustained exothermic oxidation (combustion) of a fuel sufficient to produce readily detectable heat and light. The reconstruction of fire scenes is considerably more difficult than the reconstruction of a typical homicide scene because of the changes and destruction wrought by the event being investigated. It requires a methodical and scientific approach.

The objective of a fire scene reconstruction is to provide reliable and defensible answers to the following questions.

1. Where did the fire begin, that is, where was the origin of the fire?
2. What was the first fuel involved in the fire (and what fuels supported its spread)?
3. What was the cause of the fire, that is, what circumstances brought an ignition source into contact with the first fuel such that a fire resulted?
4. Who, if anyone, was responsible for the fire occurring?

5. What factors contributed to the ignition and growth of the fire?
6. What other events occurred (and in what order) in connection with the fire—death, injury, forced entry, or burglary?

Forensic fire scene reconstruction, when applied properly, can aid in the hypothesis testing that is so critical to defending conclusions in court. This goes far beyond the physical reconstruction of putting furniture back in its prefire location based on burn patterns and protection patterns. This reconstruction involves a fire engineering analysis of the elements of the fire (fuels, ventilation, and heat sources) to evaluate direction of fire spread, intensity of fire exposure, duration of exposure, effects on materials, effects on people in the fire environment, and timelines of events.

Criminalistic evidence has played a critical role in the reconstruction of both intentional and accidental fires. This evidence includes shoe impressions, fingerprints, blood, tool impressions, physical match, and trace evidence.

Death involving fire is not a simple exposure to a static set of conditions at a single moment in time. Fire is a complex event, and a fire death investigation is even more complex and challenging. A coalition of talents and knowledge working together as a team is the only way to get the correct answers to the major questions: What killed the victim? Was the fire accidental or deliberate? How did those two events interact?

QUESTIONS

1. The crime of arson requires three basic elements of proof. What are they?
2. The products of combustion fall into three basic categories. What are they?
3. Define *glowing combustion* and *flaming combustion*.
4. Several problem areas can complicate fatal fire investigations. Explain one of these problems.
5. List two major lethal agents in structural fires.

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Sexual Assault: Issues in Evidence Examination and Interpretation

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Key Terms

Colposcopy; Defeminization; “Grab” injuries; Facts; False allegations; Mental incapacity; Rape; Semen; Sexual assault; Sexual homicide

The terms *rape* and *sexual assault* are legal in nature, referring to the violation of specific criminal statutes. Depending on the jurisdiction, they may also be used interchangeably. For our purposes, it is necessary to make a distinction.

As explained in [Savino and Turvey \(2011\)](#), **rape** refers to nonconsensual sexual penetration. It is a form of **sexual assault**, which refers generally to any nonconsensual sexual contact. Using these definitions, it is possible for a victim to be sexually assaulted (e.g., groped, kissed, pinched, rubbed) without being raped (e.g., orally, vaginally, or anally penetrated). Neither requires evidence of injury, but rather proof of criminal intent on the part of the offender and the absence of consent on the part of the victim. Generally it also requires the evidence of physical force, threats, or intimidation.

The purpose of this chapter is to provide the reconstructionist with an applied understanding of the variety of physical evidence involved in cases of alleged rape and sexual assault, how to evaluate it, and how to interpret it.

DATA: KNOWN AND UNKNOWN

Sexual assault is quite prevalent; consequently, the reconstructionist is likely to encounter related behavior and injuries in his or her casework. Crime data in the United States, reported by participating police agencies to the U.S. Department of Justice, reveal the following ([Rand, 2008](#)):

- In the United States, there was a 25% increase in total reported rapes and sexual assaults between 2005 and 2007 (from 190,600 to 248,300 cases per year).

- Reported victims were most often female (236,980, or 95%, of all reported cases), and reported offenders were most often nonstrangers, such as friends, acquaintances, and intimates (58%).
- 91% (226,410) of reported cases did not involve a weapon of any kind, with the clear weapon of choice being a knife in 3% (6280) of reported cases. Firearms were the least reported weapons of choice, at less than 1% of total cases.

Although sexual assault is reported to police with predictable regularity, the number of actual victims is unknown. As explained in [McKibbin and colleagues \(2008, p. 86\)](#):

Rape is a fact of life across cultures (Roze'e, 1993; Sanday, 1981). In American samples, estimates of the prevalence of rape vary with the population studied, but are as high as 13% for women (Kilpatrick, Edmunds, & Seymour, 1992). Rape is likely more common, however, because rapes often go unreported. Researchers estimate that 67–84% of rapes are not reported (Greenfield, 1997; Kilpatrick et al., 1992).

To assess the frequency of sexual assaults not reported to police, one study examined data collected from 2155 adult victims. These individuals had sought medical care at a crime victim's treatment center in the emergency department of a hospital in a major city between January 1998 and September 2009 ([Securro et al., 2010](#)). Results of this study found that, subsequent to receiving medical treatment, sexual assault was reported to the police only one-third of the time (33.3%). Victim sex did not make a difference in whether the crime was ultimately reported (94% of the victims were female). However, the victim was more likely to report the crime if the attacker was a stranger.

It must be acknowledged that a small percentage of those individuals reporting rape and sexual assault to receive medical care will also be false reporters (see [Brown et al., 1997¹](#)). Often this is done to get free medical tests and treatment that accompany a sexual assault exam [e.g., pregnancy testing, sexually transmitted disease (STD) testing, or Plan B to prevent unwanted pregnancy]^{2,3}; to alibi pregnancy or the contraction of STDs during consensual sexual behavior by a juvenile, by an adult outside of a committed relationship; or at the urging of intimate partners, friends, or family members that a false report has been made to, as part of a "snowballing" effect.

¹ Brown and colleagues (1997) conducted research to address the issue of genital injury in female sexual assault victims. This study examined 311 rape victims who entered San Louis Obispo General Hospital's emergency room in California between January 1985 and December 1993. The study also examined a control group of 75 women, from the same location and time period, who had engaged in consensual intercourse. Of those 75 women, 48 had initially been evaluated as victims of rape, but later admitted that their encounters had been consensual. Although not conducted to address the issue of false reports specifically, this study ultimately revealed a 13% rate of self-confessed false rape reporters. This study, it should be remembered, involved victims and alleged victims who presented to an emergency room. This is necessarily a different sample than presents at police departments to merely file a report; we would expect a lower percentage of false reporters to submit willingly to a physical examination.

² [Boykins \(2005\)](#) provides that (p. 166): "Sexual assault forensic exams for emergency medical-legal treatment—including evidence collection and prophylactic treatment for sexually transmitted diseases (STDs) and pregnancy—are often performed by sexual assault nurse examiners (SANEs) at a sexual assault center."

³ A common motive for false reporting to a medical treatment center, some facilities will not administer a sexual assault examination protocol unless the complaining patient has first obtained a police report number. This requires filing a report of the attack with law enforcement. This is intended to minimize the number of false reports and unnecessary exams.

The majority of those who do not report their attacks to police subsequent to receiving medical treatment, however, represent a significant percentage of victims who have no desire to get law enforcement involved, to make their attack known to others, or to suffer the indignity of the criminal justice system.

THE ROLE OF RECONSTRUCTION

Law enforcement investigators are tasked with investigating complaints of sexual assault to determine what happened and whether a crime actually occurred. As explained by the Attorney General's Sexual Assault Task Force (SATF), in the State of Oregon (SATF, 2009):

Law enforcement is responsible for determining whether reports of sexual assault meet the criteria of a criminal offense as determined by the state criminal code. This responsibility includes determining the credibility and, ultimately, the investigative outcome of sexual assault reports.

The criminal investigation of a sexual assault is accomplished by proper crime scene investigation; interviews with complainants, the accused, and any witnesses; and the reconstruction of physical evidence. It is not accomplished by accepting the statements of one party over another without evaluation or by making arrests prior to investigating and establishing the facts (Savino and Turvey, 2011).

The purpose of reconstruction is to establish what did and did not happen during an event by virtue of an objective examination of the physical evidence. This can aid the efforts of law enforcement, and the courts, tremendously. As explained in Boland and colleagues (2007, p. 110):

The fundamental role of a forensic scientist is to help those who address the burdensome issue of guilt or innocence in a court of law. . . .

A large percentage of crimes against the person, dealt with by forensic science laboratories, are crimes of sexual assault. . . . In these cases, finding semen and in fact getting a matching DNA profile, may offer no additional evidential value to the case. Other examinations, such as damage interpretation, possibly indicating a struggle or that force was used, may be critical. This analysis may be used to corroborate or refute a particular scenario and indeed, in a small, but significant number of cases, damage interpretation may be critical in preventing false allegations proceeding to prosecution.

Forensic examiners are not allowed to assume facts for the purposes of a reconstruction: facts must be established.⁴ This may seem redundant, as **facts** are generally defined as verifiable and undisputable circumstances or information. However, it is not uncommon for the investigative assumptions and theories generated early in a case to be treated as facts and to remain uninvestigated or unexamined. This is particularly true of witness statements that favor prevailing or expedient investigative theories. The uncritical acceptance of any statement, without an assessment of its internal integrity or evidentiary corroboration, provides an insufficient basis for the reliable reconstruction of events. A scientific examination investigates the evidence to learn the facts, seeking to support or refute the elements of crime-related behavior. It does not assume them.

⁴ See Chapter 5: Practice Standards for the Reconstruction of Crime.

FALSE ALLEGATIONS OF SEXUAL ASSAULT

False allegations refer to any untruthful statement, accusation, or complaint to authorities asserting that a crime occurred, which in reality did not. In many, if not most, jurisdictions, false allegations are a crime, and the convicted false reporter may suffer fines and even jail time (Turvey and McGrath, 2009). In some jurisdictions, false allegations are a crime even when reported to authorities by a third party.

The “not insignificant” frequency of false rape allegations has been found as high as 30 to 40% in some studies (Kennedy and Witkowski, 2000, p. 44; see also the literature review in McGrath and Turvey, 2011a/2011b). This rate is much higher than is generally accepted by victim advocates and is denied by the inexperienced and unknowledgeable. This includes improperly educated, trained, or experienced sex crimes investigators and attorneys, as some of these maintain an improper agenda to blindly protect or even “rescue” those who present as victims—to shield them from legitimate questions regarding their claims.

When presented with any witness statement, objective science requires equal consideration of truthfulness and falsity as viable. The witness may be lying, may be telling the truth, or may be mixing truth with select fictions. Each of these possibilities must be considered without prejudice as a function of both good science and the accused’s right to due process. This is especially true in a forensic context when there is an accusation of rape or sexual assault. As explained in Gross (2009), “failing to consider the accuser may be intentionally lying effectively eradicates the presumption of innocence.”

SEXUAL ASSAULT EXAMINATION PROTOCOLS

This section discusses the purpose, procedures, and evidence interpretations involved in a sexual assault examination. In general, the guidelines provided in the [National Institute of Justice \(NIJ\) \(2004\)](#) regarding “Forensic Medical Examination and Evidence Collection Procedures” should be followed. Reconstructionists should read these and become familiar with them. It should not need to be explained that both the complainant and the suspect must undergo the same level of forensic sexual assault examination. It is, after all, an investigation to determine the facts, and not a one-sided procedure intended to screen only for evidence that supports the complainant’s version of events.

History

When a patient (a.k.a. complainant) presents for a sexual assault examination, documenting the history of the event, as well as any medical/surgical history, is the first step of the evidentiary process. Taking a good history is probably the single most important task in the workup. Reliable patient information lays the foundation for a thorough physical exam and subsequent evidence collection.

Components of the history assist the examiner in reaching a differential diagnosis or otherwise distinguishing one finding from another. For example, a patient may present stating that he or she was sexually assaulted. He or she may also have a history of illness or an injury that is

present but unrelated to the sexual assault. Differentiating and documenting those kinds of findings are significant to the case and to the patient's continuum of care and referral for additional medical services.

Rationale

The importance of taking a history as part of a patient examination is universally understood as best practice for just about any of the helping professions. This includes medical and mental health specialists of every kind, who accept that what presents in a given case is a reflection of, and can be affected by, past events. Moreover, they are mindful that any diagnosis or treatment must take into account the changes brought about by past treatment efforts. In addition, both medical and mental health professionals are trained to recognize behavioral indicators of those presenting false symptoms (e.g., drug-seeking behavior and malingering). Consequently, the failure of medical and mental health practitioners to take an adequate history prior to diagnosis and treatment efforts is generally considered a form of malpractice.

The importance of gathering victim background information is understood within the forensic professions as well. Without it, there is no context for criminal complaints or for the interpretation of the evidence gathered in relation to them. For example, medical examiners, coroners, and their respective death investigators are meant to understand this, as reflected in the NIJ manual, *Death Investigation: A Guide for the Scene Investigator* (NIJ, 1999, p. 39):

Establishing a decedent profile includes documenting a discovery history and circumstances surrounding the discovery. The basic profile will dictate subsequent levels of investigation, jurisdiction, and authority. The focus (breadth/depth) of further investigation is dependent on this information.

Sex crimes investigators agree, as reflected in the importance of gathering information related to complainant criminal, medical, and mental health background prior to conducting formal interviews provided in Savino⁵ and Turvey (2011).

Patient history is also a required component of sexual assault examinations, performed by medical specialists as part of their dual treatment and evidence-gathering mission. As explained in Jamerson (2009, p. 114):

... intake and history information is necessary to competently inform and prioritize the physical examination ... Each patient is unique; any treatment and forensic efforts should be individually crafted to his or her particular condition and history.

*Medical history*² is a significant component of the evaluation in the context of any suspected sexual assault, child molestation, or domestic assault. It provides a baseline of information for the examiner so that recent trauma and injury can be discriminated from past conditions and events. Therefore, it must cover all body systems. In this way, the examiner can identify any acute or chronic problems, as well as any history of past injury or surgeries. It also informs the nature, extent, and sequence of the forensic medical exam. A failure to document and report medical background information prevents informed medical treatment and leaves the forensic examiner without the proper context for accurate interpretations. Ultimately, conducting an accurate forensic medical examination in the absence of a patient medical history is not possible.

Fn.2 *Medical history* is the information about a patient gathered by a health care professional for the purposes of making examinations, providing treatment, and rendering a diagnosis. It commonly involves asking patients

⁵ John O. Savino is a retired senior detective with the NYPD, Manhattan Special Victim's Squad.

questions regarding the current and former state of their physical and mental health. Without this background information, examinations, treatments, and diagnoses are at best uninformed, and at worst potentially lethal.

This also specifically includes (pp. 117–120) “recent consensual sexual activity,” “postassault activities,” “history of drug abuse,” history of mental health and behavioral problems, and history of STDs.

The forensic necessity of this extensive history is affirmed in the NIJ guidelines, *A National Protocol for Sexual Assault Medical Forensic Examinations* (2004), which mandates that informed sexual assault examinations require a complete victim history (p. 81):

Coordinate medical forensic history taking and investigative interviewing. Examiners typically ask patients to provide a medical forensic history after initial medical care for acute problems and before the examination and evidence collection. This history, obtained by asking patients detailed forensic and medical questions related to the assault, is intended to guide the exam, evidence collection, and crime lab analysis of findings.

Inherent in these guidelines is the understanding that evidence and injury observed in relation to the alleged victim or crime scene may not be the result of criminal activity. Such evidence or injury may, in fact, be the result of some previous and unrelated activity or event. For example, a complainant may present with extensive bruising of the shins and may not clearly recall their origins. Such injuries might be related to a sexual assault, depending on the events described. Alternatively, upon conducting a history, the forensic examiner may learn that the complainant played a soccer game in the days preceding the alleged attack, in which her shins were kicked repeatedly. The forensic examiner interpreting these injuries without the relevant history could improperly make the assumption that they must be related to a sexual assault.

It is also important to note that investigators and forensic examiners will not know what features of complainant history are relevant to an examination until well after they have begun their work. In one case it may be a question of toxicology. In another it may be which bedroom of the home they occupied. In yet another there may be a question of sexual habits, preferences, or diseases. All of these issues and related details have turned cases, despite seeming irrelevant or minor at the outset. Each victim is different, each case is different, and, therefore, less victim history is not better.

Collecting History

Collecting history from the complainant, as well as collateral sources (e.g., friends, family members, other witnesses), is necessary to ensure that the most complete and accurate information is relied upon during forensic examinations. As provided in NIJ (2004, pp. 83–84):

The specific questions asked of patients by examiners for the medical forensic history vary from one jurisdiction to the next, as do forms used to record the history. However, the following information should be sought routinely from patients:

1. Date and time of the sexual assault(s): It is essential to know the period of time that has elapsed between the assault and the collection of evidence. Evidence collection may be directed by the time interval since the assault. Interpretation of both the physical exam and evidence analysis may be influenced by the time interval between the assault and the exam.

2. Pertinent patient medical history: The interpretation of physical findings may be affected by medical data related to menstruation, recent anal–genital injuries, surgeries, or diagnostic procedures, blood-clotting history, and other pertinent medical conditions or treatment.
3. Recent consensual sexual activity: The sensitivity of DNA analysis makes it important to gather information about recent consensual intercourse, whether it was anal, vaginal, and/or oral, and whether a condom was used. A trace amount of semen or other bodily fluid may be identified that is not associated with the crime. Once identified, it may need to be associated with a consensual partner, and then used for elimination purposes to aid in interpreting evidence.
4. Postassault activities of patients: The quality of evidence is affected both by actions taken by patients and the passage of time. It is critical to know what, if any, activities were performed prior to the examination (e.g., have patients urinated, defecated, wiped genitals or the body, douched, removed/inserted a tampon/sanitary pad/diaphragm, used oral rinse/gargled, washed, brushed teeth, ate or drank, smoked, used drugs, or changed clothing?).
5. Assault-related patient history: Information such as whether there was memory loss, lapse of consciousness, vomiting, nongenital injury, pain and/or bleeding, and anal-genital injury, pain, and/or bleeding can direct evidence collection and medical care. Collecting toxicology samples is recommended if there was either loss of memory or lapse of consciousness, according to jurisdictional policy.
6. Suspect information (if known): Forensic scientists seek evidence on cross-transfer of evidence among patients, suspects, and crime scenes. The gender and number of suspects may offer guidance to types and amounts of foreign materials that might be found on patients' bodies and clothing. Suspect information gathered during this history should be limited to that which will guide the exam and forensic evidence collection. Detailed questions about suspects are asked during the investigative interview.
7. Nature of the physical assault(s): Information about the physical surroundings of the assault(s) (e.g., indoors, outdoors, car, alley, room, rug, dirt, mud, or grass) and methods employed by suspects is crucial to the detection, collection, and analysis of physical evidence. Methods may include, but are not limited to, use of weapons (threatened and/or injuries inflicted), physical blows, grabbing, holding, pinching, biting, using physical restraints, strangulation, burns (thermal and/or chemical), threat(s) of harm, and involuntary ingestion of alcohol/drugs. Knowing whether suspects may have been injured during the assault may be useful when recovering evidence from patients (e.g., blood) or from suspects (e.g., bruising, fingernail marks, or bite marks).
8. Description of the sexual assault(s): An accurate but brief description is crucial to detecting, collecting, and analyzing physical evidence. The description should include any:
 - Penetration of genitalia (e.g., vulva, hymen, and/or vagina of female patient), however slight;
 - Penetration of the anal opening, however slight;
 - Oral contact with genitals (of patients by suspects or of suspects by patients);
 - Other contact with genitals (of patients by suspects or of suspects by patients);
 - Oral contact with the anus (of patients by suspects or of suspects by patients);
 - Nongenital act(s) (e.g., licking, kissing, suction injury, and biting);
 - Other act(s) including use of objects;
 - If known, whether ejaculation occurred and location(s) of ejaculation (e.g., mouth, vagina, genitals, anus/rectum, body surface, on clothing, on bedding, or other); and
 - Use of contraception or lubricants.

These questions require specific and sometimes detailed answers. Some may be difficult for patients to answer. Examiners should explain that these questions are asked during every sexual assault medical forensic exam. They should also explain why each question is being asked.

This information is essential for the forensic examiner to gather before starting any examination, as some preexisting conditions mimic or may be confused for abuse (e.g., skin conditions, allergic reactions, medical conditions, nonviolent or sports-related injuries unrelated to assault) and will need to be differentiated clearly. Also, having an awareness of the medical history

guides the clinician in making necessary referrals for other problems that may be assessed during the examination.

Ultimately, the purpose of taking a history is to inform collection efforts and eventual interpretations of findings. As stated in the [NIJ \(2004, p. 8\)](#), forensic examiners must “avoid basing decisions about whether to collect evidence on a patient’s characteristics or circumstances (e.g., the patient has used illegal drugs).” Too often, there is a failure to document evidence, including areas of noninjury and history, because the examiner is either uncomfortable or preferential with respect to the patient. In cases of extreme bias, there may even be attempts to suppress or conceal such evidence. This is professionally unacceptable. Each patient must undergo the same level of examination and documentation—there can be no exceptions. In particular, the forensic examiner must comprehend and acknowledge the importance of history to the integrity of their examinations, interpretations, and subsequent court testimony.

Physical Examination: Head to Toe

A head-to-toe physical exam is the next step in the process. This allows the examiner to conduct a general survey of the patient’s body and to assess normal versus abnormal findings, as well as inflicted injuries versus accidental injuries the patient may have sustained. During this assessment, the examiner should take scrupulous notes of where injury is found, and where it is not. He or she must pay particular attention to the locations and orientation of injuries, injury patterns, and any plausible injury mechanisms. Concurrently, the examiner needs to maintain clinical awareness of whether a given injury, or its absence, is consistent with the stated history of events ([Giardino and Giardino, 2003](#)).

Full Body Photos

Full body photos should be taken of the patient, including individual stills of the front, back, and sides of their head, torso, arms, hands, legs, and feet. Such documentation is very helpful to have in the patient’s chart, or in the patient database, as it provides a pictorial view of their presentation at the time of assessment if such questions arise at a later time. It also provides for *negative documentation*—recording of areas of the body where there is no evidence of defect, disease, injury, or potential transfer. As explained in [Dolinak and colleagues \(2005\)](#), “negative examination” is often useful for exonerating alleged suspects. The forensic examiner must refrain from becoming a tool of either the prosecution or the defense and simply document what he or she finds as completely as possible. The absence of findings is, in fact, a significant forensic finding.

In any case, all areas of injury must be photo documented contextually and with close-ups, both with and without a measuring scale. The orientation of injuries must be made clear, as well as their size. Notes should also be taken as to their color, given that what is seen by the eye and recorded by the camera are not always in sync.

Physical Injuries

Injuries resulting from sexual assault can occur on multiple sites on the patient’s body. They can also occur from differing levels of force, varying with respect to disease, diet, medication, and age. Again, without a complete history, it is not always possible to assess etiology with accuracy. Common injuries to assess for include:

Abrasions: A scraping away of a portion of skin or mucous membrane, resulting when the skin contacts a rough object with sufficient force.

Bruises: An injury producing a hematoma or diffuse extraversion of blood without rupture of the skin.

Chop wounds: These injuries are the result of heavy instruments with a sharp edge. They go deep into the tissue, can be associated with bone fractures, and can have a combination of incised and lacerated characteristics. Examples include injuries inflicted by axes, hatchets, machetes, swords, and meat cleavers.

Contusions: These are injuries (usually caused by a blow of some kind) in which blood vessels are broken, but the skin is not. They can be patterned (imprinted, not directional) and nonpatterned. They include bruises and hemorrhages, which can often be aged based on color. Differentiating postmortem and antemortem contusions is also an important consideration in reconstruction (Adelson, 1974, p. 382).

Ecchymosis: An irregularly formed hemorrhagic area of the skin (i.e., a bruise); the color is blue-black, changing over time to shades of greenish brown or yellow.

Edema: A local or generalized condition in which body tissues contain an excessive amount of tissue fluid.

Erythema diffusum: A redness caused by capillary dilation.

Hematoma: A solid swelling of clotted blood within the tissues.

Hymenal transaction: A complete or partial tear or laceration through the width of the hymenal membrane extending to (partial) or through (complete) its attachment to the vaginal wall; if the transaction is nonacute and does not extend to the vaginal wall, it is called a cleft; hymenal transections may be associated with acute and nonacute injuries.

Incise wounds (cuts): These injuries are the result of sharp instruments being drawn across the surface of the skin, even into the tissue, and are generally longer than they are deep.

Lacerations: An injury resulting from ripping, crushing, overstretching, pulling apart, bending, and shearing; lacerations result from blunt force. These are torn or jagged wounds that tend to have abraded and contused edges. They can be differentiated from sharp force injuries by the recognition of tissue bridging from one side of the laceration to the other (indicating shearing or crushing force). Adelson (1974) warns examiners to beware that bullets striking the skin tangentially, without penetrating, can mimic lacerations and incise wounds.

Stab wounds: These injuries are the result of being pierced with a pointed instrument. The depth of the injury into the tissue is usually greater than its width in the skin.

Some of these are discussed further in this chapter, as they relate to specific kinds of attacks and wound patterns.

Bruise and Other Injury Patterns

As mentioned previously, a bruise is an injury producing a hematoma or diffuse extraversion of blood without rupture of the skin; it appears as an area of discolored skin on the body. Bruises are caused by a blunt force blow or impact that ruptures underlying blood vessels. This impact

can result in a distinctive pattern of bruising and/or lacerations that reflect the type of object used because of its shape, or the position of the victim and/or the attacker because of its location.

While there are an infinite number of possibilities with respect to potential bruise and injury patterns in cases of sexual assault, there are characteristic patterns that tend to repeat, and even some “unique identifiers of the particular event” (Dolinak et al., 2005, p. 480).

Inner Thighs

Forcible penetration of the vagina from the front, with the victim on her back, can result in a characteristic bruise pattern to either side of the inner thighs (Figure 16.1). Redness and some bruising are expected to result from consensual sexual encounters. However, forced sex may be determined by evidence of repeated injury that breaks the skin, even to the point of bleeding.

Physical Restraint and Bindings

The offender may physically restrain the victim during the assault. This is most often accomplished manually. However, it may also involve the victim’s jewelry or clothing being grabbed, or some kind of ligature.

Manual restraint most often results in bruising to the inner aspect of the victim’s arms, resulting from a violent grab (Dolinak et al., 2005). The authors have observed that such “grab” injuries are often characterized by two, three, or four contusions visible on one side of the victim’s arm, and one on the other, corresponding with the offender’s fingers and thumb.

Binding materials, or ligatures, commonly include rope, twine, electrical wire, electrical cords, shoelaces, wire coat hangers, telephone cords, and even handcuffs. Each leaves behind a patterned ligature furrow in the skin, characteristic of its shape and any surface patterns. Often, the victim’s jewelry or clothing is used as a ligature because of its availability (e.g., necklace, shirt, bra, underwear, belt, necktie, stockings). In these cases, the distinctive pattern of the material (e.g., the weave of the cloth or the marks on metal) is often left behind on the skin. Bunched material leaves behind an irregular pattern. Restraints are placed most commonly on the wrists and/or ankles (Figure 16.2). The victim may be restrained to himself or herself or to an object such as a bed or chair.



FIGURE 16.1 The victim in this case was raped, strangled with a ligature, and then disposed of (partially nude) at an outdoor location. Note the characteristic abrasions and contusions to the inner thighs.

FIGURE 16.2 The victim in this case was bound at the wrists with her own shoelaces after being rendered unconscious, but prior to being sexually assaulted. Note the absence of abrasions or contusions associated with the ligature furrow, indicating a lack of resistance.



In living victims, tight restraints result not only in redness and patterned furrows, but also abrasions and contusions at the same location. These are a result of the victim's struggle. This is especially true when victims are restrained and sexually assaulted during the same interval, as physical pain, along with efforts to recoil and break free, may intensify. The absence of such injury associated with binding suggests a lack of physical resistance, binding after the loss of consciousness, or binding after death, as in cases of sexual homicide.

Hands and Forearms

Victims use their hands and forearms defensively to ward off physical attacks or to protect their heads from physical blows. Evidence of sharp force injury to the fingers, palms, and forearms are the common result of a knife attack. As the offender moves in for a sharp force attack, the victim may react by putting up his or her hands and arms or even grabbing at the blade of the sharp force weapon. Similarly, blunt force trauma and broken fingers, hands, or forearms are commonly the result of repeated blows with a blunt object (e.g., fist, baseball bat). In either case, this type of defensive injury is an indication that the victim's hands/arms were not restrained during this part of the attack, if at all. It also indicates that he or she was conscious, facing the attacker, and aware of the attack (Figure 16.3).

Neck

There are a variety of injuries that a victim may suffer to the neck. They include manual strangulation, ligature strangulation, and self-inflicted defensive abrasions and contusions. Symptoms and physical signs of strangulation are detailed in [Stapczynski \(2010\)](#):

With strangulation, the initial presenting symptoms and physical signs may be deceptively minimal. It takes time for hemorrhage and edema to develop after compressive injuries, and the full clinical manifestations may not occur for 36 hours after the event.

The following specific clinical manifestations are possible in strangulation victims:

- * Voice changes are reported in up to 50% of manual strangulation victims and may range from a raspy or hoarse voice to complete inability to talk.



FIGURE 16.3 The victim in this case was sexually assaulted after being overpowered by an offender wielding a steak knife. She grabbed the blade defensively and was cut between the thumb and the forefinger. This is a typical defensive injury, resulting from a sharp force weapon attack.

- * Swallowing abnormality is not a common symptom on initial emergency department assessment, but is reported during the subsequent two weeks in 44% of women who survive a domestic violence strangulation episode. Swallowing may be painful (odynophagia) or difficult (dysphagia).
- * Breathing difficulties are common, seen in up to 85% of women during the initial two weeks after a strangulation event. The dyspnea can be psychogenic in origin and may be due to anxiety, fear, depression, or hyperventilation. Difficulty breathing can also be due to laryngeal edema or hemorrhage, although those injuries are less common in surviving victims.
- * Pain in the throat or neck is common after strangulation. The patient may be able to localize it to a specific area of injury, or it may be diffuse and poorly localized.
- * Mental status changes can be due to the occurrence of cerebral hypoxia or from concomitant intracranial injury or ingestion of drugs or ethanol.
- * Neurologic symptoms are frequently reported in victims of strangulation and include changes in vision, tinnitus, eyelid droop, facial droop, or unilateral weakness. While common, many of these reported symptoms may not be detectable or confirmed by neurologic testing.
- * Injury to the soft tissues in the neck may manifest with edema, hyperemia, ecchymoses, abrasions, or scratches. Abrasions and scratches may be defensive in nature, as the victim has tried to remove the assailant's hands from his or her neck. The hyperemia may be transient and not visible by the time of assessment. Ecchymoses and swelling may take time to develop and may not be visible on initial assessment. Ligature marks can be hidden within the natural skin folds of the neck and potentially missed on cursory examination, especially if the cervical collar is not removed and good lighting is not used. Chin abrasions have been reported to occur from the defensive actions of the victims as they flex their cervical spines forward and bring their chins down in an effort to protect their necks from the manual strangulation of the assailant.
- * Petechiae can occur at or above the area of compression and are most frequently reported on the face and conjunctiva. More extensive cutaneous and mucosal bleeding, such as a subconjunctival hemorrhage, is generally seen only after a particularly vigorous struggle between the victim and the assailant.
- * Laryngeal injuries can manifest with focal tenderness of the laryngeal cartilage or subcutaneous emphysema over or around the laryngeal cartilage.
- * Pulmonary findings can be due to aspiration pneumonitis if the victim vomits and then inhales during the strangulation event. As noted above, pulmonary edema can occur, but this is generally only seen in hanging victims who remain comatose after emergency department arrival.
- * Neurologic findings can include ptosis, facial droop, and unilateral weakness. In many patients, the findings are transient and believed to be incited by focal cerebral ischemia produced by the strangulation process that resolves with time. In rare cases, damage to the internal carotid artery may induce thrombosis with a delayed neurologic presentation.

The authors have observed that manual strangulation injuries, when visible, are often characterized by two, three, or four contusions visible on one side of the victim's neck, and one on the other, corresponding with the offender's fingers and thumb. As described in [Downing \(2006, p. 9\)](#):

Circular or oval contusions on the neck caused by the fingertips of the assailant's grasp may be visible. Singular thumb impressions are more commonly found, as the thumb causes more pressure than other fingers.

These contusions may also be characterized or interrupted by characteristic crescent-shaped lacerations and abrasions from the offender's fingernails ([Figures 16.4–16.7](#)).

When ligature strangulation is suspected or alleged, careful examination of the neck is required. A ligature pattern is generally going to be located at the level of the victim's larynx or lower. In homicide cases, it is generally going to be a uniform and horizontal mark encircling the neck completely. But it can also be a partially circling mark, visible only in the front, the assailant having pulled the ligature tightly from behind. This is in keeping with a homicidal strangulation rather than suicidal or homicidal hanging. In either case, the ligature pattern will mark the skin of the neck generally the same way all around and will not rise sharply to a suspension point.

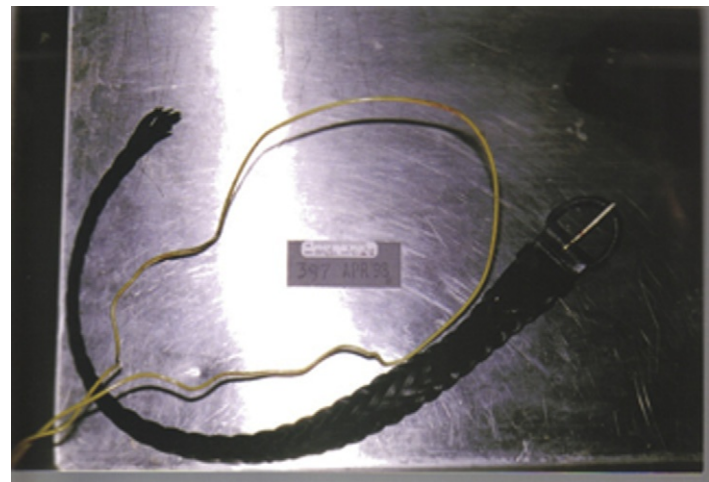
The ligature pattern should be documented (photos and measurements) as soon as possible, as it may disappear in a short period of time. It can also be used to determine whether suspected ligatures could have caused the patterned injury. In severe cases, the ligature pattern may become more pronounced as bruising develops and healing occurs, in which case follow-up photos may be required.

If the ligature is not immediately present (i.e., around the victim's neck or found at the scene), the pattern and furrow left behind should evidence the kind of ligature to search for at the scene or during the subsequent investigation.

As mentioned in [Stapczynski \(2010\)](#), defensive abrasions and contusions may also appear on the victim's neck and chin in association with both manual and ligature strangulation. These injuries may also be self-inflicted, observed in cases where the victim scratches at his or her neck and anything that is compressing the airway. As described in [Downing \(2006, p. 9\)](#): "Superficial curvilinear abrasions are usually the result of the victim's struggle to pry the assailant's hands off his or her neck." These are the result of victim struggle and resistance, indicating consciousness and the absence of restraint. Such defensive resistance can cause injury to the offender's hands and forearms as well and result in DNA transfer beneath the fingernails of the victim.

Knees

Injury to the victim's knees suggests their direct contact with a hard surface. This generally requires them to be bent, unless it is an artifact or dragging. It can also be an indication of forced oral sex. Although certainly oral sex may be forced without resulting in knee injuries, their presence is consistent with it. The type of injury will depend on the surface that the victim kneels on, any clothing that might be covering the area, and any additional force applied by the offender. The authors have seen a wide range of such knee injuries, from mild redness and swelling, to bruising, to bleeding lacerations. When confronted with injuries to the knees (one or both) in a sexual assault, this line of inquiry is suggested ([Figure 16.8](#)).



FIGURES 16.4–16.7 This male victim of a sexual homicide was taken willingly to a hotel room by another male that he met at a bar. During or subsequent to a consensual sexual encounter, he was asphyxiated with his own belt and a coat hanger from the room. Note the curvilinear abrasions, reflecting the shape of fingernails, along the right side of the neck, resulting from the victim's attempts to break free of the ligatures.

FIGURE 16.8 The victim in this case was sexually assaulted and tortured for over 3 hours in a box van before being let go by her rapist. During the attack, she was forced to perform oral sex multiple times while kneeling on a plywood floor with bare knees. The injuries shown resulted.



Breasts

Common injuries to the victim's breasts associated with sexual assault include forceful sucking, pinching, slapping, and biting. In extreme cases, violent acts of tearing and cutting have been known to occur, up to and including the removal of the entire breast (such destructive acts are referred to as **defeminization**). Injury to the breast may be accomplished through the clothing, resulting in injury patterns on the skin from clothing material and corresponding damage to the clothing itself. Injury to the breast may also be accomplished after the clothing has been removed (Figure 16.9).

If any injury to the victim results in blood flow, it is useful to examine the corresponding site on all items of clothing that might have covered the area for blood patterns and damage (often multiple layers of clothing are involved). This will indicate what the victim was wearing, or not, when attacked.

Aging Bruises

It can be difficult to determine the age of a single bruise and to associate it with a particular event. As bruises heal, they change color; this is the primary means of determining when bruising occurred. Of the five different classification schemes for aging bruises reviewed in [Bialas and Stephenson \(1996\)](#), all of them provide that yellowing associated with a bruise-type injury (blunt force trauma) is an artifact of healing and is evident only 1–2 weeks after the injury. Their own research found that green and yellow coloring in a bruise suggests that the injury is at least 24–48 hours old.

Therefore, if presented with a yellowing bruise, it is not reasonable to associate it with a sexual assault reported to have occurred within 24 hours. However, different people bruise differently, and their bruises age differently, owing to many factors such as diet, medication, illness, and substance abuse. A patient history on this issue is necessary for the most informed opinions.

However, most cases do not involve the evaluation of one bruise, but rather multiple bruises and bruise patterns. If the patient presents with multiple bruises in the same general location, in

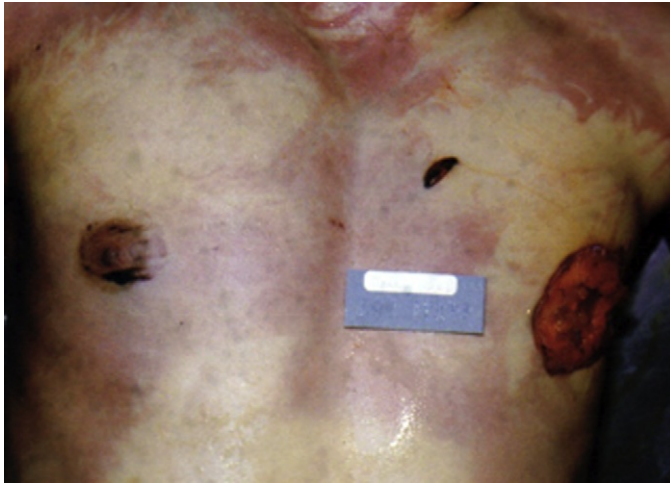


FIGURE 16.9 The victim in this case, a young adult male, was mutilated postmortem. Subsequent to sexual assault and homicide by strangulation, his right nipple was bitten, resulting in a characteristic bite mark; his left nipple was cut off with a knife; and he was stabbed multiple times (note the single stab injury shown here, above the nipples). The same injuries are commonly inflicted upon females under the same circumstances.

radically different stages of healing, this suggests that they are the result of injuries inflicted at different times.

The important thing to note here is that aging bruises is not impossible, and their association with a sexual assault must be investigated and confirmed or refuted—not assumed.

Genital Examination

After a thorough head-to-toe physical exam, with corresponding documentation, the next component is the general survey of the patient's genitalia, both macroscopically and with a colposcope. A colposcope is a lighted magnifying instrument used by a gynecologist to examine the tissues of the vagina and the cervix. The process of using a colposcope during a vaginal and cervical examination is called **colposcopy**.

A colposcope allows the forensic examiner to assess for, and record, the presence or absence of genital injury. It's like a camera, flashlight, and microscope all in one. It allows visualization of genital tissue areas that may be missed with the naked eye or poor lighting. As explained by [Finkel \(2002\)](#), the colposcope provides not only excellent magnification of the genital tissue, but also an excellent light source that identifies and captures any potential injury or abnormalities on tape or film. Furthermore, it provides a noninvasive method for examining the genitalia—and because the examination is on a screen or monitor, it actually makes the process less intimidating. A genital examination conducted macroscopically, without a colposcope and corresponding documentary photos, is essentially incomplete.

In terms of the sexual assault examination, injuries, if present, vary according to force of the penetrating object, the object itself, time elapsed between assault and examination, position of victim, and/or use of lubrication. The most common sites of female genital injury are the posterior fourchette, the labia minora, hymen, and fossa navicularis. The examiner must have a strong foundational knowledge of normal genital anatomy, and normal anatomical and cultural variations, in order to competently assess genital abnormality. Identification and interpretation of abnormal findings evolve from there.

During the genital exam, the forensic examiner must also pay close attention to injury, and the absence of injury, in the anal and perianal regions. As explained in [Dolinak and colleagues \(2005\)](#), finding injury here is not necessarily evidence of sexual penetration, unless the proper context is present (p. 475):

The passage of feces could result in rectal bleeding. However, radiating perianal lacerations seen around the anus without trauma to the rectal mucosa rule out the passage of hard feces as an etiology. The mechanism of such radiating tears is an object pushed from outside in and not an object from within coming out.

It is also relevant to note that injury to the anogenital region can occur during consensual sexual activity, and that many cases of rape do not involve visible trauma. [Cybulska and Forster \(2010\)](#) report that (p. 235) "Genital injuries are found in 24–53% of cases; most require no treatment. About 20% of women have no injuries following rape." As explained in [Keller and Nelson \(2008\)](#), there are many factors to consider (p. 135): "genital tissues are vulnerable to tearing, bruising, scraping, irritation, and swelling during sexual contact, whether it is consensual or non-consensual. Additionally, trauma from consensual or forced sexual intercourse varies depending on the female's age and sexual experience." In other words, the absence of genital trauma does not invalidate a claim of rape, and the presence of trauma does not prove it ([DiMaio and DiMaio, 2001](#)). Injury must be assessed in its context and informed by sufficient history to screen for confounding or misleading artifacts.

Evidence of Sexual Activity

Although not proof of rape or sexual assault on its own, establishing evidence of sexual activity (or its absence) is a key issue in the reconstruction of any suspected sex crime. Evidence of recent sexual activity can include, under the proper circumstances, the presence of condoms and/or lubricant; the presence of semen and/or sperm; evidence of saliva; and even evidence of fecal matter. However, positive findings related to sexual activity must not be interpreted out of context. Victim history must be collected and investigated to establish whether artifacts from prior, recent, and consensual sexual activity are being confused for, or blended with, evidence of sexual assault.

Evidence of sexual activity cannot be understood, let alone ascribed to criminal intent, outside of its context. It also must not be interpreted as an isolated behavior. When placed in the context of victim history, physical evidence, and other reconstructed events, the meaning of any established sexual activity is understood more completely.

Semen and Sperm

Semen is the fluid mixture of male bodily secretions that contains the sperm. There are certain secretions in semen considered to be reliable markers for confirming the presence of semen, due either to uniqueness or to quantity. These markers are categorized by the results of tests performed to assay them as either presumptive or conclusive. Using these markers, forensic examiners are able to make reasonable statements about the presence of semen in a sample of evidence.

ACID PHOSPHATASE

The acid phosphatase (AP) test is a well-documented *presumptive* test for the presence of semen. There is generally a large amount of the enzyme AP in human semen. If the amount assayed in a sample of evidence is large enough (there is no consistent agreement as to how

much is enough), then it can be said that semen could be present, that is, a finding consistent with the presence of semen. For example, if the examiner achieves this result on an oral swab, a nasal swab, or from clothing stains up near the head or shoulders, then this result is consistent with oral sex. But it is not confirmed.

P30

P30 is a protein specific to semen; it has not been found in any other body fluids or organs. It is easily detectable at even the lowest average levels in semen of the average male, making it an excellent marker when examining very small amounts of trace evidence. A positive result for P30 is also a strong confirmatory result for semen, even without the presence of sperm. This becomes important given the large number of males in the general population who have undergone vasectomy operations and who subsequently have ejaculate that contain no sperm. If the examiner achieves a confirmatory result for the P30 antigen, then semen is present.

SPERM

The microscopic identification of sperm cells is the most reliable and widely used forensic technique for confirming the presence of semen ([Virkler and Lednev, 2009](#)). As argued in [DiMaio and DiMaio \(2001\)](#):

In living individuals, motile sperm are usually seen only up to 6 h, occasionally 12 h, and, very rarely, up to 24 h. In the latter case, it is probable that the sperm was obtained from cervical mucus. Thus, it is important when searching for motile sperm in an individual alleged to have been raped only a few hours before to obtain this material from the vaginal pool and not from the cervix.

Non-motile sperm with tails in the living individual are usually seen up to 26 h, with occasional reports of 2 to 3 days. In the latter cases, these are probably sperm trapped in cervical mucus. The identification of only a single sperm on one or two slides should make the examiner wary that he may have one of those cases in which there is unusual prolonged survival of the sperm, that is, sperm from cervical mucus. In most rape cases, numerous sperm will be seen on each smear. The presence of several sperm on a slide, with a history of the last voluntary intercourse 2 or 3 days before, would be inconsistent with the sperm's originating at that time, but would be consistent with a recent rape.

Any sperm identified should be collected and DNA tested for suspect comparisons and eliminations. Semen may also contain epithelial cells from the male urethra and can therefore also be submitted for DNA testing.

DNA

DNA testing may be used to confirm the ownership of cells collected from swabs taken during the sexual assault examination, but it does not discriminate the type of cell tested. This must be accomplished visually or by other means of testing. The presence of suspect DNA indicates only that contact, or penetration, occurred. Its meaning in a given case cannot be interpreted unless the conditions of that contact and evidence transfer have been reconstructed carefully using other physical evidence.

Saliva

Saliva is transferred in association with a broad range of sexual activity, including oral sex (mouth to genitals) and the kissing or licking of eroticized objects and body parts (e.g., sex toys, lips, breasts, buttocks). It is also transferred in association with bite mark evidence. While there are no confirmatory tests for saliva, suspected transfer sites can be swabbed and tested for the epithelial DNA that it carries.

Fecal Matter

The presence of fecal matter (excrement) on an object, on a victim's body or clothing, or simply in a crime scene can indicate anal penetration or activity. When the result of anal penetration, it is often found smeared on the victim's buttocks, legs, clothing, or on towels found nearby. This transfer evidence is found in association with an attacker withdrawing his penis, or an object, from the victim's rectum and then wiping it off with whatever is available.

While fecal matter does not have DNA of its own, as it is digested material, it is coated with trace amounts of bodily mucus and often blood that contains its owner's DNA. This can be tested and its ownership established.

Condoms

Condoms are often reported and collected in association with rape. Use of a condom, and any associated spermicidal lubricants, does not imply victim consent nor does it necessarily imply offender precaution—to avoid evidence transfer that might leave behind physical evidence of identity. Rather it may suggest offender concern for contracting sexually transmitted diseases.

When a condom is found at a crime scene, it can be DNA tested both internally and externally: internally for ejaculate (semen and/or sperm) and epithelial cells from the male's penis and externally for epithelial cells sloughed off from the complainant's mouth, vagina, or anus. This is done to establish the identity of those who used the condom, as well as to allow a clear inference that sexual penetration of some form took place. To determine whether the penetration was oral, vaginal, or anal, an external examination of the condom for saliva, fecal matter, or lubrication associated with a particular orifice, for contrast with the results of the physical examination, is necessary.

Toxicology

Drug use, most commonly alcohol, is a vital consideration in reconstruction of an alleged sexual assault. As such, it is standard forensic protocol to collect blood and/or urine from both complainants and suspects during the investigation. The failure to collect and test toxicological samples is substandard, and in some cases may indicate a desire to protect the complainant from the outcome.

Alcohol: The Real Date Rape Drug

In some instances, drugs are given intentionally yet surreptitiously to a victim by an offender to facilitate rape. There are, in fact, many different kinds of "date rape" drugs, including sedatives, sleeping pills, and, more specifically, Rohypnol. These can each incapacitate victims, induce sleep, and cause memory loss depending on type and dosage.

However, the number one drug associated with sexual assault is alcohol. Research has found that in more than 50% of reported sexual assaults, the victim, the offender, or both had been consuming alcohol (Busch-Armendariz et al., 2010). Along with other well-known side effects, it lowers inhibitions, impairs judgment, and ultimately prevents informed consent (Bates, 2007). As reported in the *Journal of the American Medical Association* (Cole, 2006, p. 504):

According to a 2003 US Department of Justice (DOJ) report (available at <http://www.cops.usdoj.gov/mime/open.pdf?Item=269>), rape is the most common violent crime at US universities. The incidence of rape is estimated to be 35 per 1000 female college students per year in the United States, although less than 5% of these rapes are reported to police. Women may decline to report rape for a variety of reasons, including shame, fear of social isolation from the assailant's friends, and self-reproach for drinking with the assailant before the rape.

Ninety percent of college women who are raped know their assailants, according to the DOJ report. Most rapes occur in social situations, such as at a party or studying together in a dormitory room, and about half of perpetrators and rape survivors are drinking alcohol at the time of the assault, according to a National Institute on Alcohol Abuse and Alcoholism (NIAAA) review of recent studies of alcohol and sexual assault (available at <http://pubs.niaaa.nih.gov/publications/arh25-1/43-51.htm>). Henry Wechsler, PhD, of the Harvard School of Public Health, in Boston, who has conducted studies of alcohol use by college students, says that most nonconsensual sex is fueled by alcohol. "Alcohol is the number 1 rape drug," says Wechsler.

This is further supported by findings reported in Cowan (2008, pp. 904–905):

Research has shown that the level of alcohol use in sexual assault cases is alarmingly high. Andrea Finney's 2004 summary of various research studies in this area shows that around 60% of perpetrators have been drinking just prior to the offense of sexual assault. However, statistics on the proportion of victims who have been drinking prior to the offense vary widely and depend partially on the sample—for instance, in student populations, up to 81% of incidents can involve drinking on the part of the victim. There has been no substantive research on intoxication of victims in the U.K. to date and the data referred to by Finney is generated in the U.S. However, more recent research in the U.K. (aimed at analyzing the attrition rate in rape cases rather than the rate of alcohol consumption per se) found that in a sample of 676 cases over eight police force areas, 38% of victims aged 16 and above had been drinking, though not necessarily to the point of intoxication, prior to the assault.

It is important to note that alcohol does not generally require surreptitious delivery—some patients will regularly ingest alcohol to excess and of their own free will. In fact, it is often used precisely because of its narcotic effects, not in spite of them, as a form of recreation. However, this creates an environment of increased risk wherever such activity takes place, especially within large groups.

Mental Incapacity

As explained already, the use of drugs and alcohol in sufficient quantities prevents the user from thinking rationally, and subsequently from being able to form any kind of rational intent (victims and offenders alike). This bears directly on cases of rape involving drug and alcohol use, described in Cowan (2008, pp. 900–901):

A complainant's intoxication can impact consent in a rape trial in two possible ways. First, the complainant and the defendant could disagree about the fact or level of intoxication, i.e., capacity, so that the defendant claims either that the complainant was not drunk at all, or that she was not drunk to the degree that she was incapable of consenting but merely was disinhibited, and therefore she was in fact capable of, and did, consent. Second, there could be disagreement about whether or not there was consent, i.e., the defendant claims that the complainant gave consent, albeit drunken, and that she was capable even though intoxicated, whereas the complainant states

that she cannot remember what happened because she was extremely drunk but that she knows that she did not want to have sex with the defendant (and she may also claim that she was too drunk to resist). The claim then could be either that she was not intoxicated (enough) and capable, or, that despite a high level of intoxication, she did consent.

Although referring specifically to alcohol intoxication, the issues discussed in [Cowan \(2008\)](#) remain the same with other drugs that cause similar mental defects. This temporary state of being incapable of rationally appraising the nature of one's own conduct is referred to as **mental incapacity**.

Significantly, research published in [Boykins \(2005\)](#) found that half of the sexual assault victims in her study reported current use of prescription medication, primarily for mental health problems such as depression. This becomes more significant with respect to perception and memory if such medications are mixed with alcohol.

Substance Abuse

It is important to ask the patient if he or she has a history of substance abuse. If the answer is yes, then immediate follow-up questions must include which substances, when was the last use, and how much was taken. Here, it is critical that the forensic examiner explain to the patient the importance of being honest.

The patient needs to fully understand that if he or she has recently ingested a substance such as alcohol, marijuana, cocaine, heroine, methamphetamine—or any other illicit drug—that it will likely show up on the lab tests submitted for analysis. Therefore, it is better for patient's health and overall credibility to be up front about drug use. Patients need to know that if they deny drug use and test "hot" for the presence of something illicit, this will make them look intentionally deceitful, as though they are trying to hide information. The forensic examiner should explain that it is better to establish a pattern of honesty during the forensic medical examination so that any other information provided may be trusted if trust is required.

Ultimately, victim toxicology will be used to inform estimates of the patient's physical and mental capabilities, as well as to assist with addressing the issue of consent. This is discussed in [Pittel and Spina \(2004, pp. 151–152\)](#):

In contrast to the vast majority of rapes in which an unwilling victim is forced to engage in sexual acts by threats of bodily harm, the alleged victim of drug-facilitated rape may or may not have been a willing and active participant in previous acts of consensual sex, may or may not have voluntarily consented to use drugs with the alleged perpetrator, or may engage in sexual acts in situations where they had sought to obtain drugs from the alleged perpetrator.

With the growing popularity of GHB and Ecstasy (MDMA) as "club drugs" that are commonly used by members of both sexes to enhance energy and to produce euphoria at all-night dances or "raves," it is also likely that at least some alleged victims of drug-facilitated rape were not drugged involuntarily, and that they may have encouraged or initiated sexual intimacies that they later regret or that they perceive to have been forced upon them.

In other cases, the victim may have met the perpetrator at a bar or party and had been willingly talking, dancing, and drinking with him before he slipped something into her drink. At this point, she may become noticeably more flirtatious and amorous, and most people would just assume that she is drunk. People who observe her may believe that her increased sexual behavior is an indication of her interest in the person she is with.

However, it is important to note that if she had ingested Rohypnol, MDMA, or especially GHB, such behavior is very much part of the effect of the drug. It is also possible that during her intoxicated and disinhibited state, she will "voluntarily" ingest other recreational drugs. Such behaviors may appear to be "consensual" to others and in such cases, interviewing waitresses, and other witnesses may be important in determining if the victim was

behaving uncharacteristically, even though her behavior appeared to be voluntary. In addition, an indication of a drug being slipped in a drink is that the alleged victim will notice that she feels far more “drunk” than expected, given the amount of alcohol she has ingested, particularly if she had a drink she usually consumes.

In cases involving recreational use or abuse of drugs and alcohol by the patient, it may be necessary to obtain collateral descriptions of the patient’s typical behavior while under the influence from friends and family members. In this way, the forensic examiner will have a more complete understanding of how particular drugs affect a particular patient to inform subsequent interpretations—although not necessarily his or her own. That is to say, there are happy drunks, loud drunks, “amorous” drunks, forgetful drunks, and angry drunks. It helps to know which the patient is.

Clothing

As suggested already, complainant and suspect clothing must be collected and examined carefully for any evidence of injury or force, such as biological material, rips, tears, and cuts. However, clothing damage from an attack should not be confused with regular garment wear and tear. Again, the complainant interview should act as a guide, establishing whether clothing was reported to be removed forcibly or whether injuries were reported to be inflicted through the clothing. As explained in [Boland and colleagues \(2007, p. 110\)](#):

Clothing damage analysis is an integral part of the examinations carried out in sexual assault type cases. This analysis can be used to corroborate different versions of events and is at its most powerful in elucidating false allegation cases and consent cases.

The forensic examiner must therefore note whether injuries to the clothing match the complainant’s report or line up with corresponding injuries to the body.

The complainant’s underwear and bra are of particular forensic value. If either is cut or torn, this may indicate force unless there is an established history of consensual activity that involves this behavior as part of fantasy sex-play. Again, this determination requires a complete and honest history from the complainant, or collateral history from other evidence sources or witnesses. Further, as discussed in [DiMaio and DiMaio \(2001\)](#):

The victim is asked whether she douched, bathed, showered, defecated, or urinated prior to the examination. All the aforementioned factors can influence whether the physical evidence needed to document sexual intercourse is present. Vertical drainage from the vagina is the worst enemy to the collection of evidence. Because of this, it is recommended that the examiner retain the [undergarment] the victim was wearing. Thus, any drainage of semen into the [undergarment] can be documented.

Drainage can occur on any surface where the complainant sits or lies after being attacked, not just their underwear: a coat, a sanitary napkin or tampon, a bed sheet, a blanket, or a vehicle seat—all have been on the receiving end of such material. Developing the timeline of activities, and actively searching for drainage material to potential transfer sites, should be a forensic priority.

Presentation of Findings

As explained in the [NIJ \(2004\)](#) guidelines, forensic nurses must conduct and document every examination they perform thoroughly, as though it will go to trial, even though many will not. This is part of maintaining a forensic mind-set.

The purpose of any forensic examination is to educate the court system. Examination reports that do not provide interpretations about whether and how findings may be consistent with forcible sexual activity or the patient's account as provided in the forensic interview (with the appropriate caveats) are unfortunately common. Such reports are also unprofessional—they allow forensic examiners to vacillate in their ultimate interpretations; they leave a false or confused impression in the minds of those who read them; and they allow attorneys to characterize findings with their own adventitious interpretations.

However, forensic examiners must not invade the province of the jury by addressing the issue of guilt or innocence. As explained in [DiMaio and DiMaio \(2001\)](#):

In court, the physician or forensic nurse is never expected to state whether the crime of rape has occurred. Rape is not a diagnosis, it is a matter of jurisprudence. All that the examiner can do is document any evidence of trauma, determine, if possible, whether there has been recent sexual intercourse, and collect trace evidence.

Forensic interpretations of exam findings must be made in light of the known victim history and the most current advances in relevant research, methods, and other developments in the field. This places the burden of thorough forensic interviewing squarely on the forensic examiner, as well as the requirement of continuing education. The court should treat forensic interpretations made in the absence of these considerations with skepticism.

To be clear, all forensic reports should say what the examiner did, what he or she found, and what it means—not in general, not in part, and not in collusion with a particular side. In other words, the forensic examiner's report should be the truth, the **WHOLE** truth, and nothing but the truth. For further instruction, see Chapter 19: Forensic Examination Reports.

THE CRIME SCENE

In too many cases of alleged sexual assault, investigators ignore the crime scene while focusing their attention on a living complainant. The crime scene must be investigated just as thoroughly in these cases as in any other or vital evidence will be missed (see Chapter 7: Crime Scene Investigation). It must be examined to determine whether it actually exists and can be found,⁶ whether the evidence present is consistent with the complainant's version of events, and whether evidence remains that can still be collected. If investigators and forensic personnel fail to perform an adequate crime scene investigation, the development and elimination of case theories are made that much more difficult, if not impossible.

⁶ One of the authors (Turvey) has worked multiple cases where the complainant could not recall, or could not locate, the location where she was attacked. Sometimes they were abducted to the location while blindfolded, sometimes they were suffering the effects of substance abuse, and sometimes they were making a false report.

SEXUAL HOMICIDE

The term **sexual homicide** refers to any homicide with a sexual component, to include sexual assault. Such crimes generally receive more attention and forensic examination than a sexual assault by itself, as the penalties are higher along with the budget appropriations. Additionally, the presence of a living witness can lead investigators and attorneys to the erroneous conclusion that physical evidence is not necessary to understand the crime or “build a case.” Consequently, reconstructionists are more likely to be involved in the examination of an alleged rape–homicide. The examination issues are the same, however—with the subtraction of a complainant statement and the addition of sexual assault protocol conducted by a forensic pathologist along with a cause and mechanism of death.

Consider the physical evidence and reconstruction issues in the following case.

CASE EXAMPLE

California v. Lewis Brent Turvey

The author (Turvey) has examined and testified in many cases where victimology has been crucial to the reconstruction, including *California v. Jack Lewis*. This case involved the homicide of the defendant’s 48-year-old girlfriend in San Diego, California, on September 8, 2005. According to investigative reports, her nude body was discovered at 1144 hours by police officers responding to multiple anonymous 911 calls. She was located face up on her bedroom floor with a bowl of unmelted ice cubes next to her head. Her body evidenced pulled hair; multiple blunt force injuries to the body, head, and neck; and bite mark injuries—some in different stages of healing. There was also a Mag-Lite present with a ring of fecal matter dried on the handle: it was suggested by the police and prosecution that the defendant had used it on the victim as a means of torture (Figure 16.10).

Within 48 hours, her domestic partner of 12+ years (starting in 1993), Jack Lewis, 39, turned himself in to authorities and made statements that implicated him in her death.

Police and prosecutors developed a theory of the case that accounted for everything found at the scene, assuming that it all took place at the same time, and ignored the victim’s history with the defendant: a torture-related homicide committed out of anger while viewing a sadistic sex tape. The defense theory was that the death was an accident, resulting from rough sex combined with mutual present and chronic drug abuse.

The author requested that the blood and mucus coating the fecal matter be tested for DNA and that the victim’s history be examined to determine which theory was best supported by the evidence. Taken from Turvey (2008):

It is not reasonable to assume that all of the injuries described in the autopsy report must be associated directly with the homicide.

Such an assumption would in fact be a common fallacy of logic that is referred to in Chisum and Turvey (2006, p. 113): “*Cum hoc, ergo propter hoc*,” or “*with this, therefore because of this*”: When one jumps to a conclusion about causation based on a correlation between two events, or types of event, that occur simultaneously. Just because two things are found together, at a crime scene, does not mean that they must be the result of the same actions, or must have occurred at the same time.

This requires consideration of at least the following facts and circumstances:

FIGURE 16.10 This photo depicts the scene after crime scene processing efforts were under way, but prior to evidence collection efforts. Note item 27, the bowl of ice cubes (by then melted); item 31, a “Vaseline” lotion bottle; and item 36, the Mag-Lite. In August 2008, Jack Lewis was convicted of first-degree murder and related charges.



1. The victim has a self-reported history of sexual activity and domestic violence injury with the defendant going back several years prior to the homicide that includes at least the following nonlethal activity in sexual and nonsexual contexts:
 - a. Slapping during sex
 - b. Kicking
 - c. Head-butting
 - d. Hair pulling during sex
 - e. Biting during sex
 - f. Broken bones
 - g. Methamphetamine use during sex
 - h. Choking to the point of unconsciousness during sex
 - i. Blunt force injuries resulting in bruises, large and small

This history is confirmed by the autopsy report (healing bone fractures), statements of family members, photographs of prior injuries, and court records. In specific, she previously reported to her family and others:

- She has suffered injury from Jack Lewis numerous times over the past few years.
- She stated that she and the defendant both frequently injected or used methamphetamine prior to having sex.

- She stated that the defendant had choked her to the point of unconsciousness during sex more times than she could count.
- 2. The autopsy report, by Medical Examiner Glen Wagner, D.O., is unclear as to the precise age and timing of many of the injuries discussed, using the word “recent” to describe approximately three areas. The word “recent” is not used to describe injuries associated with the manual strangulation (which would necessarily be among the most recent injuries suffered), but it is used to describe both healing bones and the injuries to the vaginal vault and rectum. This usage appears inconsistent and does not provide a clear indication of which of the non-lethal injuries are associated specifically with the hour of her death.
- 3. According to the cross-examination testimony of Medical Examiner Glen Wagner, D.O., he interpreted the age of all of the injuries to the victim as occurring within the same 12-24 hour period based on general color consistency of hemorrhaging and bruising. He did not actually biopsy any of the bruises to confirm this opinion. In any case, this opinion does not associate the non-lethal injuries directly with the actions that caused her death.
- 4. According to the cross-examination testimony of Medical Examiner Glen Wagner, D.O., he has never worked a case death resulting from non-homicidal *sexual asphyxia*.⁷ This suggests that his opinions in this area are more speculation than not.
- 5. Cooking oil and lotion were found in the bedroom (Diagram Item 31—Vaseline lotion bottle on floor next to body, nearly empty; Diagram Item 42—Cooking oil bottle in closet, nearly empty). The location and state (near empty, on the floor, open, hair transfer evident) suggest their use as sexual lubricants. This is consistent with a plan to lubricate and facilitate non-violent penetration, and is not consistent with torture.
- 6. There was a pornographic videotape in the VCR titled “Astounding Ass Pounding” by Vivid Video; it is a four hour compilation tape of non-violent heterosexual anal sex scenes. This videotape is not consistent with torture fantasy related material.
- 7. A “Mag-Lite” flashlight was discovered on the bed (Diagram Item 36). It was smeared with [a ring of] fecal matter from the defendant. This is consistent with insertion of the Mag-Lite into the defendant’s rectum.
- 8. According to forensic reports, both the victim and the defendant tested positive for methamphetamine.
- 9. A bowl of ice was found next to the victim’s head. This may have been used for eating, cooling off beverages, or in course of consensual sexual activity. None of these possibilities is consistent with torture.

In the context of these facts and circumstances, it is inappropriate to assume that the nonlethal injuries must be directly associated with the injuries that caused the victim’s death—until such time as they can be accurately aged or associated by a careful forensic examination and comparison to any known prior incidents or injuries.

⁷ As explained in [Turvey and McGrath \(2011a/2011b\)](#): “*Sexual asphyxia* is practiced both as an autoerotic activity and as a consensual behavior between two or more people. . . . When true consensual sexual asphyxia results in death, the death is accidental and not a homicide. This can be difficult to ascertain at times, as the surviving participant may not be eager to trust the police with understanding the difference between a consensual/accidental sexual asphyxia and an intentional homicide.”

SUMMARY

Rape refers to nonconsensual sexual penetration. It is a form of *sexual assault*, which refers generally to any nonconsensual sexual contact. The purpose of this chapter was to provide the reconstructionist with an applied understanding of the variety of physical evidence involved in cases of alleged rape and sexual assault, how to evaluate it, and how to interpret it.

A small percentage of sexual assault reports will be *false allegations*—untruthful statements, accusations, or complaints to authorities asserting that a crime occurred, which in reality did not. Therefore, when presented with any witness statement, objective science requires equal consideration of truthfulness and falsity as viable. The witness may be lying, may be telling the truth, or may be mixing truth with select fictions. Each of these possibilities must be considered without prejudice as a function of both good science and the accused's right to due process.

An investigation of an alleged sexual assault case should include the following sexual assault examination protocols: complainant history, physical examination, full body photos, documentation of physical injuries, documentation of bruising and other injury patterns, genitalia examination, documentation of evidence of sexual activity, toxicology, examination of clothing, and presentation of findings. An investigation of the crime scene must be just as thorough or vital evidence will be missed.

Reconstructionists are more likely to be involved in the examination of an alleged *sexual homicide*, which is any homicide with a sexual component, to include sexual assault. The examination issues are the same, however—with the subtraction of a complainant statement and the addition of sexual assault protocol conducted by a forensic pathologist, along with a cause and mechanism of death.

QUESTIONS

1. Explain the difference between *rape* and *sexual assault*.
2. In the United States, most reported sexual assault victims were female and reported offenders were most often strangers. True or false?
3. List three sexual assault examination protocols.
4. List three potential sources of DNA evidence commonly collected from swabs taken during a sexual assault examination.
5. What is the number one drug associated with sexual assault?

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Reconstructing Digital Evidence

Eoghan Casey

Key Terms

Cybertrails; Digital evidence; Internet Protocol (IP) address

Information is flowing through wires and air all around us, from one computing device to another, frequently finding a resting place on storage media along the way. Given the ubiquity of digital data, criminal activity today often leaves digital traces stored on or transmitted using computers. Law enforcement and regulatory agencies have recognized that they cannot afford to overlook these traces and are therefore devoting resources to the collection and forensic examination of **digital evidence**. The resulting evidence provides an abundance of information that can be useful when investigating a crime. Even if digital evidence does not contain the “smoking gun,” it can reveal actions, positions, origins, associations, activities, and sequences useful for reconstructing the events surrounding an offense.

Forensic examiners of computer systems are called on to answer both simple and complex questions relating to crimes. Investigators may need to know something as simple as whether a particular document can be located on a computer or when the document was created or printed. In some cases, digital evidence may provide a decisive lead, such as the floppy diskette that was sent by the Bind Torture Kill (BTK) serial killer to a television station and contained data that led investigators to a computer in the church where Dennis Rader was council president. Computers also have physical properties that can be embedded in the digital evidence they produce. The electronics in every digital camera has unique properties that specialized forensic analysts can utilize to link digital photographs to a specific device ([Fridrich et al., 2005](#); [Geradts et al., 2005](#)). Some color printers place their serial number on pages in millimeter-sized yellow dots that are only visible under certain light frequencies, enabling investigators to associate an item with a particular printer ([Tuohey, 2004](#)). A person’s Internet communications and digital documents contain verbal evidence that forensic linguists can analyze to learn more about a victim or offender ([Chaski, 2005](#)).

Information stored and created on computers can be used to answer fundamental questions relating to a crime, including what happened when (sequencing), who was responsible

(attribution), and the origination of a particular item (evaluation of source). At the same time, the complexity of computer systems requires appreciation that individual pieces of digital evidence may have multiple interpretations, and corroborating information may be vital to reaching a correct conclusion. Forensic examiners need to understand, and make regular use of, the scientific method to ensure that conclusions reached are solidly based in fact. Familiarity with the limitations of forensic examinations of digital evidence will help investigators and attorneys exculpate the innocent and apprehend modern criminals.

This chapter presents the use of digital evidence to reconstruct actions taken in furtherance of a crime, providing case examples to demonstrate key concepts. The focus of this chapter is on how digital evidence can be useful in violent crime investigations. Specifically, this chapter describes how digital evidence that is handled and interpreted properly can be used to apprehend offenders, authenticate documents, assess alibis and statements, and determine intent. Other approaches to analyzing digital evidence and underlying technical details are beyond the scope of this text. For more in-depth, technical coverage of how forensic science is applied to computers and networks, see [Casey \(2004\)](#).

OVERVIEW OF DIGITAL EVIDENCE

Computers can be involved directly in many types of criminal activities, including terrorism, organized crime, stalking, and child exploitation. For example, sex offenders and obsessional harassers use computers to threaten and control victims, making the computer an instrument of the crime as well as the storage container of evidence relating to the crime. For forensic purposes, it is generally not computers themselves that are of primary interest but, rather, data they contain. Digital evidence is defined as any data stored or transmitted using a computer that support or refute a theory of how an offense occurred or that address critical elements of the offense, such as intent or alibi ([Casey, 2004](#)). Homicide, sexual assault, and other violent crimes can involve digital evidence from a wide range of sources, including personal computers, handheld devices, servers, and the Internet, helping investigators reconstruct events and gain insight into the state of mind of individuals.

The digital footprints we leave as we move through the world create **cybertrails** that investigators can retrace to determine what we were doing, where, and when. Third parties, such as mobile telephone providers, banks, credit card companies, and electronic toll collection systems, can reveal significant information about an individual's whereabouts and activities. The computers we use at home and work contain remnants of documents, photographs, Internet communications, and other details that generally reveal a great deal about our daily life, inner thoughts, and motivations. Data that have been "deleted" often remain on a computer indefinitely, and technically savvy individuals can store data in unused areas of a hard disk. A victim's handheld device may contain entries or photographs that indicate where she was or who she met at a particular time. Records from a missing person's mobile telephone provider or car navigation system may indicate where he went. Computers could contain details about a murder plot, from a to-do list in a personal digital assistant to communications between conspirators. A trained forensic examiner can recover and use these data to reveal evidence that a criminal sought to hide and glean a great deal about an individual and his activities.

When a large quantity of digital evidence is involved, forensic examiners employ key word searches and other data reduction techniques, as well as reconstruction tools such as timelines and link charts. Some link analysis tools can import e-mail and other digital data to help investigators identify patterns and relationships. Figure 17.1 depicts an example of how the contents of a short message service (SMS) message found on the victim's phone could lead to a suspect and how the locations of mobile telephones could be used to place the suspect at the crime scene.

Some forms of digital evidence contain additional information, called metadata, that specialists can extract to aid an investigation. Consider the following data embedded in a Microsoft Word document extracted using Metadata Assistant (www.payneconsulting.com), which reveals when the document was originally created, when it was last modified and printed, the various file names of the document, and the names of the last 10 authors:

Document Name: suicide-note.doc
 Path: C:\Documents and Settings\Jane Doe\Desktop\
 Document Format: Word Document
 Built-in Document Properties:
 Built-in Properties Containing Metadata: 3
 Title: Note
 Author: John Doe
 Company: Personal
 Document Statistics:
 Document Statistics Containing Metadata: 6
 Creation Date: 7/22/2005 4:31:00 PM
 Last Save Time: 6/19/2005 1:58:00 PM
 Time Last Printed: 6/19/2005 1:44:00 PM
 Last Saved By: Jane Doe
 Revision Number: 3

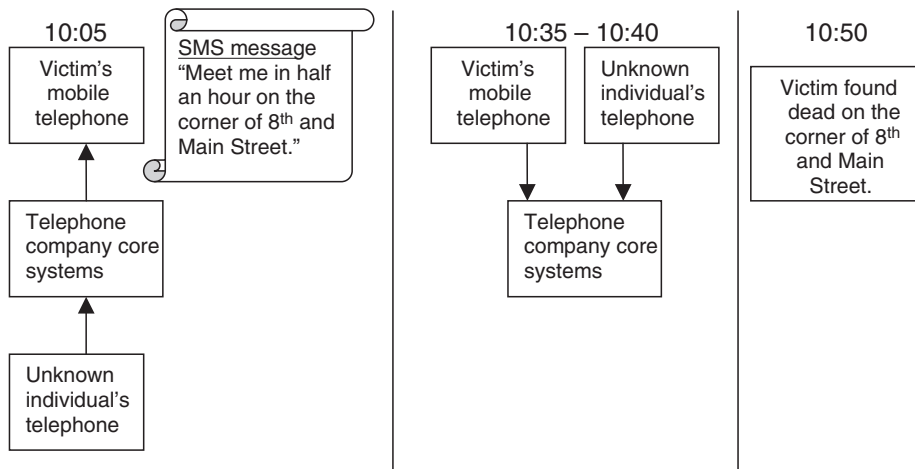


FIGURE 17.1 Links between victim and suspect established using an SMS message and the location of the mobile telephone at given times.

Total Edit Time (Minutes): 5 Minutes

Last 10 authors:

Has Last 10 Data

Author: John Doe Path: A:\note.doc

Author: John Doe Path: C:\Documents and Settings\John Doe\Application Data\Microsoft\Word\AutoRecovery save of note.asd

Author: John Doe Path: A:\note.doc

Author: Jane Doe Path: A:\note.doc

Author: Jane Doe Path: C:\Documents and Settings\Jane Doe\Desktop\ suicide-note.doc

Track Changes:

Tracked Changes: 1. Tracked Changes are On.

1 Type: Delete Author: Jane Doe

My husband did not kill me.

Location: Main Text

This type of embedded metadata can answer a variety of questions regarding a document, including its provenance and authenticity. For instance, although this document appears to have been last printed and saved on 6/19/2005, the original creation date suggests that it was not created until more than 1 month later on 7/22/2005. This date sequence is explained through examination of the last 10 authors, which reveals that the document named “note.doc” was originally created on a floppy diskette using John Doe’s computer (corresponding to the “Creation Date” of 7/22/2005) and was subsequently transferred to Jane Doe’s computer, where it was saved as “suicide-note.doc” and given a “Last Saved Time” on 6/19/2005, possibly because the clock on Jane Doe’s computer had been backdated. Metadata also show that the line “My husband did not kill me” was deleted from the document at some time. A forensic examination of the computers and floppy diskette would likely uncover remnants of the note on the husband’s computer, additional temporal information showing when the document was actually created and transferred onto the wife’s computer, and other data that would help determine who wrote the note and gain insight into the author’s intent.

As another example of the investigative usefulness of digital evidence, e-mail and AOL Instant Messages provided the compelling evidence to convict Sharee Miller of conspiring to kill her husband and abetting the suicide of the admitted killer (an ex-cop named Jerry Cassaday), whom she had seduced. Miller used their Internet correspondences to control Cassaday’s perception of her husband, as demonstrated in the following excerpt from one of their online chat sessions ([Bean, 2003](#)).

[Sharee Miller] twice told Cassaday she was pregnant with his babies—even though she’d had her tubes tied after her third child. In a chat session on Sept. 23, 1999, Miller wrote, “This next part will be hard—I lost my baby, Jerry.”

“No,” Cassaday replied.

“I never thought I would ever tell you that he hits. I got in trouble because I was with you,” she continued. Cassaday wanted to know more.

“Sharee, you can tell me now, or in person when I beat it out of him.”

“It made me start having bad thoughts of killing him,” she wrote.

“Where did he hit you?” Cassaday asked.

“Jerry, I can’t tell you.” But Cassaday insisted.

“He didn’t hit me, Jerry; he raped me—I lost the baby because of the force.”

In another case, the murderer's work computer revealed his intent to commit a crime, and his home computer contained a fake suicide note created after his wife's death (*State of South Dakota v. William Boyd Guthrie*, 2001). On May 14, 1999, Doctor Guthrie, a Presbyterian minister, called 911 for emergency assistance because his wife Sharon was unconscious in the bathtub. Sharon later died in the hospital. Based on the amount of temazepam and other agents in her system, a forensic pathologist determined that her death was not natural and not accidental, but from the autopsy alone he could not resolve whether it was suicide or homicide. A computer specialist examined the contents of the computer in William Guthrie's church office and found evidence of numerous Web searches on subjects related to household accidents, bathtub accidents, and prescription drugs. Some of these Internet activities occurred at approximately the same times as earlier suspicious accidents in the Guthrie household. In April 1999, 2 days after Web pages describing various drugs including temazepam were viewed on the computer in the church office, William Guthrie visited his doctor complaining of insomnia and persuaded the doctor to prescribe him temazepam. The defense argued that Sharon Guthrie had committed suicide and produced a purported suicide note that Guthrie claimed he discovered in his church office 3 weeks after Sharon drowned. The unsigned note was dated the day before Sharon's death and was addressed to her daughter. The note, replicated here with its spacing and typographical errors, was apparently created on a computer:

May 13,1999
Dear Suzanne,
I am sorry I ruined your wedding, Your dad told me about your concerns of my Interfering in Jenalu's and the possibility I might ruin hers. I won't be there so Put your mind at ease. You will understand after the wedding is done. I love you all Mom.

Because there was insufficient time for experts to examine all of the fingerprints on the note, only four fingerprints were analyzed, none of which could be attributed to a specific individual. The computer specialist was called on again, this time to examine Guthrie's home computer, and he found an earlier draft of the suicide note. However, the file on the computer had been created on August 7, 1999. William Guthrie denied that he created this note but admitted to creating another note on August 11 that was found on his home computer with Sharon again as the purported author. It listed various grievances Sharon addressed to Guthrie, including one line that stated, "I'm upset that you have had an affair and have not come clean with me, I have thought of ending my life and you would have to face up to it. Believe me I known how to do it." Guthrie claimed that he wrote this note to work through the emotional trauma of Sharon's death. William Boyd Guthrie was convicted of first-degree murder for the killing of his wife.

William Guthrie was evidently unaware of the digital traces he was leaving behind. As criminals become more aware of these cybertrails, however, they are taking steps to conceal their digital footprints. This concealment behavior includes changing their computer clock to hamper reconstruction, encrypting data to restrict access, and using disk-cleaning tools to destroy digital evidence. One disk-cleaning tool, Evidence Eliminator (www.evidence-eliminator.com/product.d2w), is specifically advertised as a program that defends against digital forensic examination tools such as EnCase.

Other forms of evidence dynamics can make crime reconstruction using digital data more difficult. Digital evidence can be lost if it is not seized in a forensically sound or timely manner, as any use of a computer can overwrite existing data. Relevant network data may be similarly

volatile because businesses only keep logs for a limited time. Therefore, it is critical to have digital crime scenes processed by qualified professionals to ensure that the evidence is preserved properly and examined thoroughly.

DIGITAL CRIME SCENE INVESTIGATION

Computers and networks should be considered an extension of the crime scene, even when they are not involved directly in facilitating the crime. It is useful to think of them as secondary crime scenes. Like a physical crime scene, digital crime scenes can contain many pieces of evidence, and it is necessary to apply forensic principles to preserve, document, and search the entire scene. A single computer can contain e-mail communications between the victim and the offender, evidence of intent to commit a crime, incriminating digital photographs taken by the offender as trophies, and software applications used to conceal digital evidence.

Untrained individuals commonly make the mistake of turning on a computer and looking for a particular item of evidence. The act of turning on and operating a computer is comparable to trampling a crime scene, thereby destroying useful evidence and making it more difficult to reconstruct the crime. To preserve the state of a digital crime scene, professionals make a duplicate copy of the evidence using tools that do not alter the original. At the same time, they document the context of the evidence by making notes and photographs and by calculating hash values of the evidence. A hash value is a formula that reads data comprising a piece of digital evidence and calculates a unique “fingerprint” that can be used to identify and verify the evidence. The verification process is accomplished by recalculating the hash value of the evidence at any time and ensuring that it is the same as the originally calculated value. After preserving and documenting the digital crime scene, forensic professionals perform their examination on the duplicate copy to locate relevant items, determine their provenance, and answer other questions of interest to investigators.

Only searching for a particular piece of evidence on a computer is like walking into a victim’s home just to collect a suicide note without examining the scene for signs of staging. In the United Kingdom case involving Dr. Harold Shipman, changes he made to computerized medical records on his medical office computer system were instrumental in convicting him for killing hundreds of patients. Following Shipman’s arrest, police made an exact copy of the hard drive from his computer, thus preserving a complete and accurate duplicate of the digital evidence. By analyzing the computer application Shipman used to maintain patient records, investigators found that the program kept an audit trail, recording changes made to patient records. This audit trail indicated that Shipman had lied about patients’ symptoms and made backdated modifications to records to conceal the murders. Had the investigators accepted the patient records without digging deeper into their authenticity, they would have missed this key piece of evidence about the cover-up attempt. During his trial, Shipman claimed that he was familiar with this audit trail feature and was sufficiently knowledgeable about computers to falsify the audit trail if he had actually been trying to hide these activities. However, the court was convinced that Shipman had altered the records to conceal his crimes and sentenced him to life in prison.

INTERPRETATION OF DIGITAL EVIDENCE¹

Although computers can provide investigators with many tantalizing leads, digital evidence is not always what it seems and can be misinterpreted. At its basic level, digital evidence exists in a physical medium, such as a magnetic disk, a copper wire, or a radio signal in the air. Forensic examiners rarely scrutinize the physical medium and instead use computers to translate data into a form that humans can interpret, such as text, audio, or video. Therefore, examiners rarely see actual data but only a representation, and each layer of abstraction can lose information and introduce errors. For instance, analyzing the magnetic properties of a hard drive may reveal additional information useful for some investigations (e.g., overwritten data and the cause of damage to the disk). The risk of examining media at this low level is that the act of observing may cause changes that could destroy or undermine the evidence.

As described in the previous section, it is considered best practice to examine an exact replica of digital evidence to avoid altering the original. However, it can be difficult to obtain an exact and complete copy of a magnetic disk, Random Access Memory, a copper wire, or a radio signal. For instance, programmatic mistakes (a.k.a. bugs) have been found in tools for collecting digital evidence from hard drives, resulting in only a portion of data being copied. Bugs have also been found in tools for examining digital evidence on computers, resulting in an inaccurate representation of the underlying data, as shown in [Figure 17.2](#).

There are many other potential sources of error in digital evidence between the time data are created by a system and the time of preservation and analysis of the evidence. For instance, system malfunction can result in erroneous or missing log entries. Also, as with other forms of evidence, poor training or lack of experience can lead forensic examiners to mishandle or

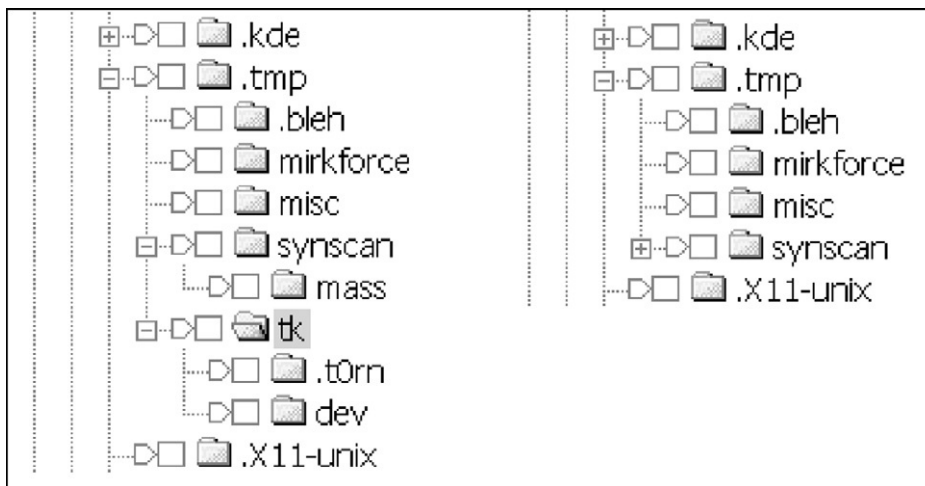


FIGURE 17.2 A folder named “tk” contained important evidence. The tk folder is visible using a newer version of a digital evidence examination tool (left) but not an older version containing a bug (right).

¹ Some examples in this section are based on [Casey \(2005\)](#).

interpret digital evidence incorrectly. In one case, a failure to adjust for the local time zone caused a defense expert to conclude incorrectly that police had operated the suspect's computer (Forster, 2004).

Digital evidence should always be interpreted in context. For example, the mere presence of an incriminating file on a person's computer may not be sufficient to demonstrate guilt if there is strong indicia that the file was placed on the system by a virus, intruder, or via a Web browser vulnerability without the user's knowledge. An analysis of the file, its location, security vulnerabilities, artifacts of system usage, and other contextual clues may help determine how a file came to be on a given system.

Similarly, a file with a creation date that is after its last modified date may be interpreted incorrectly as evidence that the system clock was backdated. In fact, the last written date of a file does not necessarily imply that the file was modified on the computer on which it is found. Copying a file onto a computer from removable media or another system on a network may not change the last written date, resulting in a file with a modified date prior to its creation date.

There are many other nuances to digital evidence caused by the intricacies of computer operations that can cause confusion or misinterpretation, and the same holds for networks. The **Internet Protocol (IP)**² address in an e-mail header may lead investigators to a particular computer, but this does not necessarily establish that the owner of that computer sent the message. Given the minor amount of effort required to conceal one's identity on the Internet, criminals usually take some action to thwart apprehension. This may be as simple as using a library computer or as sophisticated as inserting someone else's IP address into the e-mail header, requiring investigators to take additional steps to identify the culprit.

Consider a harassment case in which the offender sends the victim threatening e-mail via an intermediate server. Normally, the e-mail message would contain information about the computer used to send the message. Specifically, the e-mail header would contain the IP address of the sender's computer. However, because the harasser sent the message via an intermediate server, the e-mail header will contain the IP address of that server and conceal the actual source. For example, headers in the following e-mail sent from a Yahoo! account indicate that the message was sent from an IP address in Japan (210.249.120.210):

```
To: Count Rugen  
From: "Inigo Montoya" <inigo\_montoya@yahoo.com>  
X-Originating-IP: 210.249.120.210  
Date: Wed, 04 Jun 2003 03:51:45 -0000  
Subject: Prepare to die!
```

However, the sender merely connected to Yahoo! via this computer in Japan. Therefore, additional investigation would be required to determine the actual source of the message. Log files from the intermediate computer, such as those shown next, might contain the IP address of the actual sender's computer (172.16.34.14 in this example):

```
172.16.34.14, anonymous, 6/4/03, 03:43:24, 210.249.120.210, GET, http://mailsrv.yahoo.com/login.html, 200
```

² Every computer on the Internet is assigned an IP address to enable delivery of data.

172.16.34.14, anonymous, 6/4/03, 03:44:02, 210.249.120.210, GET, http://mailsrv.yahoo.com/inigo_montoya/inbox.html, 200

172.16.34.14, anonymous, 6/4/03, 03:45:27, 210.249.120.210, GET, http://mailsrv.yahoo.com/inigo_montoya/compose.html, 200

172.16.34.14, anonymous, 6/4/03, 03:51:36, 210.249.120.210, GET, http://mailsrv.yahoo.com/inigo_montoya/sent.html, 200

To mitigate the risks of evidence being missed or misinterpreted, experienced forensic examiners employ a variety of techniques, including comparing the results of multiple tools, validating important findings through contextual reviews, and analyzing corroborating evidence for inconsistencies.

The scientific method provides the final bulwark against incorrect conclusions. Simply trying to validate a theory increases the chance of error—the tendency is for the analysis to be skewed in favor of the hypothesis. This is why the most effective investigators suppress their personal biases and hunches and why they seek evidence and perform experiments to disprove their working theory. Experimentation is actually a natural part of analyzing digital evidence. Given the variety and complexity of hardware and software, it is not feasible for forensic examiners to know everything about every software and hardware configuration. As a result, it is often necessary to perform controlled experiments to learn more about a given computer system or program. For instance, one approach is to pose the questions, “Was it possible to perform a given action using the subject computer, and if so, what evidence of this action is left behind on the system?” Theories about what digital evidence reveals in a particular case may be tested by restoring a duplicate copy of a subject system onto similar hardware, effectively creating a clone that can be operated to study the effects of various actions. Similarly, it may be necessary to perform experiments on a certain computer program to distinguish between actions that are automated by the program and those performed by a user action.

One useful by-product of this type of analysis is exemplars of files or other artifacts created by certain actions. Comparing an item of evidence to an exemplar can reveal investigatively useful class characteristics or even individual characteristics. In one case, the offender claimed that he could not remember the password protecting his encryption key because he had changed it recently. By experimenting with the same encryption program on a test system, the forensic examiner observed that changing the password updated the last modified date of the file containing the encryption key. An examination of the file containing the suspect’s encryption key indicated that it had not been altered recently as the suspect claimed. Faced with this information, the suspect admitted that he had lied about changing the password.

In addition to presenting the facts in a case, investigators are generally expected to render an opinion about the evidence. For instance, when a program such as Evidence Eliminator is found on a suspect’s computer, the forensic examiner will generally be asked if there is any evidence of its use. It is not sufficient for a forensic examiner to conclude that Evidence Eliminator was used simply because it was installed on a computer. The following is an example of how this finding might be phrased:

Evidence Eliminator was almost definitely run on this system. The presence of a folder named “eetemp” and a detailed log file named “EElog.txt” created by Evidence Eliminator, indicate that this program was used on the subject system and was last run on 3/07/05 at 19:29. Many files referenced in the “EElog.txt” log file were altered or overwritten on 3/07/05 at 19:29, which supports the finding that Evidence Eliminator was run on the subject

system at this time. Furthermore, file slack and portions of unallocated space were overwritten with random data, which is consistent with the use of a wiping program.

Analysis of digital evidence requires interpretation that forms the basis of any conclusions reached. Investigators should assess the level of certainty underlying each conclusion in order to help the fact-finder determine what weight to attach. The C-Scale (Certainty Scale) described in [Casey \(2004, Chapter 7\)](#) provides a method for conveying certainty when referring to digital evidence and qualifying conclusions appropriately. Some digital investigators use a less formal system of degrees of likelihood that can be used in both the affirmative and the negative sense: (1) almost definitely, (2) most probably, (3) probably, (4) very possibly, and (5) possibly.

Whenever possible, investigators should support assertions with available sources of relevant evidence. Clearly state how and where the digital evidence was found to help fact finders interpret the findings and to enable another competent examiner to verify the results. Presenting alternative scenarios and demonstrating why they are less reasonable and less consistent with the evidence can help strengthen key conclusions. Explaining why other explanations are unlikely or impossible is a respected facet of the scientific method that can be applied to examination of digital evidence and demonstrate that a particular conclusion withstood critical scrutiny. If there is no evidence to support an alternative scenario, state whether it is more likely that relevant evidence was missed or simply not present. If digital evidence was altered after it was collected, it is crucial to mention this in the report, explaining the cause of the alterations and weighing their impact on the case (e.g., negligible or severe).

Two similar scenarios are presented here to demonstrate that apparently minor differences in the circumstances can lead to significantly different conclusions, with different levels of certainty.

EXAMPLES

Conclusion 1

At 17:57 EDT on 05/16/2005, shortly after the incriminating activities occurred on the computer, Evidence Eliminator appears to have been run. Although Jack Smith and Jane Doe were the primary users of this computer, a password was not required and it was in a location that was accessible to many people in the building. Evidence Eliminator was run at a time when both Mr. Smith and Ms. Doe were at another location and could not have accessed the computer remotely. The subject computer does not maintain a record of clock changes and there is no evidence to prove or disprove that the clock was tampered with. It is possible that Mr. Smith or Ms. Doe changed the computer clock to make it appear that Evidence Eliminator was run at a time when they would not be implicated. It is also possible that an unknown third party accessed the computer and ran Evidence Eliminator.

Conclusion 2

Although Evidence Eliminator appears to have been run on the subject computer shortly after the incriminating activities occurred on the computer at 17:57 EDT on 05/16/2005, there is evidence that the clock was tampered with. Based on temporal discontinuities in the Windows Event log, Evidence Eliminator was actually run at 11:45 that morning. Jack Smith and Jane Doe were the primary users of this computer, and they each had their own username and password. Windows Event logs show that Jane Doe's account was used to log into the computer at 11:24 on the date in question and logged out at

11:50. The computer was located in a room that required a key card to access, and the security logs show that Jane Doe's card was used to access the room at 11:20. Furthermore, security cameras show Jane Doe walking through the hall leading to the room at 11:19 and walking away from the room at 11:53. Therefore, it was almost definitely Jane Doe who committed the crime, altered the clock, and ran Evidence Eliminator on the subject computer.

ATTRIBUTION USING DIGITAL EVIDENCE

Digital evidence can play a direct role in identifying and apprehending offenders, helping investigators establish linkages between people and their online activities. This attribution process can be challenging using digital evidence alone, but when combined with traditional investigative techniques, these data can provide the necessary clues to track down criminals. For instance, a lead developed during a serial homicide investigation in St. Louis when a reporter received a letter from the killer. The letter contained a map of a specific area with a handwritten "X" to indicate where another body could be found. After investigators found a skeleton in that area, they inspected the letter more closely for ways to link it to the killer. The FBI determined that the map in the letter was from Expedia.com and immediately contacted the site to determine if there was any useful digital evidence. The Web server logs on Expedia.com showed that only one IP address (65.227.106.78) had accessed the map around May 21, the date the letter was post-marked. The ISP responsible for this IP address was able to provide the account information and telephone number that had been used to make the connection in question. Both the dial-up account and telephone number used to make this connection belonged to Maury Travis (Robinson, 2002).

In short, the act of downloading the online map included in the letter left traces on the Expedia Web server, on Travis's ISP, and on his personal computer. Investigators arrested Travis and found incriminating evidence in his home, including a torture chamber and a videotape of himself torturing and raping a number of women and apparently strangling one victim. Travis committed suicide while in custody and the full extent of his crimes may never be known.

In another case, Dartmouth professors Susanne and Half Zantop were stabbed in their homes with SOG Seal 2000 knives. Investigators tracked purchases of this type of knife through Internet sites, leading them to two local teenagers, James Parker and Robert Tulloch. A forensic examination of the boys' computers revealed that, after being interviewed by police, they contacted each other over AOL Instant Messenger and agreed to flee to California. Two knives were found in Tulloch's bedroom with blood matching the Zantops, and the boys were apprehended and confessed to the killings (CBS News, 2001).

However, attributing computer activities to a particular individual can be challenging. For instance, logs showing that a particular Internet account was used to commit a crime do not prove that the owner of that account was responsible, as someone else could have used the individual's account. Even when dealing with a specific computer and a known suspect, some investigative and forensic steps may be required to place the person at the keyboard and confirm that the activities on the computer were most likely those of the suspect. Considering the mobile telephone example at the beginning of this chapter (see Figure 17.1), it may only be possible for

the forensic examiner to state that the suspect's phone was used to send the victim an SMS message at 10:05 and that the suspect's phone was in the same vicinity as the victim at the time of the murder. Other evidence would be required to establish that the suspect was in possession of his phone at these times and to place him at the crime scene.

Attributing a crime to an individual becomes even more difficult when a crime is committed via an open wireless access point or from a publicly accessible computer, such as at an Internet cafe or public library terminal. In one extortion case, investigators followed the main suspects and observed one of them use a library computer from which incriminating e-mails had been sent (Howell, 2004; Khamisi, 2005).

Using evidence from multiple independent sources to corroborate each other and develop an accurate picture of events can help develop a strong association between an individual and computer activities. This type of reconstruction can involve traditional investigative techniques, such as stakeouts. For instance, a man accused of possessing child pornography argued that all evidence found in his home should be suppressed because investigators had not provided sufficient probable cause in their search warrant to conclude that it was in fact he, and not an imposter, who was using his Internet account to traffic in child pornography (*U.S. v. Grant*, 2000). During their investigation into an online child exploitation group, investigators determined that one member of the group had connected to the Internet using a dial-up account registered to Grant. Upon further investigation, they found that Grant also had a high-speed Internet connection from his home that was used as an FTP server—the type of file-transfer server required for membership in the child exploitation group.

Coincidentally, while tapping a telephone not associated with Grant in relation to another child pornography case, investigators observed that one of the participants in a secret online chat room was connected via Grant's dial-up account. Contemporaneous surveillance of the defendant's home revealed that both his and his wife's car were parked outside their residence at the time. The court believed that there was enough corroborating evidence to establish a solid circumstantial connection between the defendant and the crime to support probable cause for the search warrant.

DIGITAL DOCUMENT AUTHENTICATION

The author of a document and the date it was created can be significant, as demonstrated in the Guthrie case described at the beginning of this chapter. In that case, the offender was not technically savvy enough to change his computer's clock to an earlier date to give the impression that the document was created prior to his wife's death. Such staging can make it more difficult to determine who wrote a document and when it was created. However, there are various approaches that forensic examiners can use to authenticate a digital document.

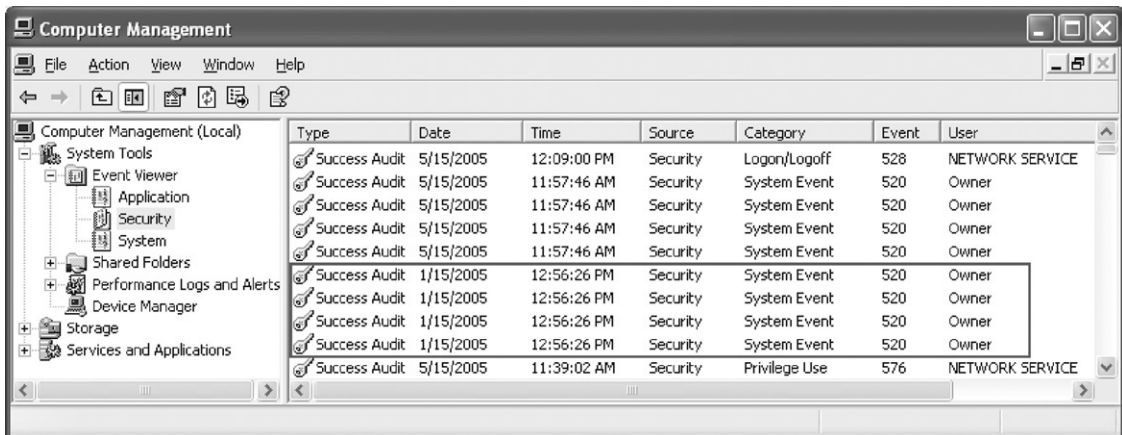
Forensic examiners can use date stamps on files and in log files to determine the provenance of a document such as a suicide note even when the digital crime scene is staged. For instance, it is possible to detect staging and document falsification by searching for chronological inconsistencies in log files and file date stamps. Nuances in the way computers maintain different date stamps can help forensic examiners reconstruct aspects of the creation and modification of a document. In addition, certain types of files, such as Microsoft Word, contain embedded

information that can be useful for authenticating a document. This embedded information may include the last printed date and the last 10 file names and authors, as shown previously.

EXAMPLE

According to Joe Smith, he created the questioned document in January 2005. However, dates associated with this document show that it was actually created in May 2005 and subsequently backdated to January. This fact is supported by dates in file slack of this document from April 2005 and by dates in a temporary copy created while the document was being edited using Microsoft Word in May 2005. Furthermore, Windows Security Event log entries from May 2005 show that the clock was backdated to January 2005 and subsequently returned to the correct date (Figure 17.3). In conclusion, the questioned document was created in May 2005 and not in January as claimed by Joe Smith.

The arrangement of data on storage media (a.k.a. digital stratigraphy) can provide supporting evidence in such forensic examinations. For instance, when a forensic examiner finds a questioned document that was purportedly created in January 2005 lying on top of a deleted document that was created in April 2005, staging should be suspected because the newer file should not be overwritten by an older one. Although the usefulness of digital stratigraphy for document authentication can be undermined by some disk optimization programs that reposition data on a hard drive, it can also be aided by the process. In one case, the suspect defragmented his hard drive prior to fabricating a document. The forensic examiner determined that the defragmentation process had been executed in 2003, causing all data on the disk to be reorganized onto a particular portion of the disk. The questioned documents that were purportedly created in 1999 were the only files on the system that were not arranged neatly in this area of the disk, which added weight to the conclusion that the questioned documents were actually created after the defragmentation process had been executed in 2003 (Friedberg, 2004).



Type	Date	Time	Source	Category	Event	User
Success Audit	5/15/2005	12:09:00 PM	Security	Logon/Logoff	528	NETWORK SERVICE
Success Audit	5/15/2005	11:57:46 AM	Security	System Event	520	Owner
Success Audit	5/15/2005	11:57:46 AM	Security	System Event	520	Owner
Success Audit	5/15/2005	11:57:46 AM	Security	System Event	520	Owner
Success Audit	5/15/2005	11:57:46 AM	Security	System Event	520	Owner
Success Audit	1/15/2005	12:56:26 PM	Security	System Event	520	Owner
Success Audit	1/15/2005	12:56:26 PM	Security	System Event	520	Owner
Success Audit	1/15/2005	12:56:26 PM	Security	System Event	520	Owner
Success Audit	1/15/2005	12:56:26 PM	Security	System Event	520	Owner
Success Audit	5/15/2005	11:39:02 AM	Security	Privilege Use	576	NETWORK SERVICE

FIGURE 17.3 Windows Security Event log from May 2005 contains entries with January date stamps, indicating that the clock was backdated.

EVALUATION OF SOURCE

Different file formats have characteristics that may be associated with their source. As shown previously, Microsoft Office documents contain embedded information, such as printer names, directory locations, names of authors, and creation/modification date-time stamps, that can be useful for determining their source. These embedded characteristics can be used to associate a piece of evidence with a specific computer. Earlier versions of Microsoft Office also embedded a unique identifier in files, called a globally unique identifier, which can be used to identify the computer that was used to create a given document (Leach and Salz, 1998). More subtle evaluations of source involve the association of data fragments with a particular originating file or determining if a given computer was used to alter a piece of evidence.

When a suspect's computer contains photographs relating to a crime, it may not be safe to assume that the suspect created those photographs. It is possible that the files were copied from another system or downloaded from the Internet. Forensic analysis of the photographs may be necessary to extract class characteristics consistent with the suspect's digital camera or flatbed scanner. The scanner may have a scratch or flaw that appears in the photographs or the files may contain information that was embedded by the digital camera, such as the make and model of the camera and the date and time the photograph was taken. This embedded metadata could be used to demonstrate that a photograph was likely taken using a suspect's camera rather than downloaded from the Internet.

If these kinds of metadata are not available in a digital photograph, it may be possible to use other characteristics of a photograph to determine its source. For instance, Europol's Excalibur system uses image recognition technology to search a database of photographs from past investigations for similarities with a given image. If two photographs contain a common component, such as a piece of fabric with a distinct design, this may indicate that they were taken in the same place, providing investigators with a lead.

If incriminating files found on a computer were downloaded from the Internet, investigators may want to locate the originating computer and search it for evidence relating to the crime. This can involve reconstructing the computer user's Internet activities to determine where the files were obtained. It may also be necessary to examine e-mail headers, logs, and other artifacts of network activity to determine where digital evidence came from.

ASSESSING ALIBIS AND STATEMENTS

Offenders, victims, and offenders may mislead investigators intentionally or inadvertently, claiming that something occurred or that they were somewhere at a particular time. By cross-referencing such information with the digital traces left behind by a person's activities, digital evidence may be found to support or refute a statement or alibi. In one homicide investigation, the prime suspect claimed that he was out of town at the time of the crime. Although his computer suffered from a Y2K bug that rendered most of the date-time stamps on his computer useless, e-mail messages sent and received by the suspect showed that he was at home when the murder occurred, contrary to his original statement. Caught in a lie, the suspect admitted to the crime.

As another example, data relating to mobile telephones were instrumental in the conviction of Ian Huntley for the murder of Holly Wells and Jessica Chapman in the United Kingdom. The last communication from Jessica's mobile phone was sent to a cell tower several miles away in Burwell rather than a local tower in Soham (BBC, 2003). The police provided a mobile telephone specialist with a map of the route they thought the girls would have taken, and the specialist determined that the only place on that route where the phone could have connected to the cell tower in Burwell was from inside or just outside Huntley's house (Summers, 2003). In addition, Huntley's alibi was that he was with his friend Maxine Carr on the night the girls went missing, but Carr's mobile phone records indicated that she was out of town at the time.

Investigators should not rely on one piece of digital evidence when examining an alibi: they should search for an associated cybertrail. On many computers, minimal skills are required to change the clock or the creation time of a file. Also, people can program a computer to perform an action, such as sending an e-mail message, at a specific time. In many cases, scheduling events does not require any programming skill—it is a simple feature of the operating system. Similarly, IP addresses can be changed and concealed, allowing individuals to pretend that they are connected to a network from another location. In addition, the location information associated with mobile telephones is not exact and does not place an individual at a specific location. As noted previously, it can also be difficult to prove who was using the mobile telephone at a specific time, particularly when telephones or subscriber identity module cards are shared among members of a group or family.

DETERMINING MOTIVATION AND INTENT

Clear evidence of intent, such as an offender's diary, may be found on a computer. Other pieces of digital data might not be useful on their own, but patterns of behavior can emerge when the pieces of digital evidence are combined with other information about a person's actions. Examples of this were observed in Shipman's modification of patient records and in Guthrie's Web searches described at the beginning of the chapter. In another case, prosecutors upgraded the charge against Robert Durall from second-degree to first-degree murder based on Internet searches found on his computer with key words including "kill + spouse," "accidental + deaths," "smothering," and "murder" (Johnson, 2000). In child exploitation cases, an offender's computer may contain evidence of soliciting and grooming victims over the Internet.

In David Westerfield's homicide trial, the prosecution claimed that Westerfield's digital pornography collection reflected his fantasies relating to kidnapping and killing 7-year-old Danielle van Dam and, in closing arguments, insinuated that the pornography motivated Westerfield to victimize the child (*California v. Westerfield, 2002*):

Not only does he have the young girls involved in sex, but he has the anime that you saw. And we will not show them to you again. The drawings of the young girls being sexually assaulted. Raped. Digitally penetrated. Exposed. Forcibly sodomized. Why does he have those, a normal 50-year-old man? Those are his fantasies. His choice. Those are what he wants. He picked them; he collected them. Those are his fantasies. That's what gets him excited. That's what he wants in his collection. . . . When you have those fantasies, fantasies breed need. He got to the point where it was growing and growing and growing. And what else is there to collect? What else can I get excited about visually, audibly?

Forensic examinations of computers can reveal other behavior that can be very useful for determining intent. For instance, evidence of clock tampering may enable a forensic examiner to conclude that the computer owner intentionally backdated a digital document. Also, disk cleaning or encryption programs on a computer can be used to demonstrate a computer owner's conscious decision to destroy or conceal incriminating digital evidence. However, these same actions may have innocent explanations and must be considered in context before reaching a definitive conclusion.

CONCLUSION

Digital evidence can help answer many questions in an investigation, ranging from the whereabouts of a victim at a given time to the state of mind of the offender. Therefore, evidence on computers and networks should be included whenever feasible in crime reconstructions. At the same time, care must be taken when interpreting the abstracted behavioral evidence that is stored on computers. People use technology in creative ways that can complicate the reconstruction process, particularly when attempts are made to conceal digital evidence. Computers also have many subsystems that interact in ways that can complicate the reconstruction process. In all cases, given the malleability and multivalent nature of digital evidence, it is necessary to seek corroborating evidence from multiple independent sources. The risk of missing or misinterpreting important details highlights the importance of utilizing the scientific method to reach objective conclusions that are solidly based on the evidence.

SUMMARY

Digital evidence is defined as any data stored or transmitted using a computer that support or refute a theory of how an offense occurred or that address critical elements of the offense, such as intent or alibi. Homicide, sexual assault, and other violent crimes can involve digital evidence from a wide range of sources, including personal computers, handheld devices, servers, and the Internet, helping investigators reconstruct events and gain insight into the state of mind of individuals. A basic knowledge of these, and how they operate, is required for a complete investigation and reconstruction.

Computers and networks should be considered an extension of the crime scene, even when they are not involved directly in facilitating the crime. It is useful to think of them as secondary crime scenes. Like a physical crime scene, digital crime scenes can contain many pieces of evidence, and it is necessary to apply forensic principles to preserve, document, and search the entire scene. A single computer can contain e-mail communications between the victim and the offender, evidence of intent to commit a crime, incriminating digital photographs taken by the offender as trophies, and software applications used to conceal digital evidence. Digital evidence that is handled and interpreted properly can be used to apprehend offenders, authenticate documents, assess alibis and statements, and determine intent.

Information stored and created on computers can be used to answer fundamental questions relating to a crime, including what happened when (sequencing), who was responsible (attribution), and the origination of a particular item (evaluation of source). At the same time, the

complexity of computer systems requires appreciation that individual pieces of digital evidence may have multiple interpretations, and corroborating information may be vital to reaching a correct conclusion. Forensic examiners need to understand, and make regular use of, the scientific method to ensure that conclusions reached are based solidly in fact. Familiarity with the limitations of forensic examinations of digital evidence will help investigators and attorneys exculpate the innocent and apprehend modern criminals.

QUESTIONS

1. Define digital evidence.
2. Explain what a cybertrail is and how it is useful in reconstruction efforts.
3. Computers and networks can be thought of as _____ of crime scenes.
4. The act of turning on and operating a computer destroys useful evidence and makes it more difficult to reconstruct the crime. True or false?
5. List one source of error that may occur in digital evidence between the time data are created by a system and the time of preservation and analysis of the evidence.

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Crime Reconstruction

Expert Testimony and the Law

Craig M. Cooley

In order to preserve the integrity of the criminal justice system . . . particularly in the face of rising nationwide criticism of forensic evidence in general . . . state courts . . . must . . . cull scientific fiction and junk science from fact. —**Ramirez v. State [810 So. 2d 836, 853 (Fla. 2001)]**

Time after time it was the expert witness, learned or ignorant in forensic medicine, careful or perfunctory, concerned or casual, who in effect determined whether the accused perished on the gallows, were transported for forced labor in the colonies, or went free. —**Forbes (1985, pp. 1–2)**

Key Terms

CSI effect; *Daubert v. Merrell Dow Pharmaceuticals, Inc.*; Forensic fraud; *Frye v. United States*; *Kumho Tire Co. v. Carmichael*

Forensic science, in the broadest sense, is the “application of scientific principles and technological principles to the purposes of justice in the study and resolution of criminal, civil, and regulatory issues” (Sapir, 2002, p. 2). In particular, forensic science attempts to uncover the actions or happenings of an event, typically a crime, by way of (1) identification (categorization), (2) individualization, (3) association, and (4) reconstruction of the physical evidence (Inman and Rudin, 2000, pp. 75–79). For more than a century, prosecutors, defense attorneys, and trial judges have relied heavily on these four aspects of forensic science to help establish a criminal defendant’s guilt or innocence (Mitchell, 1911; Thorwald, 1964). From Alphonso Bertillon’s system of anthropometry (Bayle, 1931; Rhodes, 1956) to the present-day utilization of DNA technology (Connors et al., 1996; National Institute of Justice, 2002), the legal system has faithfully called upon forensic scientists, including reconstructionists, to help answer the questions that beset our criminal justice system. To the forensic community’s credit, history has shown that even complex evidentiary issues can be answered when qualified and ethical forensic scientists using validated methods, techniques, and technologies examine physical evidence.

Although reconstructionists and other forensic examiners are influential players in the criminal justice system, their roles at trial and subsequent expectations regarding their findings have rapidly evolved during the past 20 years, principally in the past decade. This evolution can be directly linked to a number of factors, but there are two in particular: the DNA revolution and the *Daubert* insurgency in regard to admitting expert testimony at trial. This chapter's primary objective is to educate the reconstructionist as to how these revolutionary changes and other converging circumstances have transformed the various forensic science working environments and how they will continue to impact the nature of reconstruction methods and courtroom presentations. It also recommends specific reforms vital to the reconstructionist's survival as an expert forensic witness.

It is important to understand that this chapter is written from the perspective of a practicing defense attorney who also holds a number of advanced forensic credentials. It is therefore not an uninformed shot at the forensic community, nor is it intended to help zealous advocates unilaterally bar all forensic experts from court testimony. Rather, it is meant to realistically educate the reconstructionist regarding the nature and measure of the toughest challenges that will confront his or her evidence at the gates of the court in its attempt to screen for fraud and error.

If the reconstructionist believes that he has a firm grasp of all relevant courtroom issues and that he is well prepared to answer challenges from any of the lions at the gate of expert testimony, then the author understands why he may not be inclined to read further. However, if the reconstructionist believes that this is an area in which he lacks preparedness or in which he wishes to do better by virtue of advancing his craft through good scientific practice, then he is encouraged to read on.

FORENSIC SCIENCE UNDER SCRUTINY

For much of the 20th century, judges, prosecutors, and attorneys infrequently scrutinized the individualizing and reconstructive claims and qualifications of forensic experts.¹ Although various reasons subsist as to why these legal actors did not challenge such evidence forcefully and repeatedly, it is undeniable that this lack of scrutiny has permitted the forensic community to operate below the radar. Left unchecked by the courts, too many in the forensic community have grown and evolved believing that they are immune to error, and therefore free from it. Subsequently, there have been more than a few forensic examiners, and disciplines, that have felt justified in portraying themselves as essentially infallible.² This portrayal has, in turn, perpetuated the apathetic approach that courts, prosecutors, and defense attorneys have historically taken. These circumstances have also fostered an unsettling and nonscientific atmosphere in which much of the forensic community does not feel obligated to conduct research and

¹ Berger (1994, p. 1353) noted that "considerable forensic evidence made its way into the courtroom without empirical validation of the underlying theory and/or its particular application."

² This campaign continued into the early 1990s with DNA technology. As Professor William C. Thompson and Dan E. Krane (2004, p. 68) note, "Promoters of forensic DNA testing have done a good job selling the public, and even many defense attorneys, on the idea that DNA tests provide a unique and infallible identification." Even in the face of rising criticism stemming from notable misidentifications (e.g., Brandon Mayfield and Stephen Cowans), the fingerprint community's infallibility campaign seems stronger than ever (see Cole, 2005).

substantiate the certainty of their claims.³ Moreover, these circumstances have created a culture in which forensic examiners feel justified in attesting to statistics, reenactments, and interpretations that often have little, if any, foundation in science or logic. Until recently, the defense community, which is in no small part responsible for checking the findings of state forensic personnel, has taken little notice of this.

The winds of change have been accelerating steadily during the past decade, as an increasing number of legal actors (e.g., defense attorneys, judges, and scientists) have started to investigate and question the accuracy of forensic methodologies, as well as the nature of testimony regarding evidence interpretations. There are at least eight reasons why this tidal wave of scrutiny has come crashing down on the forensic community, including the following:

- The advent of DNA technology
- Noticeable correlation between forensic misidentifications and wrongful convictions
- Crime lab crisis
- Escalating discovery of forensic fraud
- Escalating discovery of forensic incompetence
- The media's impact on potential jurors
- Increased forensic awareness of criminal defense attorneys
- Daubert* revolution in regard to the admission of expert testimony

Reconstructionists are obligated to understand the context of these items because they affect their work directly. This section therefore provides a discussion of the issues and their interrelation.

DNA Technology and DNA Wars

The advent of DNA technology was (and has been) a double-edged sword for the forensic science community. Although DNA represents an individualizing technique that has a legitimate foundation in science, it has inadvertently exposed the forensic community's many shortcomings. Despite the aforementioned century-long public relations pitch that proclaimed that forensic techniques were infallible and premised on established scientific principles, it has become clear that neither is true. This undisclosed reality began surfacing when DNA scientists were hired by defense attorneys to litigate the "DNA wars" of the late 1980s and early 1990s (Thompson, 1993). Defense attorneys, along with trial courts, learned that Ph.D.-educated geneticists and DNA experts approached forensic issues, particularly the question of individuality, in a radically different manner from "police scientists" (e.g., fingerprint, tool mark, and handwriting examiners). Instead of approaching forensic issues (e.g., individuality) in an experience-based, binary manner ("it is a match or it is not a match because my experience says so"), these scientists relied on statistics and controlled empirical proficiency studies to qualify their opinions as to whether a DNA sample from a crime scene could have originated from a particular criminal defendant. This new approach to dealing with associative forensic evidence, in which actual scientists provide qualified probabilistic opinions premised on hard research and

³ Schwartz (2005) noted that "the discipline of firearms and tool mark examination has not developed the requisite statistical empirical foundations for identity claims." Srihari and colleagues (2002, p. 856) stated, "The individuality of writing in handwritten notes and documents has not been established with scientific rigor."

experimentation, led many legal commentators and observers to question why police scientists had yet to endorse such an approach.⁴

This was the time when defense attorneys, and the courts, began to attenuate themselves to the differences between science, reconstructions based on scientific evidence, and evidentiary interpretations based merely on unchallenged or unqualified examiner experience.

Forensic Misidentifications and Wrongful Convictions

Aside from revealing a persistent lack of actual science and scientific methodology in the forensic identification sciences, the DNA revolution unquestionably debunked the notion of forensic examiner infallibility.⁵ To date, there have been at least 182 convictions thrown out

⁴ [Saks and Koehler \(1991\)](#) comment on the stark difference between the DNA community and the “police sciences.” For example, consider how the Florida Supreme Court described this binary, experienced-based process:

The State’s experts testified that an identification under this procedure is a subjective judgment that is based entirely on the examiner’s experience and training. For instance, at the Frye hearing below, Hart testified as follows [*Ramirez v. State*, 810 So. 2d 836, 851 n.45 (Fla. 2001)]:

THE COURT: But it is not—you keep using the word criterion, but from what you are telling me, there isn’t a criterion. There is a sense that you have enough training, you look at it and you say this is a match, this is not a match. Is that it?

THE WITNESS: Basically that is correct. There is not a numerical count score. . . .

⁵ The “infallibility” claim is still made routinely by publicly employed forensic examiners. See, for example [Koehler \(1993\)](#), quoting a number of similar statements from DNA analysts), *United States v. Crisp*, 324 F.3d 261, 268 n.4 (4th Cir. 2003) (“Brannan, the [Government’s] fingerprint expert, testified to achieving perfect scores on all of her proficiency tests.”); *United States v. Havvard*, 260 F.3d 597, 599 (7th Cir. 2001) (“[FBI examiner] Meager . . . testified that the error rate for fingerprint comparison is essentially zero.”); *United States v. Ewell*, 252 F. Supp. 2d 104, 113 (D.N.J. 2003) (“The [FBI] has demonstrated the scientific method [of DNA analysis] has a virtually zero rate of error.”); *United States v. Sullivan*, 246 F. Supp. 2d 700, 703 (E.D. Ky. 2003) (noting that the FBI examiner “asserts that the rate of error for the ACE-V methodology is essentially zero.”); *United States v. Lewis*, 220 F. Supp. 2d 548, 554 (S.D.W.Va. 2002) (“There were aspects of Mr. Cawley’s testimony that undermined his credibility. Mr. Cawley testified that he achieved a 100% passage rate on the proficiency tests that he took and that all of his peers always passed their proficiency tests. Mr. Cawley said that his peers always agreed with each others’ results and always got it right.”); *United States v. Allen*, 207 F. Supp. 2d 856, 862 (N.D. Ind. 2002) (“[Examiner] Vanderkolk testified that the error rate of the [footprint identification] process . . . is zero.”); *United States v. Llera Plaza*, 179 F. Supp. 2d 492, 511 (E.D. Pa. 2002) (“[Fingerprint Examiner] Meagher’s response to the question whether ‘you have an opinion as to what the error rate is for the work that you do, latent print examinations’: ‘As applied to the scientific methodology, it’s zero.’”); *United States v. Trala*, 162 F. Supp. 2d 336, 347 (D.Del. 2001) (“The FBI methodology has been developed to result in a zero error rate within acceptable measurement error conditions (error being understood as yielding an incorrect result), if the methodology is followed and properly calibrated instruments are used.”); *United States v. Gaines*, 979 F. Supp. 1429, 1437 (S.D. Fla. 1997) (“Dr. Tracey testified that he was familiar with some of the proficiency tests that had been performed on FBI agents and examiners in other laboratories, and that all of the FBI proficiency tests with which he was familiar were error-free.”); *United States v. Peters*, 1995 U.S. Dist. LEXIS 20950 *54 (D.N.M.) (“Dr. Budowle testified that the FBI lab’s error rate for declaring false positives or false negatives is zero.”); *State v. Proctor*, 595 S.E. 2d 480, 482 (S.C. 2004) (“[South Carolina Law Enforcement Division lab] produced an affidavit from SLED Lt. Ira Jeffcoat that outlined the general test procedures, and stated that the SLED examiners have never made an incorrect ‘match’ in any proficiency test.”); *State v. Payne*, No. 02AP-723, 2003 WL 22128810, at 13 (Ohio Ct. App. Sept. 16, 2003)

or overturned because postconviction DNA tests conclusively exonerated a previously convicted felon or cast such doubt on the State's case that the State moved to have the defendant released and all charges dismissed.⁶ Although a certain number of these flawed convictions stemmed from eyewitness misidentification (Kooosed, 2002), false confessions (Drizin and Leo, 2004), jailhouse snitches (Zimmerman, 2001), and incompetent defense counsel (Scheck et al., 2001), a perceptible correlation has surfaced between these cases and forensic misidentifications (Cooley, 2004a). Of these problems with physical evidence, Dr. Michael J. Saks (2001, p. 423), legal evidence expert and professor of law and psychology at the Arizona State University College of Law, notes:

If the criminal justice community and the public were startled to learn that numerous innocent people were convicted of serious crimes and sentenced to long terms of imprisonment and sometimes even to execution, they will be even more surprised to learn that *forensic science has played a large part in those erroneous convictions*.⁷

In many of these cases, forensic identification examiners or police scientists offered opinions that were later proven to be inaccurate by DNA evidence (see www.law-forensic.com, which lists and discusses many of the wrongful conviction cases). For instance, scores of convicted defendants, who were originally linked to a victim or crime scene by way of microscopic hair analysis, garnered their freedom when DNA tests on the hair conclusively excluded them or the victim as the donor.⁸ Likewise, an increasing number of defendants who were initially

(quoting a fingerprint examiner's testimony that "the error rate [of fingerprinting] is essentially zero"); *Ramirez v. State*, 810 So. 2d 836, 851 (Fla. 2001) (noting that the State's tool mark expert in a death penalty case "testified that the method [of tool mark identification] is infallible, that it is impossible to make a false positive identification."); *Commonwealth v. Teixeira*, 662 N.E. 2d 726, 728 (Mass. App. Ct. 1996) (noting that Agent Quill testified "that the error rate was reduced to zero by reason of his lab's method of multiple-sample [DNA] analysis."); *State v. Jones*, 922 P.2d 806, 809 n.1 (Wash. 1996) (crime lab examiner "testified that the Washoe County laboratory is subject to external blind tests and proficiency testing and presently has a tested lab error rate of zero."); *Commonwealth v. Blasioli*, 685 A.2d 151, 165 n.29 (Pa. Sup. Ct. 1996) (crime lab director "testified that the Pennsylvania State Police lab had an error rate of zero: No errors had ever been detected."); *State v. Johnson*, 905 P.2d 1002, 1012 (Ariz. 1995) ("[State's DNA expert] testified that the laboratory had undergone several proficiency tests and that its laboratory error rate was currently zero."); *Hicks v. State*, 860 S.W. 2d 419, 423 (Tex. Crim. App. 1993) ("Dr. Kevin McElfresh, Ph.D. . . . testified . . . that the [RFLP] procedures utilized had the ability to exclude suspects absolutely and that a false positive result was impossible."); *People v. Wesley*, 589 N.Y.S. 2d 197, 200 (N.Y. App. Div. 1992) ("It was unrefuted that it is impossible under the RFLP procedure to obtain a false positive result, i.e., to identify the wrong individual as the contributor of the DNA being tested."); *People v. Shi Fu Huang*, 546 N.Y.S. 2d 920, 921 (N.Y. Crim. Ct. 1989) ("Dr. Baird [the State's DNA expert] testified that it is impossible to get a false positive reading. Environmental effects could at worst result in 'no result,' but never in a false positive reading."); *Cobey v. State*, 559 A.2d 391, 392 (1989) ("[A]n incorrect match is an impossible result.").

⁶ See Cardozo Law School's Innocence Project at www.innocenceproject.org (accessed July 15, 2006); Gross et al. (2005) (noting that of the 328 exonerations between 1989 and 2003, 145 were exonerated with DNA analysis).

⁷ Possley and associates (2004, p. 1) noted, "A [Chicago] Tribune examination of the 200 DNA and death row exoneration cases since 1986—including scores of interviews and a review of court transcripts and appellate opinions—found that more than a quarter involved faulty crime lab work or testimony."

⁸ Connors and colleagues (1996) noted that out of 28 erroneous convictions, 6 had hair comparison testimony supporting the original conviction.

associated to a victim via bite mark identifications have walked free from prison due to DNA technology, which is able to test the cells transferred to the victim from the offender's mouth during the act of biting via saliva.⁹

More notably, fingerprinting and DNA analysis, the gold standards of forensic science, have not been immune from acting as causal agents in erroneous convictions. Three of the more noteworthy wrongful conviction and accusation cases of the recent past have dealt with fingerprint and DNA evidence (Liptak, 2003a; Saltzman and Daniel, 2004; Stacey, 2005a). The Brandon Mayfield misidentification (discussed later), for example, has been dubbed by some as "the most highly publicized fingerprint error ever exposed" (Cole, 2005, p. 985). These cases make clear that "[b]old statements or broad hints that [forensic] testing is infallible . . . are not only irresponsible, they border on scientific fraud" (Burk, 1990, p. 80). As Professor Max Hirschberg (1940, p. 34) noted more than 60 years ago, "A real student of science is too well aware of the fallibility of scientific knowledge to presume infallibility, while a charlatan tries to force his infallibility on his public." His cautionary words have never been more appropriate.

It should be noted that the overwhelming majority of exonerations, DNA or otherwise, are noncapital. However, noncapital cases infrequently suffer the consistent level of appellate attention or postconviction review afforded capital cases for lack of funds and lack of exigency. Given this state of affairs, one is led to surmise that if the DNA lens could be pointed at more of the identifications in noncapital convictions, the frequency of exonerations might just explode.

The reconstructionist has a duty to understand the limits of her evidence and not extend her interpretations beyond established science (as discussed thoroughly in Chapters 2–4). This should include a refusal to render conclusions that prefer to sell an image of forensic infallibility and certainty. It should also include a willingness to admit the historical existence and current possibility of error and to further embrace the necessary component of independent peer review required to uncover it. That the courtroom has two sides is not an accident—it is by design.

The Crime Lab Crisis

Another reason why the forensic community is under intense scrutiny is that there has been persistent trouble with "one of the foundations of the modern criminal justice system—the crime lab" (Tanner, 2003, p. A18).¹⁰ As discussed in the Preface and in Chapter 3, during the past

⁹ For instance, consider Dan Young Jr. and Harold Hill's cases. Young and Hill were convicted and sentenced to life in prison for raping and strangling Kathy Morgan in October 1991. The key piece of forensic evidence used to link Hill and Young to Morgan's murder were bite marks discovered on Morgan's body. According to the State's forensic odontologist (Dr. John Kenney), Hill and Young were responsible for the marks on Morgan. In closing arguments, a Cook County prosecutor told the jury, "The biggest piece of evidence that backs up [the State's theory], ladies and gentleman, is Dr. Kenney's testimony about the bite mark evidence" (Main, 2003, p. 12). When new DNA testing was performed in 2005, the results excluded Hill and Young as potential contributors. As a result, the Cook County state's attorney's office dropped all charges against Young and Hill (see Mills and Coen, 2005). See also Weinstein (2002), who discusses Ray Krone's wrongful capital conviction; Krone's capital conviction, like Dan Young Jr.'s and Harold Hill's, was premised on the testimony of a forensic dentist who opined that Krone's teeth marks matched a bite mark on the murder victim's breast. DNA tests in 2002, however, excluded Krone as a possible donor. Krone was released from prison in April 2002.

¹⁰ A *U.S. News & World Report* article commented, "In recent years, the integrity of crime labs across the country, including the vaunted FBI crime lab, has come under attack for lax standards and generating bogus evidence" (Roane, 2005, p. 48).

decade there have been numerous audits of publicly funded laboratory systems. These audits have repeatedly identified systemic problems within crime labs throughout the United States.¹¹ One fundamental issue can be traced back to many, if not all, of these problems—a pervasive lack of funding.¹² Inadequate funding prevents crime labs from performing the following necessary tasks and functions:

- Hiring a sufficient number of staff
- Hiring adequately educated staff
- Adequately paying current staff (which results in high turnover)
- Purchasing up-to-date technology
- Purchasing basic supplies and equipment
- Properly training both new and experienced lab examiners
- Implementing congressionally or statutorily mandated quality assurance programs¹³

The current state of U.S. crime labs, and their regular lack of qualified personnel, has forced Barry [Scheck \(2004, p. 4\)](#), defense attorney, DNA expert, and cofounder of the Innocence Project, to conclude:

¹¹ [Possley and colleagues \(2004, p. 1\)](#) noted, “Revelations of shoddy work and poorly run facilities have shaken the criminal justice system like never before, raising doubts about the reputation of labs as unbiased advocates for scientific truth.”

¹² [The National Institute of Justice \(2001, p. 55\)](#) noted, “Public crime laboratories historically have suffered from low funding.” For instance, in 1967, the President’s Commission on Law Enforcement and Administration of Justice (p. 255) commented that “the great majority of police department laboratories have only minimal equipment and lack highly skilled personnel able to use the modern equipment now being developed and produced by the instrumentation industry.” [A later commission concluded, “Too many police crime laboratories have been set up on budgets that preclude the recruitment of qualified, professional personnel” ([National Advisory Commission on Criminal Justice Standards and Goals, 1974](#)).]

¹³ [The National Institute of Justice \(2003, p. 2\)](#) states, “Most . . . crime labs lack sufficient numbers of trained forensic scientists. . . . State and local governments with shrinking budgets lack adequate resources to hire trained scientists.” [Martinez \(2002, p. 1\)](#) notes, “Massachusetts law enforcement teeters on the brink of disaster due to a seriously underfunded, understaffed, and overworked corps of state medical examiners and other forensic investigators.” [CBI Labs Need a Boost \(2002, p. E-6\)](#) discusses several reasons why evidence is stockpiling at the Colorado Bureau of Investigation’s crime laboratory; also arguing that “Gov. Bill Owens and the legislature should make increased CBI funding a priority so this crime-fighting organization can expand its inadequate staffing and facilities. That would be money well spent and send an unmistakable message to the bad guys.” [Bailey \(2003, p. E-06\)](#) discusses how the Alabama Department of Forensic Sciences has “a backlog of 9000 drug cases, 2000 DNA cases, 900 toxicology cases, and 500 firearms cases, a shortage of at least three forensic pathologists and a budget with about 2.5 million fewer dollars than last year’s.” [Silver and Lash \(2003, p. A-1\)](#) discuss how Pittsburgh’s crime laboratory has a DNA backlog of 350 cases, 1100 drug cases, 900 firearms cases, and 400 fingerprints cases because of inadequate funding. [Labs Hope to Get Funds Requested \(2003\)](#) notes that the Louisiana legislature approved a \$1 million appropriation for the Louisiana crime labs for 3 years, but the funding is not in the proposed state budget. [Upshaw \(2003, p. 1\)](#) discusses how Arkansas investigators have “been forced to rely mostly on old-fashioned police work to solve [cold murder cases] and other cases since the state crime laboratory shut down its mitochondrial DNA testing section earlier this year because of a lack of money.”

Everyone should know our crime laboratories are in a crisis, reeling from an epidemic of scandals reflecting decades of shoddy work, usually from bad actors producing incompetent or fraudulent results, but sometimes from methodologies that have been exposed as unreliable.

Although some may argue that Scheck's comments must be viewed through a cautious lens, given his allegiance to the criminal defense bar, it must be conceded that his position is actually reinforced by numerous high-ranking forensic practitioners and administrators. For instance, Milton E. Nix, director of the Georgia Bureau of Investigation's crime lab, admitted to Congress, "You may find this an unusual statement, but I am in total agreement with the National Association of Defense Attorneys when it comes to quality and accuracy of crime lab examinations and analysis" ("[Crime Lab Modernization](#)," 2001). Similarly, Barry Fisher, director of the Los Angeles County crime lab, made the following comment regarding the lack of crime lab oversight (as quoted in [Graham, 2001](#), p. 10): "I don't think anyone can tell you what's really going on [in the nation's crime laboratories]. . . . The truth is, we don't know."

Although we cannot know the entire picture, we do know that there are well-documented, recurring cases of forensic fraud, ineptitude, and error that have been steadily uncovered at the Federal Bureau of Investigation's (FBI) crime lab, and that's just since 1997 ([Associated Press, 2001](#); [Buchanan, 2003](#); "[The FBI Laboratory](#)," 1997; [Pitsch, 2003](#); [Solomon, 2003](#); [Willing, 2003](#)). Far from being the exception, these same kinds of problems have also been identified and exposed across the numerous careers of individual examiners, and within more than a few major police laboratory systems. This includes publicly investigated crime labs and crime lab systems such as those in Washington,¹⁴ Oklahoma,¹⁵ Phoenix,¹⁶ Indianapolis,¹⁷ Texas,¹⁸ and Virginia.¹⁹

¹⁴ The *Seattle Post-Intelligencer* has conducted an in-depth investigation into the Washington State Patrol Crime Lab system, documenting recurring problems with poor oversight, DNA contamination, errors, and unqualified or discredited forensic personnel (see <http://seattlepi.nwsourc.com/specials/crimelab/>).

¹⁵ [Hamilton \(2001\)](#) discusses the systemic origins of the Joyce Gilchrist scandal, which spans at least 21 years and more than 1400 criminal cases. The *Oklahoman* also maintains a database of public documents regarding the ongoing investigation at <http://newsok.com/news/gilchrist>.

¹⁶ [Carroll and Sowers \(2003\)](#) note how Phoenix Police Department crime lab technicians have overstated the probability of a suspect's genetic material in at least nine criminal cases since 2001, resulting in the need to review hundreds of cases.

¹⁷ [Ryckaert \(2003\)](#) notes that at least 64 cases were called into question because a DNA technician bypassed crucial steps that would have verified the accuracy of his work. This has resulted in the need to review hundreds of cases.

¹⁸ As the result of an ongoing investigation into the Texas Department of Public Safety crime lab system, [Boyd \(2003\)](#) and [McDonald \(2002\)](#) note that a Fort Worth Police Department senior DNA analyst was fired for failing proficiency tests and for submitting a questionable and unsolicited DNA report that forced prosecutors to drop the death penalty in a case. So far the Office of the Independent Investigator, who maintains an archive of reports at <http://www.hpdlabinvestigation.org/>, has uncovered numerous instances of drylabbing, poor evidence storage, false or misleading testimony, and unqualified personnel. The *Houston Chronicle* also maintains an archive of public findings at <http://www.chron.com/content/chronicle/special/03/crimelab/>.

¹⁹ Virginia's crime laboratory has erred in at least three separate DNA tests in a capital case ([Dao, 2005](#)). According to an independent investigation by the American Society of Crime Laboratory Directors, the Virginia crime lab's internal review process was flawed and found that lab employees had felt pressured by their superiors, as well as the office of the governor, to produce quick results with bad evidence in high-profile cases. As a result of this

Add the astounding revelations brought to light by the Houston Police Department (HPD) crime lab investigation to this list as well. According to forensic experts, the HPD crime lab “has been something akin to a crime lab from hell for the past several years” (McVicker and Khanna, 2003, p. A15). The HPD crime lab services Harris County, which has the dubious distinction of being the county that has sent the most defendants to death row in the United States. At least 1000 cases, including approximately 20 death penalty cases, have been under review for approximately 2 years. In May 2005, the independent auditing team brought in to inspect the crime lab disclosed publicly that it had uncovered four separate incidences of “dry-labbing,” which is perhaps “the most egregious form of scientific misconduct that can occur in a forensic science laboratory” because it is essentially the “fabrication of scientific results” (Bromwich, 2005).

Far from being the case of a few bad apples spoiling the barrel, the crime lab crisis is nationwide, and it reflects a particularly negative image of the current state of forensic science.

Forensic Fraud and Incompetence

As suggested already, interwoven with the crime lab crisis are problems of forensic fraud and scientific incompetence. As former Illinois Governor George Ryan’s 2002 capital punishment commission report noted, “[I]n some highly publicized cases, it has been alleged that *incompetence and intentional misconduct* has resulted in defendants being accused or convicted of crimes they did not commit” (Report of the Governor’s Commission on Capital Punishment, 2002, p. 52). An analogous remark was made in Massachusetts Governor Mitt Romney’s 2004 death penalty council report: “Serious problems, including both inadvertent errors of omission and commission, as well as *deliberate and conscious acts of wrongdoing*, have arisen in crime laboratories, medical-examiner offices, and forensic-service providers around the country” (Report of the Governor’s Council on Capital Punishment, 2004, p. 24).

With respect to forensic fraud, a 2005 *U.S. News & World Report* article highlighted this recurring problem (Roane, 2005, p. 48): “Dozens of coroners, crime lab technicians, police chemists, forensic anthropologists, crime-reconstruction experts, and other forensic specialists . . . have been fined, fired, or prosecuted for lying under oath, forging credentials, or fabricating evidence.”

According to Paul C. Giannelli, a professor of law at Case Western Reserve University School of Law who has conducted and published extensive research on the subject of forensic experts and evidence, a number of “world-class fabricators have surfaced” within the forensic science community (Giannelli, 2002; see also Giannelli, 1997). Professor Giannelli’s sentiments are echoed by former FBI trace evidence examiner Max Houck, who says (as quoted in Roane, 2005, p. 48), “For some reason, the forensic sciences have always had their fair share of charlatans.”

audit, the crime lab was separated from the Department of Criminal Justice Services (law enforcement) and restructured under the auspices of Governor’s Secretary of Public Safety as the Department of Forensic Science. A laboratory audit report can be found at the Innocence Project’s Web site: www.innocenceproject.org/docs/VA_ASCLD_Audit_Report.pdf (accessed July 30, 2005).

Instances of forensic fraud during the past few decades have included fabricating fingerprints,²⁰ testifying to autopsies that were never performed,²¹ knowingly excluding information from a forensic report that is unmistakably exculpatory,²² providing knowingly false testimony,²³ testifying to forensic analyses that were never conducted (i.e., drylabbing),²⁴ data dredging,²⁵ testifying beyond the limits of acceptable science or beyond one's expertise,²⁶ and presenting testimony based on unsubstantiated techniques.²⁷ Similar to unintentional forms

²⁰ Roth (1997) details the largest fingerprint fabrication scandal in U.S. history. According to Charlie Stuart (as quoted in Midkiff, 2004, p. 67), former head of the New York State Police Troopers Union, New York State troopers fabricated evidence regularly: "There were a lot of fingerprints found in places where they never should have been found. . . . The feeling was, if you had a good suspect, it wouldn't hurt to have a few more things against him." In regard to the New York State Police fingerprint fabrication scandal, Stuart added, "They'll never get to the bottom of this, it's too big, it's too deep and it's been going on way too long." Gerald Aurenberg, executive director of the National Association of Chiefs of Police, reinforced Stuart's fabrication claims: "These things happen every single day on the street and if you don't believe that, you're living in a crystal palace" (as quoted in Hansen, 1994, p. 22). Well-respected fingerprint examiner Pat Wertheim "believes these cases number in the hundreds or even thousands" (Wertheim, 1994, p. 653; see also Geller et al., 1999).

²¹ Ralph Erdmann, the now discredited Texas forensic pathologist, immediately comes to mind (see Campbell, 1993). Fricker (1993, p. 46) quotes a law enforcement official as stating Ralph Erdman treated autopsies as if they were "kindergarten classes or show and tell."

²² Midkiff (2004, pp. 55–60) discusses Chicago Police Department crime lab forensic serologist Pamela Fish's willingness to exclude plainly exculpatory evidence from her lab reports. Herguth (2001, p. 5) states, "[Pamela] Fish . . . provided false or incomplete testimony in nine cases, including one involving Billy Wardell and Donald Reynolds, who were wrongly convicted of the 1986 rape of two University of Chicago students. They were exonerated through DNA testing." Possley (2000) suggests that Fish's misleading testimony presumably resulted in John Willis' wrongful conviction.

²³ Former FBI metallurgist Kathleen Lundy pled guilty to intentionally providing false testimony about the FBI's comparative bullet lead analysis technique in a Kentucky murder case (see Pitsch, 2003).

²⁴ Khanna and McVicker (2005) discuss how two Houston crime lab examiners drylabbed results in four cases. Maier (2002) discusses how a former Wisconsin State Police fingerprint analyst skipped tests and then claimed in his reports that he had conducted the tests. Osborne (2001) discusses how a former Texas Department of Public Safety crime lab analyst falsified fingerprint reports. Thornton (1997) discusses how a San Diego Police crime lab DNA analyst falsified reports.

²⁵ According to forensic evidence expert Gil Sapir (2002, p. 35), "All too often the [crime] laboratory [examiner] states a conclusion, then gets data to support it after being challenged, thereby supplying the facts post hoc."

²⁶ Joyce Gilchrist, once again, comes to mind. The Oklahoma Court of Criminal Appeals overturned Curtis Edward McCarthy's first-degree murder and death sentence because of Gilchrist's misconduct. According to the Court [*McCarty v. Oklahoma*, 2005 Okla. Crim. App. LEXIS 9, *11–12 (June 14, 2005)], Ms. Gilchrist, while acting as an agent of the State and in relation to her role as an expert in Petitioner's case, withheld evidence, most likely lost or intentionally destroyed important and potentially exculpable (or incriminating) evidence, provided flawed laboratory analysis and documentation of her work, testified in a manner that exceeded acceptable limits of forensic science, and altered lab reports and handwritten notes in an effort to prevent detection of misconduct; and . . . as a result of Ms. Gilchrist's actions, Petitioner did not receive a fair trial and resentencing proceeding.

²⁷ Drs. Michael West and Louise Robbins best exemplify this category. See Murr (2001), who questions Dr. West's dubious, and as yet substantiated, ability to identify imperceptible bite marks with an ultrablue light. Quade (2002) describes Dr. Robbins' remarkable ability to individualize indecipherable footprints or shoeprints.

of errors, forensic fraud has played a significant role in various wrongful conviction cases.²⁸ More significantly, however, when each new instance of forensic fraud has surfaced, it has further eroded an already diminished confidence in all the forensic sciences, and forensic institutions, regardless of whether the science is legitimate and the institution is competent.²⁹

Injustices originating from the forensic sciences and reoccurring crime lab scandals have also provided considerable evidence that an alarming percentage of forensic practitioners have a questionable understanding of science and the scientific method. For instance, according to David L. Grieve (2000, p. 148), one of the nation's top fingerprint examiners, an intolerable number of forensic practitioners are in fact scientifically illiterate:

What is usually not taught is the protocol of the scientific method, how to formulate a hypothesis, the prudent value in the formulation of a counter or null hypothesis, the way in which experimentation and comparative analysis are used to prove or disprove the stated theory and the means by which evaluation and validation are applied to the results. In short, students are usually not properly taught about sameness and difference, at least not in a way that enables them to understand what each truly is, how each is caused and to what extent each may be recognized.³⁰

Grieve's comments come on the heels of a similar opinion offered by forensic science pioneer (and cocontributor) Dr. John Thornton (1997a, pp. 484–485), who stated the following about the state of scientific awareness within the forensic science community:

Daubert may . . . serve a useful adjustive purpose for the forensic science profession. . . . Forensic scientists may be nudged in the direction of learning more about the scientific method. . . . Science is often viewed as a product rather than in terms of process, and it certainly couldn't hurt to have the forensic scientist more attentive to the process. I find that many forensic scientists, even those who are entirely competent in their profession, have an exceedingly poor grasp of what constitutes the scientific method. . . . [My experience] has convinced me that many, perhaps even most, forensic scientists are not just inattentive to the scientific method, but ignorant.

²⁸ See Cooley (2004a, pp. 401–408), who discusses forensic fraud problems and wrongful convictions, and Giannelli (2002), who discusses various forensic fraud wrongful convictions.

²⁹ For instance, see the Florida Supreme Court's comment (*Ramirez v. State*, 2001) regarding the increased skepticism of forensic science and examiners. Likewise, Inman and Rudin (2000, p. x) hit the nail on the head when they commented that the "reputation of the forensic science community has been significantly tarnished" because of these "unethical, unprofessional, and immoral acts."

³⁰ Only in the past decade have questions of forensic science competence and literacy been raised from within the forensic science community in a meaningful way. In 1999, for example, the NIJ sponsored a report into the general standing of the forensic community with respect to training, technology, methods, and quality of services. In the foreword, past ASCLD president Kevin Lothridge wrote (NIJ, 1999b, p. 1):

It has been more than 20 years since the last status and needs of the forensic sciences were studied. The need for a document that not only addressed the current challenges facing the forensic science profession, but offered possible solutions, became obvious.

This report spurred the NIJ's creation of the technical working group for education and training in forensic sciences and the AAF's creation of the Forensic Science Education Programs Accreditation Commission. As of this writing, these have yet to gain national acceptance or bear significant fruit.

In light of this mounting evidence, as well as permeation of the previous sentiments among legitimate forensic scientists, many prominent forensic practitioners are conceding that a number of purported forensic scientists are actually technicians,³¹ or nondegreed law enforcement officers, performing scientific functions without any actual science background.³² Unfortunately, it is common in the forensic science community to label any individual who works for a crime lab or handles evidence as a forensic scientist, despite the limits of their role or education.³³ For example, it is not only likely, but indeed usual, “that a person with a bachelor’s degree in chemistry, geology, biology, or other scientific discipline, has not had a single college lecture on precisely how the scientific method works” (Thornton and Peterson, 2002, p. 15).³⁴ This is to say nothing of the fact that a percentage of forensic technicians and police scientists have yet to obtain an undergraduate degree of any sort.³⁵ Thus, forensic science is not always being practiced by qualified forensic scientists, although their education or title may suggest otherwise.

Problems of forensic fraud and forensic incompetence arise most commonly from unchecked professional bias and scientific ignorance made worse by inadequate funding. These subjects have been discussed in previous chapters. Reforms that may help the reconstructionist address these issues are discussed later.

³¹ A scientist is a researcher devoted to the scientific method, which is “the persistent critique of arguments, in the light of tried canons for judging the reliability of the procedures by which evidential data are obtained, and for assessing the probative force of the evidence on which conclusions are based” (Nagel, 1961, p. 13). To guarantee objectivity, scientists regularly design “blind” tests to discover whether a certain outcome is a legitimate by-product of the expected amalgamation of variables or by the chance intrusion of an impurity. Technicians, however, “merely follow prescribed routines, and [are] not expected to understand their underlying fundamentals.” The technician “knows how, but not why” (Kirk, 1964, pp. 393–394). See also Kirk (1947, pp. 165–166), who states, “A technician is understood to be a person who is incapable of doing independent work but is skilled in the routine performance of laboratory operations according to a predetermined routine established and supervised by others.” As Professor Moenssens (1993, pp. 5–6) also explained, “[Technicians] have been taught to use the complex instruments, such as the infrared spectrophotometer, or the gas chromatograph, or a whole host of other delicate scientific apparatus or even “simple” breathalyzers, as “bench operators” who have only a superficial understanding of what the instrument really does, and how the read-out is generated.

³² Selavaka (2005, p. 74) states, “In our nation, most of the examinations for forensic purposes of fingerprinting and guns are performed by law enforcement officers, who were hired for one thing but became an expert in another.” Dr. Selavaka is the director of the Massachusetts State Police crime lab.

³³ The National Institute of Justice (2004, p. xi) states, “[N]ew hires who analyze drugs, DNA, trace, and toxicological evidence in forensic science laboratories typically have a degree in chemistry, biochemistry, biology, or forensic science” [see also Furton et al. (1994)].

³⁴ As one forensic science commentator noted, “While some have gone on to earn advanced degrees, possession of such a degree is usually not characteristic of the laboratory criminalist” (Lindquist, 1995, p. 64).

³⁵ The National Institute of Justice (2004, p. 8) reports that although forensic scientists involved in the recognition and comparison of patterns (such as latent prints, firearms, and questioned documents) historically may not have been required to have a degree, the trend in the field is to strengthen the academic requirements for these disciplines and require a baccalaureate degree, preferably in science.

CSI or CS-Lies? The CSI Effect

Forensic fraud and forensic incompetence may only intensify in the future in response to the so-called **CSI effect**. This is a “phenomenon in which actual investigations are driven by the expectations of the millions of people who watch fake whodunits on TV. It has contributed to jurors’ desire to see more forensic testimony from the stand” (Hempel, 2003, p. 13). In a Nielsen’s rating poll, 7 of the top 20 TV shows were premised on forensic investigations and courtroom dramas, meaning that more than 120 million viewers, many of whom are prospective jurors in criminal cases, watch these shows each week (Salmon and O’Brien, 2005). Regrettably, Hollywood’s portrayal of forensic science is far from accurate, as these “shows tend to embellish and exaggerate the science, ignore actual time lines for testing and raise expectations of the general public, law enforcement, and judicial system to an extremely absurd and totally unrealistic level” (Wecht, 2003, p. D03).

The CSI effect may exacerbate the forensic fraud problem in two respects. First, according to many prosecutors, the CSI effect has raised their burden of proof³⁶ to such an extent that it is “killing” legitimate prosecutions (Terrence Farley, a prosecutor in Ocean County, New Jersey, as quoted in Coscarelli, 2005).³⁷ For instance, the Delaware Supreme Court held that a trial judge abused his discretion when he failed to reprimand a prosecutor who complained to a jury that the standard for guilt was no longer “beyond a reasonable doubt.” The prosecutor argued that the new standard is “the TV expectation that [criminal defendants] hope folks like you want. Can they meet ‘C.S.I.’? If they don’t have fingerprints, he can’t be guilty. On TV, they would have found fingerprints. But this isn’t TV, this is real life” (*Boatswain v. State*, 2005 Del. LEXIS 168 at n.3; the error was ruled harmless because “the evidence introduced at trial produced overwhelming proof of guilt”).

The prosecutorial perception that these shows will or have already raised the prosecution’s burden of proof may cause otherwise ethical prosecutors to request or even demand the

³⁶ As an Illinois state’s attorney complained, these CSI-type shows “[project] the image that all cases are solvable by highly technical science, and if you offer less than that, it is viewed as reasonable doubt. . . . The burden it places on us is overwhelming” (Peoria County State’s Attorney Kevin Lyons as quoted in Roane, 2005, p. 48). Another prosecutor emphasized this concern by commenting, “The jurors’ expectations of criminal prosecutions have been altered by these shows. . . . They expect fingerprints. They expect all the DNA evidence. The prosecution has to bring the jury home in that what they see on ‘CSI’ does not typically happen in a real case” (Allegheny County Common Pleas Judge John Zottola as quoted in Newhouse, 2005). The most brazen prosecutorial disparagement of jurors came from Los Angeles District Attorney Steve Cooley, who called jurors “incredibly stupid” for acquitting Robert Blake (the actor) of murdering his wife. Mr. Cooley claimed that the jurors fell for the “C.S.I. effect” and said that the show “create[s] false expectations” (as quoted in Winton, 2005, p. 1). Andrew Blankstein and Jean Guccione (2005, p. A1) quote Joshua Marquis, an Oregon prosecutor and member of the board of directors of the National District Attorneys Association, as stating, “There is no doubt that there’s increasing expectation by jurors of [the evidence] they’re going to see. . . . Prosecutors across the country are very concerned about this.” McMahan (2005, p. 1A) states, “Prosecutors worry jurors develop impossibly high expectations about how easily and conclusively criminal cases can be solved with DNA analysis and other forensic science.”

³⁷ Some forensic watchdogs, conversely, take issue with this claim. Simon Cole, for instance, wrote that “to argue that ‘C.S.I.’ and similar shows are actually raising the number of acquittals is a staggering claim, and the remarkable thing is that, speaking forensically, there is not a shred of evidence to back it up” (Cole and Dioso, 2005).

unreasonable and the impossible from their crime scene investigators and forensic scientists (e.g., physical evidence or statistics that do not exist or that are minimally or greatly exaggerated). It is conceivable that this, in turn, may lead even the most objective and neutral crime scene investigator or forensic examiner to fabricate physical evidence or massage forensic reports to ensure that a murderer or child molester is not able to “walk” because the State’s case lacks the requisite CSI-type of evidence.³⁸ In the DNA era, such conduct can prove to be even more detrimental to innocent defendants because refuting an accurate DNA identification from a planted, fabricated, or misrepresented piece of physical evidence is difficult or even impossible.³⁹

Second, the entertainment media’s distorted representations of the forensic sciences (i.e., forensic science has all the answers and can deliver them fast) place the forensic community’s credibility in serious jeopardy in that jurors will be (and already are) more antagonistic toward forensic evidence and testimony that do not measure up to the images portrayed on shows such as *CSI* or *Crossing Jordan*. To blunt any potential attacks to their façade of infallibility, and to bolster their image to correspond with the public’s enhanced perception of forensic science, forensic examiners, on their own volition (and not at the behest of an aggressive attorney), may resort to

³⁸ Starrs (1985, p. 299) notes that “the pressures upon the expert to give the prosecutor or [law enforcement] what they want . . . is sometimes overpowering, even when to do so will convey the misleading notion that the impossible is, in fact, possible.”

³⁹ Consider Odell Barnes’ case in Texas. Barnes was convicted and sentenced to death for brutally murdering his next-door neighbor Helen Bass. The strongest pieces of physical evidence against Odell were two small bloodstains that were allegedly discovered on his overalls by forensic examiners from the Southwestern Institute of Forensic Science (SWIFS) in Dallas. Barnes, however, proclaimed his innocence from the very beginning and thus could not account for the two small bloodstains on his pants. Curious as to whether the blood evidence may have been planted by SWIFS lab examiners or someone else working for the prosecution, Barnes’ postconviction attorneys had portions of one bloodstain sent to blood-preservative expert Kevin Ballard. Ballard tested the spot of blood found on Barnes’ overalls. Ballard’s DNA tests confirmed that the blood came from the victim and thus, from the looks of it, clearly inculpated Barnes. Barnes’ story, nevertheless, did not end at this point. Because Ballard was a blood-preservative expert, Barnes’ attorneys asked Ballard to examine whether the blood spot found on Barnes’ overalls had a high concentration of any type of blood preservative. If the results indicated a high concentration of a blood preservative, it would bolster Barnes’ claim the blood was planted onto Barnes’ overalls. To his astonishment, Ballard’s test revealed that the blood from Barnes’ overalls contained an unbelievable amount of blood preservative. Ballard’s conclusion was that the blood was either accidentally spilled from a vial onto Barnes’ overalls by the state crime lab or deliberately planted there. According to Ballard, “This is the most blatant case of tainted evidence I’ve ever seen” (as quoted in Burtman, 2000). Even with Ballard’s blood-preservative evidence and other evidence pointing strongly toward Barnes’ innocence, Barnes’ was executed in March 2000. (See A&E, *Forensic Fraud*, originally aired on December 2, 2002.) Immediately prior to his execution, the district attorney who prosecuted Barnes said he was 100% certain Barnes killed Bass. Why was he 100% certain? Because of the DNA evidence. Thus the reason for this example: It is very difficult to rebut DNA evidence even when you have your own forensic expert and testing. See also Phoebe Zerwick (2005, p. A1), who quotes Rich Rosen, a law professor at the University of North Carolina at Chapel Hill and a member of the North Carolina Actual Innocence Commission, as stating, “The revolution in forensics . . . provides a real opportunity for resolving cases accurately, but it also presents us with some real dangers. . . . For instance, if you get a wrong DNA result presented to a jury, it’s far worse than faulty eyewitness identification because everyone believes the DNA is the absolute answer.”

unethical tactics such as fabricating physical evidence, misrepresenting findings, or exaggerating the significance of their conclusions.⁴⁰

The CSI phenomenon may also exacerbate the forensic incompetency issue. Shows such as *CSI* and *Crossing Jordan* have ignited an unprecedented interest in forensic science at all levels of education. Indeed, one survey by student lender Sallie Mae suggests that forensic science is the fastest-growing college major (Sappenfield, 2003). Although increased interest in forensic investigation may speak volumes about Hollywood's ability to lure students into believing in the existence of "hip" and high-tech crime labs, and may represent a financial windfall for innumerable universities and colleges throughout the country, it may also have a negative impact on the quality of work generated in crime labs in the future.

Even before Hollywood turned the crime lab examiner into a "sexy" pop culture icon, the adequacy of forensic education was a reoccurring problem. A variety of factors, which were outlined in a groundbreaking and controversial article on the subject by Randolph N. Jonakait (1991a), a professor of law at New York Law School, led to the unfortunate yet undeniable reality that would-be forensic scientists and examiners were not being educated adequately in the principles and practices of science.⁴¹ These educational inadequacies were correlated to the "substandard performance[s]" of crime labs during the 1970s, 1980s, and early 1990s (Jonakait, 1991a, p. 124).⁴² Key factors identified by Professor Jonakait and others, such as inadequate funding, lack of instrumentation, and an insufficient quantity of qualified hard science professors, still exist today. Despite these shortcomings, many colleges and universities throughout the country have jumped into the forensic science business by creating inadequate and uninformed forensic science curriculums and programs.⁴³ As one forensic science scholar explained, many of these "so-called fly-by-night programs . . . are pretty poor. . . . [So poor that] people don't even

⁴⁰ As Professor James E. Starrs (2002, p. v) insightfully wrote:

Soon, if we are not exceedingly careful to rein in the public portrayals of the forensic sciences to a more realistic scientific level, the forensic sciences will be found to be wanting in credibility by juries for failing to measure up to public image. Worse yet, forensic scientists, to keep pace with this public misperception of forensic science, will render opinions as experts in courts by expressing more scientific assurance than they should or can.

Jon J. Nordby (2003, p. 6) offers a similar insight:

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.

⁴¹ Unfortunately, Professor "Jonakait's critique of crime laboratories [and forensic education] was passionately attacked by forensic scientists despite the validity of most of his observations" (Giannelli, 2003, p. 245). Consequently, throughout the 1990s very little was done in terms of rectifying the educational inadequacies in forensic science.

⁴² Lindquist (1995, p. 66) notes, "Some of these programs lacked specialized instrumentation and . . . a large number of the instructors had neither a strong science background nor crime laboratory experience."

⁴³ Roane (2005, p. 48) notes, "Forensic practitioners say the popularity of the field may make things even worse, noting that new forensics-degree programs are cropping up all over the place, some turning out questionable candidates."

hire their [own] graduates" [Professor Joe Mascarenhas, State University of New York at Albany, as quoted in [Crime Labs \(2003\)](#)].⁴⁴

That an increasing number of potential forensic examiners are graduating from these questionable programs should give rise to concern. As already shown, the occurrence of questionably educated forensic examiners currently employed in public crime laboratories is already unsettling, demonstrated in the wrongful convictions and lab scandals already discussed. However, this number may pale in comparison to that of the coming generation of forensic examiners. The more low-quality forensic science programs, the more low-quality job applicants will flood the community.

It should be noted that the first steps toward national forensic science education standards have been taken with the June 2004 publication of "Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students" (available at <http://www.aafs.org>) by the Technical Working Group for Education and Training in Forensic Science (TWGED). A major problem with this important effort is that it fails with respect to establishing a hard science degree requirement for practicing forensic scientists. Rather, it suggests a trend in that direction without any discussion as to why it might be important.

The reconstructionist's duty in this regard is to not only achieve a solid education in the sciences, which includes receiving an actual degree, but also to know and practice the scientific method, and thereby learn to recognize a lack of scientific rigor in the work of others.

An Educated Defense

Another reason why reconstructionists and other forensic examiners are under much more scrutiny these days is that the criminal defense bar is becoming increasingly educated regarding forensic science and its limitations. As already discussed, throughout much of the 20th century most attorneys were ill-equipped to deal with scientific or forensic evidence.⁴⁵ Not having the scientific or forensic wherewithal to understand and confidently cross-examine forensic examiners, defense attorneys rarely attempted to deconstruct their methods, assertions, or data.⁴⁶ This passive and even fearful stance toward forensic evidence and testimony allowed

⁴⁴ Brian A. McGaw and Jon Hanna (2003, p. 15) state, "Many courses with forensic in the title may indeed have insufficient science content." [Stink Tanks \(2003\)](#) notes, "Most of the 360-plus undergraduate forensic science courses offered are of dubious worth. Most are taught by academic chemists with no forensic science training or experience."

⁴⁵ Sapir (2002, p. 3) states, "Most lawyers and judges are scientifically unaware if not uninformed. They are ill equipped and underprepared by training and experience to handle the complexities of scientific evidence." [Faigman and colleagues \(2002a, p. v\)](#) write, "Judges and lawyers . . . are not known for [their] expertise in science. . . . Nor is science a subject given significant attention in American law schools."

⁴⁶ According to Professor [Jonakait \(1991b, pp. 348–349\)](#):

Many lawyers and judges feel unable to deal with issues raised by forensic science. Perhaps as a group, attorneys are reasonably bright people who became lawyers partly because they were afraid of science and math. Perhaps when lawyers lie awake in the dark of night, they fear that scientists are smarter than they are. If so, lawyers will not examine the scientific evidence with as much skepticism as they would other information. As a result, the jury will not be as completely informed as it ought to be.

a surprising number of novel (but unsubstantiated) techniques and dubiously qualified examiners to influence the outcomes of more than a few criminal prosecutions.⁴⁷

The playing field, as mentioned, has changed considerably during the past decade. Out of ingenuity and necessity, an increasing number of attorneys have become more in tune with the relevant assumptions, premises, and practices that characterize the various forensic sciences. This increased forensic awareness has had two salient effects. First, it has enabled defense attorneys to independently identify potential issues and problems related to the forensic evidence allegedly linking their client to a charged offense. Second, defense attorneys are better prepared to perceive and then contact the most appropriate forensic expert. Subsequently, they are more likely to get the specialized expertise needed to effectively review, cross-examine, or even deconstruct the State's physical evidence.

As a result, experienced criminal defense attorneys are now more likely to file comprehensive exclusionary motions regarding forensic evidence or vigorously attack the lack of science in the forensic sciences. According to the (past) president of the American Academy of Forensic Science (AAFS), Graham R. Jones (2002, p. 437):

Defense lawyers have also become more critical and aggressive in challenging forensic evidence and are more willing to hire qualified forensic experts to assist them. At one time challenges to forensic science evidence were based largely on nonscientific issues and the legal admissibility of the evidence. Now, increasingly, the scientific validity and reliability of every major forensic science discipline are being challenged. Even the reliability of fingerprinting, previously accepted with little comment, has recently undergone a major challenge in the courts and continues to be challenged.⁴⁸

Ronald L. Singer (2004, p. 1), another (past) president of AAFS, made a similar observation:

Trying cases involving forensic evidence has changed dramatically. . . . The recognition that not all science is necessarily good science, appellate court decisions such as Daubert and Kumho Tire, and the potential of DNA to essentially identify individuals are but a few examples that have caused trial strategies and techniques to evolve into something quite different than was previously known. In criminal trials, the prosecution can no longer call expert witnesses to the stand and expect them to go unchallenged, and more and more defense attorneys are utilizing experts not only to review what has already been done but also to delve into areas not addressed by the state.

Appellate or postconviction defense attorneys have also been able to use their newly acquired forensic knowledge to expose embellished forensic reports and junk forensic science. In fact, most of the wrongful convictions in which forensic science played a role have come to light not because the forensic community was policing itself, but because dogged appellate defense attorneys refused to accept a forensic examiner's testimony or reports at face value.

The defense bar's full-throttle approach to attacking forensic examiners and their evidence is not entirely unanticipated, especially when one considers the shortcomings and lack of reform in the forensic and reconstructive communities during the past 40 years. In the 1960s, for example,

⁴⁷ Giannelli (1980, p. 1243) states, "A surprising number of novel techniques have gained admissibility without the presentation of defense expert testimony."

⁴⁸ Hansen (2000, p. 20) notes, "In the last year alone, more than a dozen so-called Daubert challenges to the admissibility of fingerprint identification evidence have been filed in state and federal courts around the country. In the three cases that have been decided so far, the courts have all admitted the fingerprint evidence. But critics say the battle isn't over yet."

James W. Osterburg (1966, p. 269), a preeminent forensic scholar of his day, foresaw a time when the defense bar would have more than enough ammunition to wholly expose the inadequacies of forensic science: “Unless measures are taken to correct . . . pervasive shortcoming[s] in many areas of criminalistics, the day is not far off when the legal profession will become sufficiently sophisticated in science to make cross-examination a justifiably harrowing experience.”

For reconstructionists, this means expecting, being prepared for, and even inviting a thorough voir dire and cross-examination of their credentials and findings. Ultimately, there needs to be an acceptance of this process so that courts can separate legitimate from junk science for the triers of fact. If their findings can withstand legitimate scrutiny, then reconstructionists and the court alike can be better assured that what they are presenting is the best evidence possible, as opposed to the most helpful evidence for their client or employer.

Actual Admissibility

In *Frye v. United States* [293 F. 1013 (D.C. Cir. 1923)], the court of appeals for the District of Columbia affirmed the exclusion of a psychologist’s finding, based on blood pressure measurements, that the defendant was being truthful when he denied committing a murder. The *Frye* court required a showing that the psychologist’s novel scientific test for deception be generally accepted by the relevant scientific community. According to the court (293 F. 1013):

Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained *general acceptance* in the particular field in which it belongs.

Although many courts throughout the United States embraced *Frye*’s general acceptance standard [see *United States v. Addison*, 498 F.2d 741 (D.C. Cir. 1974); *Reed v. State*, 391 A.2d 364 (Md. 1978); and *People v. Kelly*, 549 P.2d 1240 (Cal. 1976)], it still had numerous admitted shortcomings (Giannelli, 1980). In 1975, the Federal Rules of Evidence were signed into law. Rule 702 revolutionized expert testimony by sweeping away the restrictive doctrine that curtailed expert testimony under the common law. Rule 702 employed a “helpfulness” test that departed from the common law’s stricter standard requiring an expert’s testimony to be “beyond the ken” of an ordinary trier of fact. Rule 702 stated:

[I]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.

Legal scholars and courts characterized this rule as a “relevancy test” (Giannelli, 1994).⁴⁹ As applied, this test often meant that once a court qualified a witness, so too was his or her technique automatically qualified (Giannelli and Imwinkelried, 1999). Ironically, neither the

⁴⁹ As Professor McCormick (1954, pp. 363–364) explained:

Any relevant conclusions which are supported by a qualified expert witness should be received unless there are other reasons for exclusion. Particularly, its probative value may be overborne by the familiar dangers of prejudicing or misleading the jury, unfair surprise, and undue consumption of time.

advisory committee's commentary nor Rule 702 mentioned *Frye*. The failure to clarify whether Rule 702 superseded *Frye* produced confusion among federal (and even state) courts during the 1970s and 1980s.

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (509 U.S. 579, 1993), the Supreme Court held that Rule 702 superseded *Frye*. *Daubert* stressed that trial judges were obligated to utilize their "gatekeeping" capacities when screening expert testimony to make certain that it is "not only relevant, but reliable" (509 U.S. 589). In carrying out their gatekeeping responsibilities, the Supreme Court instructed trial judges to assess not merely whether a technique or theory was generally accepted but also whether it was testable and falsifiable and whether it possessed an identifiable error rate and had undergone the rigors of peer review (509 U.S. 589). *Daubert's* primary gatekeeping function was to ensure that experts were testifying to "good science" (509 U.S. 593). Thus, *Daubert* generally focuses on four factors:

- Error rate
- Peer review
- Testability (or falsifiability)
- General acceptance

Daubert, nevertheless, left open the question of whether "technical" and "specialized knowledge," the two other forms of expert testimony identified in Rule 702, fell within the parameters of *Daubert's* reliability standard.

In *Kumho Tire Co. v. Carmichael* (526 U.S. 137, 1999), the Supreme Court held that *Daubert* "applies not only to testimony based on 'scientific' knowledge, but also to testimony based on 'technical' and 'other specialized' knowledge" (526 U.S. 141). The Supreme Court believed it would be an administrative nightmare if trial judges were required to apply different admissibility standards to areas of knowledge where "there is no clear line that divides . . . one from the other" (526 U.S. 148). *Kumho Tire* put forth another significant, although less overt, principle that the gatekeeping decision must focus on the "task at hand" and not the standard reliability of a generally and broadly defined vicinity of expertise (Risinger, 2000).

Rule 702 was amended in 2000. The amendment codified the Supreme Court's decisions in *Daubert*, *Kumho Tire*, and *General Electric Co. v. Joiner* (522 U.S. 136, 1997, holding that abuse of discretion is the proper standard of review for district court evidentiary rulings). Rule 702 now reads:

If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

Like *Daubert* and its progeny, newly amended FRE 702 forces courts to question the empirical underpinnings of all expert testimony and to exclude those opinions "connected to existing data only by the ipse dixit of the expert" (*General Electric Co. v. Joiner*, 522 U.S. 136, 146, 1997).⁵⁰

⁵⁰ As the district court in *United States v. Hines* wrote, *Daubert* and its offspring "plainly invite a reexamination even of 'generally accepted' venerable, technical fields" [55 F. Supp. 2d 62, 67 (D.Mass. 1999)].

Since *Daubert* was handed down, courts and legal observers have expressed trepidations that *Daubert*'s emphasis on empirical testability, scientific falsifiability, and error rates poses serious trouble for the forensic sciences.⁵¹ For example, Judge Louis Pollack's initial opinion in *United States v. Llera Plaza* [179 F. Supp. 2d 492 (E.D. Pa. 2002) vacated by *United States v. Llera Plaza*, 188 F. Supp. 2d 549 (E.D. Pa. 2002)], in which he barred the government's fingerprint experts from testifying that they were able to match the defendant's prints to a crime scene print, illustrates these various shortcomings. Although Judge Pollack ultimately "changed his mind" when he vacated his original opinion [*United States v. Llera Plaza*, 188 F. Supp. 2d 549, 576 (E.D. Pa. 2002)],⁵² both opinions unmistakably indicate that many of the professed forensic sciences have much work ahead of them if they wish to continue influencing the criminal process.⁵³

In short, although many of the forensic sciences are still admitted routinely even under intense legal jousting, chinks in the armor of forensic science have begun to show due in large part to the *Daubert* revolution. Moreover, the forensic science community is discretely aware that *Daubert* continues to offer criminal defense attorneys a powerful weapon to effectively attack many of the forensic fields that have a tenuous relationship with science and the scientific method. This includes crime reconstruction.

⁵¹ See, generally, [Fradella et al. \(2004\)](#); *United States v. Mikos*, No. 02 CR 137, 2003 U.S. Dist. Lexis 22069 *16 (N.D. Ill. Dec. 9, 2003) ("There is no body of data to corroborate the government's (comparative bullet lead analysis) expert's further opinion that from this finding it follows that the bullets must or even likely came from the same batch or melt."); *United States v. Crisp*, 324 F.3d 261, 269–70 (4th Cir. 2003) (Michael, J., dissenting) ("Nothing in the history of the use of fingerprint and handwriting evidence leads me to conclude that it should be admitted without the scrutiny now required by *Daubert*."); *United States v. Lewis*, 220 F. Supp. 2d 548, 553 (S.D. W.Va. 2003) ("The Government had the burden of establishing by a preponderance of the evidence that Mr. Cawley's [handwriting] testimony was sufficiently reliable to be admissible under Rule 702. The court found that the Government did not meet its burden."); *United States v. Hidalgo*, 229 F. Supp. 2d 961, 967 (D. Ariz. 2002) ("The Government offers the uniqueness of handwriting as a scientific principle. But there is no evidence before me to support the thesis that handwriting is unique. . . . We therefore find and conclude that the principle of uniqueness of handwriting or handprinting fails to satisfy a *Daubert*/*Kumho* analysis."); *United States v. Llera Plaza*, 188 F. Supp. 2d 549, 560 (E.D. Pa. 2002) ("ACE-V—the system of fingerprint identification . . . is not, in my judgment, itself a science."); *United States v. Horn*, 185 F. Supp. 2d 530, 549 (D. Md. 2002) ("The doctrine of judicial notice is predicated upon the assumption that the source materials from which the court takes judicial notice are reliable. Where, as here, that reliability has been challenged, the court cannot disregard the challenge, simply because a legion of earlier court decisions reached conclusions based on reference to the same then-unchallenged authority. For the reasons that will be explained below, on the record before me, I cannot agree that the HGN, WAT and OLS tests, singly or in combination, have been shown to be as reliable as asserted by Dr. Burns, the NHTSA publications, and the publications of the communities of law enforcement officers and state prosecutors."); *United States v. Starzeczyzel*, 880 F. Supp. 1027, 1038 (S.D. N.Y. 1995) ("Forensic document examination, despite the existence of a certification program, professional journals, and other trappings of science, cannot, after *Daubert*, be regarded as 'scientific . . . knowledge.'").

⁵² For a critique of Judge Pollack's second opinion, see [Kaye \(2003\)](#).

⁵³ For instance, Professor Simon [Cole \(2003, p. 74\)](#) notes,

While fingerprint identification has thus far emerged from the controversy unscathed in a strictly legal sense—in that forensic fingerprint evidence remains unconditionally admissible—the terms of its admissibility have, in fact, changed greatly in ways that have profound implications for other areas of forensic science.

WHAT IS EXPECTED FROM THE RECONSTRUCTIONIST?

Reforms in [forensic science] are desperately needed and long overdue.
—Senate President Robert E. Travaglini (as quoted in *Klein, 2003, p. B4*)

As the previous section makes clear, it is a “brave new world” in terms of evaluating and deconstructing opinions premised on forensic technology, scientific interpretations, and reconstructions of the physical evidence. Accordingly, reconstructionists must be equipped with the requisite technical and scientific comprehension to survive in the 21st-century courtroom. This section suggests various related reforms that the reconstruction community needs to embrace, from a defense attorney’s perspective. Implementing these reforms would go a long way to blunt the intense scrutiny being directed at the forensic and reconstruction communities because they would help substantiate the reliability, validity, and proficiency of interpretive forensic conclusions in the eyes of the criminal justice system.

A caveat is that these suggested reforms are not all-inclusive. They are a start, but only a start, and will not cure all ills. A comprehensive overview of forensic reform is needed, which is a subject large enough to fill another whole textbook.

Education and Training

[I]t is the responsibility of all forensic scientists to keep up to date on not only their area(s) of specialty, but to continually seek out knowledge and training that will maximize the application of their specialty within the totality of forensic science.

—Moran (2002, p. 697)

Education reforms should be considered essential and necessary in each of the forensic sciences. Crime lab problems during the past decade have demonstrated that an alarming number of forensic examiners are trained inadequately in science, the scientific method, statistics, and ethics. The reconstruction profession is susceptible to the dangers of diminished education, and this is made worse because of the move toward forensic specialization (for a discussion, see the Preface).⁵⁴ Under a “specialist” model, forensic examiners are trained predominantly in one area of analysis (e.g., DNA, toxicology, firearms, tool marks, or fingerprints).⁵⁵ Although “specialists” may take short courses in other forensic disciplines, the bulk of their training is devoted to mastering one area of evidence. Even though it may be desirable in other professions, and it may even enhance the professional status of the forensic science community in some ways, specialization nevertheless spells disaster for the reconstruction community.

This text has been written from the perspective that evidence interpretation and crime reconstruction are functions of objective forensic scientists. Crime reconstruction in particular should be the domain of forensic generalists, working separate from the direction and influence of the

⁵⁴ According to Moran (2001, p. 698), “In light of technical advancements in the field of forensic science and in our zeal to pursue a greater degree of professionalism, we have moved toward increased specialization.”

⁵⁵ Kirk and Bradford (1965, p. 50) note, “By definition, the specialist is someone who, by reason of training or experience, may be assumed to know much more about a limited subject than he does about related subjects in the same general field.”

police investigation. This is in conflict with the notion that reconstruction should be a function of police crime scene investigators who by and large lack a scientific background and, in many instances, a formal education.

Forensic Generalists vs Law Enforcement–CSIs

Forensic examiners who become forensic specialists often have a novice-level understanding of science and the scientific method. This is the case because few forensic science programs require budding forensic specialists to partake in a rigorous physical science curriculum that includes extensive laboratory work.⁵⁶ Similarly, forensic specialists are commonly uninformed with regard to statistics because they are “rarely forced to take one statistics course, let alone an entire series of classes, during their undergraduate or graduate education” (Cooley, 2004a, p. 698). Thus, although the mantle of specialist may be used to imply that a particular forensic professional has a deep and highly technical understanding of a narrowly defined area of science, evidence suggests this implication is misleading (e.g., crime lab mishaps, proficiency testing programs, and wrongful convictions cases). Put simply, many of today’s forensic specialists are poorly trained “technicians” who follow mandatory laboratory procedures and are not expected to comprehend the underlying forensic fundamentals that comprise their chosen area of expertise.

If forensic specialists or technicians do not fully understand the fundamentals underlying their own area of forensic expertise, they surely cannot have an all-inclusive appreciation of the methods and practices of forensic science subjects in general. As Robert Adamo and his American Board of Criminalistics colleagues (Adamo et al., 2000, p. 749) wrote, “Many of these individuals do not have a sufficient understanding of the basic principles of criminalistics.” This has disturbing implications for the reconstruction profession. As forensic scientist Bruce Moran (2002, p. 698) explains, crime scene reconstruction “requires a comprehensive understanding of all forensic science disciplines.” Mr. Moran further notes (p. 698):

[Because of the specialization movement] we are steadily increasing the risk of reducing independent and innovative thinking in regards to conducting [reconstructive] casework. The generalist is indeed a vanishing breed, and with it, the “big picture thinking” and holistic approaches necessary to provide a comprehensive approach to casework is fading.⁵⁷

Paul Kirk and Lowell Bradford, two pioneers of the forensic generalist movement who, in essence, predicted the current crime lab crisis, support Mr. Moran’s modern-day comments and concerns. According to Kirk and Bradford (1965, pp. 53–54):

⁵⁶ As Keith Inman and Norah Rudin (2000, p. 302) note:

Although a number of programs can be found that list themselves as forensic science programs, a closer look shows that the majority of these programs . . . provide only a general curriculum most appropriate for an overview or introduction to forensic science in the broadest sense. Rarely are they combined with a rigorous physical science curriculum, including laboratory work.

⁵⁷ Adamo and colleagues (2000, p. 749) note, “The trend in most forensic laboratories is toward increased specialization and away from the generalist or ‘holistic’ approach to problem solving.”

Every criminalist in the laboratory should be capable of dealing with evidence otherwise belonging to another's specialty, in order that illness, vacations, and other unforeseen interruptions do not disrupt the entire laboratory output. . . . [In short], [n]o specialist can be assumed to recognize fully the potentialities of every type of evidence.

Consequently, not only have the shortcomings of the forensic specialist model inadequately prepared forensic specialists to practice in today's crime labs, they have also effectively brought the generalist–reconstructionist to the brink of extinction. The pool of qualified reconstructionists is currently so diminished that nonscience professionals, such as CSIs, detectives,⁵⁸ and police profilers,⁵⁹ have enthusiastically rushed to pick up the slack in the reconstructive arena. In fact, the three largest organizations devoted to crime reconstruction and/or evidence interpretation are composed of individuals who can best be described as law enforcement investigators (or CSIs) turned reconstructionists. The professionals who inhabit these organizations regularly proclaim that reconstructive work is an intuitive process based on special training and special abilities that defy explanation; that conclusions may be premised on an investigator's special training or bare experience, which is the source of these special abilities; and that reconstruction is best left to those with special law enforcement CSI training, not forensic scientists.

Given that the CSI–reconstructionist model runs contrary to the forensic generalist–reconstructionist model, a turf war appears to exist between CSIs and forensic generalists. Consider the exchange between two such practitioners on a public discussion forum for forensic professionals, particularly CSIs. One advocates the forensic generalist (scientific) approach, whereas the other is an advocate of the CSI (intuitive) approach. The CSI argued the following, in favor of the CSI–reconstructionist model:

Crime scene interpretation and reconstruction are best done by qualified CSIs, not scientists. The scientific analysis of evidence is extremely important and should be done by scientists at the crime lab.

Scientists supply facts to the investigator or CSI.

The CSI or investigator is the one who is actually interpreting the crime scene based on facts derived from the scene, not just the evidence.

Scientists must stick to their jobs, and not falsely proclaim how they reconstruct or interpret a crime scene, because they lack the knowledge and experience to do so—primarily because they are too academic and lack experience processing evidence.⁶⁰

Because the rest of this textbook has effectively delineated the various reasons why properly educated forensic generalists, rather than CSIs, should be performing reconstructions, there remains only the need for a short discussion of these issues from a defense attorney's perspective.

⁵⁸ Brant (1998) details how a detective with a nonscientific background and no experience in firearms reconstruction carried out a reconstructive study to determine the relative distance of a revolver from a victim when fired.

⁵⁹ See Greg McCrary's (former FBI profiler) reconstruction of the Sam Sheppard case at www.courtv.com/national/2000/0131/mccrary-ctv.html. For a more detailed analysis of why profilers should not conduct reconstructions, see Inman and Rudin (2000, pp. 182–188).

⁶⁰ Transcripts of this June 3, 2005, Web-based discussion are on file with the author.

If the reconstruction community wishes to remain legitimate in the eyes of the courts and establish scientific credibility with the public, it must exist separately from law enforcement–CSI investigative efforts, both physically and philosophically. There are several reasons for this.

First, law enforcement investigators and scene responders regularly approach their job with a confirmatory mind-set because they attempt to prove (or confirm) that a particular individual committed a certain offense in a particular fashion. Scientists (or reconstructionists), however, are obligated to approach their tasks with a skeptical (or disconfirmatory) perspective because they are trained to disprove all hypotheses before rendering an opinion that only supports (but does not categorically prove) a specific inference. These two competing mind-sets cannot coexist. If forced together, the confirmatory mind-set generally wins out because the CSI–reconstructionist, in essence, has learned his methods and habits in a nonscientific setting.⁶¹ The independence and objectivity needed to master the scientific method and apply it to crime reconstruction techniques cannot be learned accurately and effectively in an environment that suffocates skepticism and rewards compliance and certainty.

Second, simply working at or in hundreds of crime scenes does not turn a crime scene responder into a reconstructionist. There is a fundamental distinction between crime scene processing and evidence interpretation (i.e., crime reconstruction). The former is often accomplished with little or no interpretive skills, whereas the latter is completely dependent on a forensic generalist’s interpretative dexterity. As offered candidly by the aforementioned advocate of the CSI–reconstructionist model (and in contrast to his earlier position that only CSIs should be reconstructionists), “the main job of a CSI is to document, identify, and collect physical evidence at a crime scene” (Baldwin, 2005, <http://icsia.org/faq.html>). Again, it is important to understand that crime scene processing (documenting, identifying, collecting, and transporting physical evidence), as it is currently practiced by the majority of law enforcement-employed crime scene technicians, does not actually require any scientific interpretation. One is only required to have good visual and handwriting skills to successfully fulfill a CSI’s duties, which is reflected in the low CSI hiring requirements in many police departments throughout the country (e.g., most do not require college education of any kind, emphasizing prior law enforcement experience or affiliation and a valid driver’s license).

However, determining whether fibers found on a victim originated, or could have originated, from a suspect’s van is all about scientific and probabilistic interpretation. The generalist–reconstructionist must not only consider alternative hypotheses as to how the fiber became affixed to the victim (scientific interpretation) but also consider the fiber’s frequency or commonness within the environment (statistical interpretation). Ascertaining the associative value of each piece of evidence must take place before a reconstruction can even be attempted. Without

⁶¹ For instance, Baldwin (2005), a prominent promoter of the CSI model of reconstruction, stated the following about “cops” doing reconstructive work:

I am a cop. I have been one all my career and still feel that I am. I do not understand why anyone wants to be a CSI without being a cop first. It just doesn’t make sense to me. It is like wanting to be a brain surgeon but not wanting to be a doctor first. It just doesn’t make sense to me. But then I am not 21 anymore and the world and job market are different. If you want to be a CSI I think that is great! But being a cop first will give you more experience than you can ever imagine. Plus there are several avenues in law enforcement that open up new areas to find a career in.

attending to these and other related considerations, the reconstructionist risks misunderstanding the strength of her evidence and misleading the trier of fact.

A generalist–specialist analogy is appropriate here. As mentioned previously, many forensic specialists do not have a comprehensive background in criminalistics or any of the other numerous disciplines within forensic sciences. Frequently, however, as Robert Adamo and his American Board of Criminalistics colleagues point out, “laboratories confer the title of ‘criminalist’ upon these technical specialists” (Adamo et al., 2000, p. 749). They find this disturbing because a “technical specialist does not become a criminalist by virtue of title or by working in a forensic laboratory but rather by the knowledge, skills, and abilities (KSAs) needed to be a criminalist” (p. 749). This same analogy and reasoning can be employed to deconstruct the “I’ve worked hundreds of crime scenes” rationale used by law enforcement-trained CSIs. The title of reconstructionist should not be conferred on someone merely because he has processed or investigated numerous crime scenes but, rather, because he has repeatedly demonstrated his ability to accurately and competently follow established practice standards and incorporate scientific methods of inquiry and analytical reasoning into his analyses. Similarly, as discussed in more detail later, that an examiner has testified in numerous prosecutions resulting in numerous convictions does not establish an examiner’s accuracy or analytical ability.

Third, in the CSI–reconstructionist model, the influences of observer effects and examiner bias are far greater (see Chapter 3). CSI–reconstructionists are not just influenced by law enforcement personnel—they are often embedded with them in both task and spirit. This does tremendous if not irreversible damage with respect to their “professional chastity” (see Chapter 2) and may even entirely prevent them from offering truly neutral and objective reconstructions.

Fourth, the CSI–reconstructionist model endorses, like most forensic subspecialties, the non-scientific habit of supporting one’s opinion with his or her experience rather than scientifically verifiable facts, analytical logic, and critical thinking. This issue was discussed in Chapter 4 and is discussed at greater length later.

Fifth, CSI–reconstructionists, like many law enforcement-based forensic identification examiners, often claim that their reconstructions or interpretations must be correct because they have resulted in “X” number of arrests or convictions that have yet to be overturned.

A CSI’s reference to “sustained arrests and convictions” is aimed at strengthening claims that she is better equipped to perform reconstructions by virtue of a demonstrable track record of success for the prosecution. This argument is unpersuasive for several reasons. First, as any legitimate forensic scientists will attest, whether an arrest is made or a conviction is obtained (and sustained) is absolutely irrelevant. The primary and singular interest of the forensic scientist, including the reconstructionist, is to provide the fact finder with accurate information so he may appropriately infer the cause of the evidence, the relationships between items of evidence, or a sequence of events. More important, an examiner’s accuracy and analytical ability cannot be gauged by merely calculating the number of times an examiner has testified and then determining what percentage of those cases resulted in convictions or acquittals. This claim, in effect, deflects attention away from the real source of accuracy or inaccuracy—the reconstructionist’s proficiency.

The aforementioned CSI’s reference to convictions as a point of pride is similar to statements made by other “police scientists,” who try to prove the quality and accuracy of their techniques, or inculpatory identifications, by referencing other allegedly inculpatory evidence in a criminal case. Consider the following (Stafford-Smith and Goodman, 1996, p. 259):

Apologists for the technique of forensic hair comparison analysis may argue that their trade does not occur in a vacuum, and that their conclusions are buttressed by other evidence. This is correct when a confession confirms pubic hair evidence of a rape. However, real life can also cut the other way, enhancing the probability of an error, with the technician's belief that the "right" person has been arrested tainting the approach to the hair comparisons. *If it is to be accepted as probative of anything, hair analysis must stand or fall on its own merits, without reference to other evidence in an actual criminal case.*

The italicized portion says it all, in that if a reconstructionist's analysis is to be probative of anything, it must live or die on its own intrinsic worth.

Sixth, the CSI-reconstructionist model is too often premised on completing a series of short courses. For instance, many investigators attend 5-day (40-hour) workshops or courses on bloodstain pattern analysis, trajectory analysis, or crime scene reconstruction. Some may even attend advanced 2-week (80-hour) courses in these subjects. Attending these courses does not automatically transform an investigator into a bloodstain or trajectory analysis expert (see Chapter 8).⁶² As Stephen Bright, director of the Southern Center for Human Rights and forensic watchdog, explains (as quoted in [Wrolstad, 2002](#), p. 1A):

[W]hat you have in many laboratories are police officers who have been sent up to the FBI training facility in Quantico, VA, and come back after 2 weeks claiming to be experts. . . . They tend to embellish, to make statements not supported by science, that often go unchallenged because defendants are poor and don't have the resources to hire independent experts.⁶³

Using the short course model rationale, the author could justifiably claim expertise in forensic pathology. Not only has the author attended various 40-hour (5-day) seminars on forensic pathology and medicolegal death investigation, he also participated in a 3-month forensic pathology/ medicolegal death investigation course in graduate school at the University of New Haven. Moreover, considering the author's area of criminal defense (i.e., death penalty cases), he has also viewed and read innumerable autopsy reports, autopsy photos, crime scene photos, and crime scene reports.

However, the author is fully aware that such a claim of expertise is ridiculous because there is more to developing ability than acquiring knowledge. There is refinement through application and error, there is experimentation, there is proficiency at following established practice

⁶² See, for example, *Commonwealth v. Miller*, 532 A.2d 1186, 1189 (Pa. Sup. 1987) ("In the instant case, the Commonwealth did not present expert testimony regarding general acceptance of the scientific principle (i.e., consumption of alcohol causes nystagmus) upon which the HGN test is based. Rather, the only testimony concerning the validity of the HGN test came from Officer Arnold Duck, Jr., whose only specialized training in this area was a two day course on the proper use of the HGN test and other field sobriety tests. We find that this was an inadequate foundation for the admission of the testimony regarding the results of the test. Though Officer Duck's testimony mentioned the scientific principle underlying the HGN test, his brief training session on how to properly administer the test was insufficient to qualify him to testify either about the scientific principle that consumption of alcohol causes nystagmus or about the principle's general acceptance in the appropriate scientific communities."); *People v. Knox*, 459 N.E. 2d 1077, 1082 (Ill. App. Ct. 1984) (Stouder, J., dissenting) ("I do not believe that Officer Ganda's three-week training course in New York qualified him as an expert in blood spattering.")

⁶³ Stephen B. Bright (as quoted in [Liptak, 2003b](#), p. A5) states, "So many of the people who give DNA testimony . . . went to two weeks of training by the F.B.I. in Quantico . . . and they are miraculously transformed from beat policemen into forensic scientists."

standards when engaging in analysis, there is keeping current with trends within the relevant disciplines, and there is much, much more.

In their crime laboratory management treatise, Kirk and Bradford (1965, p. 58) scoffed at the notion that examiners or reconstructionists can acquire expert levels of knowledge simply by attending only short or “correspondence” courses:

A degree in science from a college or university ordinarily falls far short of meeting the minimum requirements. Except in the most unusual instances, such a *college degree must be considered an essential*, but not sufficient in itself. Directed laboratory and theoretical work in the field of *criminalistics itself* is the other essential requirement for the absolute minimum training.

Correspondence and extension courses are occasionally helpful, but generally totally inadequate except as a supplement to sounder training. The student does not learn the subject—he learns a little about it. It does not truly become part of him, either technically or philosophically. For the same reasons, reading of books, however helpful and relevant they may be, is likewise inadequate by itself to meet minimum requirements. The reading and supplementary study should accompany, not replace, the laboratory training. All of this, including the laboratory training, is still inadequate without sound groundwork in basic sciences, such as can be obtained in the colleges and universities.

Again, mastering the many scientific and technical skills needed to properly carry out a reconstructive analysis cannot be acquired in a 2- or 3-week time span. An undergraduate or graduate science degree, combined with broad-based knowledge of the forensic sciences, and a demonstrated proficiency in reconstructing crimes using analytical logic, critical thinking, and the scientific method are essential.

The short course model is just one example of how the law enforcement community has “oversimplified” a process, which by its very nature is scientifically complex, to serve its own self-interests. As one of the cocontributors to this text (Casey) has said on quite a few occasions, “The less you know about something the simpler it seems.” Unfortunately, this is how generations of CSI-reconstructionists have been educated or trained. They are taught superficial kernels of truth regarding the professed principles and practices of forensic science. Then they are told that these principles and practices are so simple that anyone can apply them to forensic or criminal investigations. Charles E. O’Hare and James W. Osterburg (1949, p. x) expressed their frustration with law enforcement’s desire to oversimplify complex forensic concepts and procedures more than a half century ago:

The student entering the field of scientific crime detection finds himself confronted by an odd assortment of texts. Most of these are popularizations which explain away the difficulties of subject matter in terms of facile analogies. The most serious works are optimistically written with a view to making a scientist out of a detective; but here again, the road to a true understanding of the principles of criminalistics is blocked by the necessity for oversimplification. A few texts meet squarely the major problem: To make a detective out of a science student, i.e., to develop from the scientist the scientific investigator of crime, by showing how the principles and techniques which he has studied can be applied to the peculiar problems of examiner clue materials.

Once more, “The less you know about something the simpler it seems.” The simpler a concept seems, the more persuasive one appears when he or she is trying to explain it to someone else—for instance, a juror assessing guilt or a district attorney contemplating whether to file charges. Consequently, it may be argued that nonscientific investigators, with their foray into reconstruction, have steadily helped remove science from forensic science to ease the State’s burden. As one of the coeditors of this text (Turvey) remarked in a discussion of these and other forensic issues, “Science without science? What’s next? Books without words?”

It bears mentioning that the disagreements between generalists–reconstructionists and CSI–reconstructionists are strikingly analogous to the turf wars of the 1920s and 1930s between up-and-coming “self-styled scientific detectives” and so-called “true detectives.” For example, in 1931 Captain Duncan Mathewson, chief detective of the San Francisco Police Department, said the following about so-called “scientific” detectives (p. 322):

[There] seems to be a pretty well-defined controversy raging in this country between some of the exponents of science on the one side and a few of the old-time detectives on the other side. . . .

Much has been said and published about the educated college policeman and detective and it is all bunk. Give me the practical detective with actual experience in handling criminals and criminal cases and with ten such men I will do more work than any college professor or so-called expert can do with one hundred of his trained nuts. Most of those that I have seen couldn't put a harness on a mule, let alone catch a crook. . . . There is an overabundance of self-styled scientific detectives and crime experts in this country. They would have a gullible public believe they are so scientific that the crooks would respond to engraved invitations to visit police headquarters and surrender. Just how long the public will stand for this rot is a question.

No sane person should care to underestimate the value of any scientific means for solving crime problems. Science in all its branches should be called into play wherever there is a possible use for it. . . . This does not mean, however, that we should go still further, as the public has been led to believe, and substitute scientific detectives with college diplomas for experienced men who show a natural aptitude for the work of criminal investigation, men of initiative, courage, and good judgment who know their business and can be depended upon to get results. . . . It is almost axiomatic that any person is better off with a college education than without one, but unless a man is endowed by nature with the true detective instinct, all the college training in the world will not make him a successful crime investigator. In the language of Shakespeare, you can't make a silk purse out of a sow's ear.

Clearly, the disagreement over who is best qualified to reconstruct crime has been going on for generations. Currently, through sheer numbers, the nonscientific CSI–reconstructionist model dominates the field. For this to change, there must be a resurgence in the educating of forensic generalists and employing them separate from that community (see Chapter 3).

Endorsing a Generalist Approach

If practicing criminalists [Keith Inman and Dr. Norah Rudin \(2000, p. 303\)](#) were correct when they begrudgingly admitted “specialization is here to stay,” what must the reconstruction community do in order to escape extinction and to legitimize their status in the eyes of the criminal justice system?

In its simplest terms, the solution is to (1) move away from the CSI–reconstructionist model with regard to courtroom testimony and then (2) work at improving the quality of our nation's science and forensic science programs, both undergraduate and graduate. This can be accomplished by developing undergraduate and graduate forensic science programs that emphasize learning and applying the natural and physical sciences in a forensic context and by requiring extensive laboratory work, forensic science experimentation, and crime scene investigation. As the National Institute of Justice's ([NIJ; 2004, p. 11](#)) report on forensic science education explained:

Forensic science is an applied science that covers an array of disciplines. Regardless of the area of forensic science pursued, an undergraduate degree in forensic science should be interdisciplinary, combining a strong foundation in the natural sciences with extensive laboratory experience.

A model undergraduate forensic science degree program should provide a strong and credible science foundation that emphasizes the scientific method and the application of problem-solving in both classroom and laboratory setting.

[Inman and Rudin \(2000, p. 302\)](#) concur with the NIJ:

Now, more than ever, the onslaught of technology obligates the criminalist (and the reconstructionist) to draw on a strong background in the physical sciences, including an understanding of statistics and logic. The scientific background cannot be only theoretical, it must include copious laboratory experience.

Requiring this kind of educational background for prospective forensic scientists and reconstructionists would, in theory, increase the likelihood that these individuals would have a fundamental grasp of science and the scientific method as it applies to crime reconstruction. Specifically, it would minimize the chance that future forensic analysts would confuse the concepts of inductions and deduction. As [John Thornton and Joseph Peterson \(2002, p. 14\)](#) have pointed out:

Forensic scientists have, for the most part, treated induction and deduction rather casually. They have failed to recognize that induction, not deduction, is the counterpart of hypothesis testing and theory revision. They have tended to equate a hypothesis with a deduction, which it is not. As a consequence, too often a hypothesis is declared as a deductive conclusion, when in fact it is a statement awaiting verification through testing.

A scientist or generalist–reconstructionist can conjure up a hypothesis about the natural world through various means—systematic study, enthused conjecture, or a rambling imagination. But others must in due course subject that hypothesis to controlled tests that are reproducible. Only if the tests support the hypothesis can the hypothesis be accepted. There must be multiple tests and the results of these tests can only support a particular hypothesis. [Inman and Rudin \(2000, p. 180\)](#) provide an excellent illustration of this problem as it pertains to reconstructionists:

It is common, particularly when attempting a reconstruction, for criminalists to try to re-create or simulate the circumstances he thinks led to the scenario found at the crime scene. This kind of experimentation can be informative, but its limits must be well understood. All too often, having set up conditions that appear to duplicate the physical observations, the investigator will then conclude that he has discerned what happened. Doing an experiment is a good idea, but it is crucial to understand that an experiment can only tell you that the evidence could have been produced using your simulated conditions. It does not tell you either that this is the only way to produce the evidence, or that the incident happened in the way you envision. . . . A simulation supports a reconstruction, it does not prove one.

Likewise, endorsing a scientific approach that produces actual scientists as opposed to technicians has the potential of minimizing prosecution bias. For instance, according to Professor Andre [Moenssens \(1993, p. 7\)](#), prosecution bias

is even more prevalent among some “technicians” (nonscientists) in the crime laboratories, for whom the presumption of innocence disappears as soon as police investigative methods focus on a likely suspect. These individuals, who are frequently trained to do forensic work on the job after obtaining an undergraduate degree in chemistry or biology, are bestowed with the job title of “forensic scientist” after only a short time in their crime laboratory function. Their pro-police bias is inconsistent with being a scientist. In fact, the less of a scientific background a lab person has, the less critical that person is likely to be in terms of investigating the validity of claims made by other laboratory personnel. These are the “experts” who typically jump on the bandwagon of anything

new that comes down the pike, and will staunchly advocate its reliability, even in the absence of any objective investigation and validated experimentation. . . . Again, many of these individuals do good work in the field in which they have been trained, but their bias is often so strongly pro-prosecution that they may lack the kind of objectivity and dispassionate judgment that one expects of a true scientist, be it forensic or otherwise.

Although improving our nation's forensic science programs is a step in the right direction, particularly for forensic specialists such as DNA analysts or trace evidence analysts, it does not completely solve the problem. Forensic generalists and specialists need additional science and laboratory training given the varied nature of their work. This is not only difficult to obtain with an undergraduate degree but also very difficult to acquire once someone has started at a crime lab as a specialist. As [Inman and Rudin \(2000, p. 303\)](#) explain, "Unless one comes up through the ranks in a full-service laboratory, it's not a simple matter to acquire this generalist background once one starts working. It is not impossible, but it does require a measure of dedication and discipline." Moreover, generalists also need schooling in crime scene processing, investigative techniques, and the ways in which these intersect with the forensic sciences. Unfortunately, very few forensic science programs offer a mixture of hard science, lab study, and crime scene work.

Thus, the fundamental dilemma for the near-extinct forensic generalist is how do up-and-coming generalists go about acquiring the broad skill set needed to perform reconstruction work? [Inman and Rudin \(2000, p. 303\)](#) offered what appears to be one of the more intelligent solutions:

A more realistic approach is to include this information (e.g., crime scene work) as part of a complete criminalistics program, along with the necessary physical science courses and associated laboratory work. As a minimum or interim solution, a criminalistics specialization could be offered as a fifth year after a more standard university curriculum. A certification program in criminalistics might culminate in the opportunity to take the General Knowledge Exam (GKE) offered by the American Board of Criminalistics (ABC).

Who will win the 21st-century turf war is anyone's guess. Nonetheless, if reconstructionists wish to be taken seriously by the courts and the public, it would be advantageous for them to embrace an educational agenda that emphasizes science and objectivity rather than arrests and convictions.

Research

Ms. Kelly's inability to cite such studies, given her high standing within the FDE community and the substantial period of time that the government had to prepare both its case and its witness, leads to an inference that there are few useful scientific studies relevant to forensic document examination. –[United States v. Starzecpyzel \[880 F. Supp. 1027, 1034 \(S.D.N.Y. 1995\)\]](#)

The government did not offer any record of testing on the reliability of fingerprint identification. Indeed, it appears that there has not been sufficient critical testing to determine the scientific validity of the technique. –[United States v. Crisp \[324 F.3d 261, 273 \(4th Cir. 2003\) \(Michaels, J., dissenting\)\]](#)

One of the major criticisms directed at forensic science, and by inference crime reconstructions based thereon, is the lack of empirical research supporting fundamental theories or conclusions. Criticisms regarding forensic research, and its absence, did not appear out of the blue after *Daubert* was handed down. Rather, forensic watchdogs have for years claimed that many

forensic disciplines are scientifically bankrupt because they are buttressed by almost no empirical data or research. James W. Osterburg (1966, p. 261) commented on the lack of research in forensic science:

Intimately connected with the question of interpretation is the problem of basic data, upon which objective criteria for the evaluation of physical evidence must be based. If the research work had been done and had been published, the problem would be relatively simple and such an evaluation possible. This indispensable, laborious work was started long ago and continues at a fantastic pace in the established sciences. In criminalistics, however . . . [published data] is almost non-existent. Testimony reported in the [Warren Commission] hearings emphasizes unintentionally the scarcity of published data through failure to mention any journals in which such vital information is available.

Although four decades have passed since Osterburg made these comments, it still appears that there is a dearth of research to support a number of the claims made by forensic scientists and reconstructions. *Daubert's* impact has only intensified these criticisms because two of the four factors identified by the Supreme Court (i.e., has or can the claim be tested and what is the technique's or examiner's known error rate) can only be gauged if empirical testing has been performed.

Accordingly, if reconstructionists want to appease *Daubert* and to quiet the critics, it would behoove them to conduct and publish research that substantiates the underlying assumptions of crime reconstruction. The following passage from Inman and Rudin (2000, p. 177) captures the current state of affairs with respect to reconstructive research:

Very little literature has been written about reconstruction as an autonomous process. Almost no scientific research has been performed, and no universal principles have been articulated. Further, the age of specialization in criminalistics has decreased the number of criminalists that are both competent and willing to undertake a true reconstruction. The state of the practice today is such that this area is the least understood procedure in forensic science.

Forensic evidence scholar Professor Edward J. Imwinkelreid (1999, p. 516) wrote similar comments with respect to the research (or lack thereof) surrounding bloodstain pattern analysis:

While bloodspatter analysis relies on many well-accepted propositions in physics . . . it rests on a limited body of empirical research. . . . Given the limited amount of empirical research, in *Daubert* jurisdictions a particular opinion might be vulnerable to an admissibility attack. Even in a *Frye* jurisdiction, by exposing the limited underlying database, an opponent might succeed in persuading the trier of fact to attach little weight to the opinion.

Furthermore, many claim Locard's notion of transfer is the "generally acknowledged law of forensic science" (Knupfer, 2000, p. 1049). This claim is misleading because Locard's transfer theory is just that—an untested theory or concept awaiting verification. According to Inman and Rudin (2000, p. 94), "As much as the Locard transfer theory has been invoked, no peer-reviewed literature exists that proffers it, tests it, or refutes it. It is axiomatic in forensic science; it is accepted as true without proof."

A concept or theory does not become a scientific law (or principle) simply because a community of experts has repeatedly proclaimed its legitimacy but, rather, it does so through rigorous empirical testing. In the end, the reconstruction community, like the forensic science community

in general, has developed concepts rather than scientific laws or principles.⁶⁴ Inman and Rudin's (2000) research supports this contention as it relates to Locard's transfer theory (p. 85):

After reviewing Locard's writings, it seems to us far more likely that, rather than intentionally articulating a global principle, he was merely reflecting on the reasons a careful scrutiny of the crime scene, including victims, suspects, and witnesses, was worth the effort. Frequently (or perhaps, in Locard's mind, inevitably) contact between two objects will be indicated by small traces of each left on the other. Find the traces, and contact is established.

If science could be premised merely on repetitive assertions about a concept's professed legitimacy, then astrologists would have a strong argument that they too are engaged in science because so many believe in astrological concepts. As Nagel (1961, p. 2) explains:

Many men take pride in being "scientific" in their beliefs and in living in an "age of science." However, quite often the sole discoverable ground for their pride is a conviction that, unlike their ancestors or their neighbors, they are in possession of some alleged final truth.

Again, simply because a community of experts strongly believes in a particular notion, concept, or idea does not turn that concept, theory, or idea into a scientific law or principle.⁶⁵ This is explained thoughtfully by the late Imre Lakatos (1998, p. 21), a Hungarian philosopher of science and Jewish survivor of the Holocaust in Nazi Germany:

The cognitive value of a theory has nothing to do with its psychological influence on people's minds. Belief, commitment, understanding are states of mind. But the objective, scientific value of a theory is independent of the human mind which creates it or understands it. Its scientific value depends only on what objective support these conjectures have in facts.

With these thoughts in mind, what are the parameters of individuality, Locard's exchange theory, and crime reconstruction in general? Are nonhuman, mass-manufactured objects uniquely identifiable? Do individuals actually leave a perceivable trace of themselves everywhere they go or are there certain requirements, technological limits, or environmental circumstances that dictate when traces are left and when they can be detected? Can a reconstruction be performed even though fire suppression activity contaminated and altered every conceivable piece of physical evidence? Ultimately, these are questions to be answered through empirical testing and scientific inquiry, not concepts to be assumed for reconstructive convenience.

⁶⁴ Inman and Rudin (2000, p. 76) note:

Over the last several decades, a theoretical framework of sorts has . . . evolved. These fundamental precepts provide a philosophical and rational framework for the application of scientific knowledge to the forensic arena. *They are concepts that guide a forensic analysis in a logical progression*, starting with understanding the origin of evidence, and culminating in a statement of the significance of the analytical result. Unfortunately, these concepts have evolved in a fragmented manner and, in fact, no published record of a comprehensive organized paradigm exists.

⁶⁵ Lakatos (1998, p. 20) argues that "a statement may be pseudoscientific even if it is eminently 'plausible' and everyone believes in it."

Eliminating the “Experience” Shield

Science endeavors to explain how and why circumstances, observed and unobserved, occur as they do. To answer these questions in an empirical fashion, scientists put forth statements, or systems of statements, that they test methodically (Popper, 1959). Testing produces empirical data that form the foundation of scientific inferences. In short (Faigman et al., 2002b, p. 120), “God does not whisper the answers into the ears of scientists, as though they were members of a modern priesthood. The only way a scientist can reach an answer to an empirical question is to conduct an empirical inquiry.”⁶⁶

When testing is conducted, the scientist is engaged in a structured and disciplined form of observation. Accordingly, although casual observation is an aspect of the scientific method, it is not enough, standing alone, to draw valid and reliable inferences. The methodology behind the observation is what distinguishes valid and invalid inferences.⁶⁷ Thus, for traditional connoisseurs of science, the fundamental word in the phrase “scientific method” is the word “method.” A finding of fact is only as sound as the method used to discover it.

Forensic practitioners, regrettably, have frequently disregarded formal methodology by basing their conclusions or inferences on the accumulation of casual observations they have accrued over years of experience.⁶⁸ Quite often, “laboratory practices are based on intuitions and deductions, not empirical proof” (Jonakait, 1991a, p. 137). Forensic scientists and others admit openly and even proudly that this is what occurs regularly, and too often confuse it for good science. For example, according to Thornton and Peterson (2002, pp. 16–17),

[E]xperts exploit situations where intuition or mere suspicion can be voiced under the guise of experience. When an expert testifies to an opinion, and bases that opinion on “years of experience,” the practical result is that the witness is immunized against effective cross-examination. When the witness testifies that “I have never seen another similar instance in my 26 years of experience . . .” no real scrutiny of the opinion is possible. No practical means exists for the questioner to delve into the extent and quality of that experience. Many witnesses have learned to invoke experience as a means of circumventing the responsibility of supporting an opinion with hard facts.

Notwithstanding the constant questions and concerns that have been directed at hair identification, “a hair technician may testify that over many years of analysis, he or she has never seen two hairs that have ‘falsely matched’” (Stafford-Smith and Goodman, 1996, p. 260). For example, in Robert Milford’s homicide trial, an FBI examiner testified that a strand of hair located at the crime scene perfectly matched Milford’s pubic hair. He testified, “It would be highly unlikely for . . . anybody else to have hairs exactly like the hairs of Mr. Milford.” The Department of Justice (DOJ) criticized his testimony by first claiming that he did not perform his tests in a scientifically acceptable manner. In addition, the DOJ claimed the examiner overstated the hair evidence’s

⁶⁶ As Jon J. Nordby (2003, p. 5) wrote, “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.*”

⁶⁷ Faigman and associates (2002b, p. 120) state, “Methodology . . . is the engine that generates knowledge that is scientific.”

⁶⁸ Faigman and colleagues (2002b, p. 120) note, “Some people or groups who call themselves scientists do not use the scientific method. . . . Their own and their field’s beliefs are based on casual observation, or intuition, or faith, or the authority of past generations of members of their field exercising their intuition.”

significance when he testified to statistical probabilities about hair comparisons. According to the DOJ, there is (and still are) no statistical database(s) to determine the likelihood that a specific hair originated from one person and not from someone else. In his rebuttal, he argued that his statistics were supported by his years of experience as an FBI examiner (Freedberg, 2001).

Similarly, in *State v. Pierce* [786 P.2d 1255 (Okla. Ct. App. 1990)], the criminalist “testified . . . that in the years during which she had been involved with hair analysis, she had never seen hair from different people that were microscopically similar in all characteristics” (786 P.2d 1265).⁶⁹ Likewise, in *State v. Butler* [24 S.W. 3d 21 (Mo. App. 2000)] the State’s chemist was permitted to testify that “she did not recall having ever seen a match with this characteristic before in her [years working as a chemist] . . . [and that] it was *very* rare to find not only two . . . unknown head hairs that happen to match somebody else, but also two hairs from totally different body regions that match the individual” (24 S.W. 3d 24).⁷⁰ Finally, during a 1988 Texas murder trial, an FBI examiner testified, “From my 21 years of experience doing bullet-lead analysis, I can determine if bullets came from the same box of ammunition” (Piller and Mejia, 2003, p. 1).⁷¹

Although the value of experience cannot be denied, forensic scientists and reconstructionists need to support their opinions by reference to logical reasoning and an established corpus of scientific knowledge. If the previously discussed analysts’ findings were based on evidence produced by empirical research, they should have been able to produce it at trial.

More important, although experience, training, and common sense are critical in any scientific endeavor, they cannot provide the valid and informative answers that surface when a belief or assertion is tested systematically and empirically. For example, “experience tells us that children resemble their mothers in some ways and their fathers in others, and that manure increases crop yield” (Black et al., 1994, p. 755). Experience or common sense, however, “does not provide *explanations* for these phenomena” (p. 755). Furthermore, even though common sense shares certain similarities with science, it fails to methodically discover the relations between incidences that are not obviously related (p. 754). The following passage from Ernest Nagel (1961, pp. 3–4), a prominent philosopher of science, encapsulates the fundamental distinction between common-sense convictions and scientific conclusions:

⁶⁹ It should be noted that this dubious hair identification testimony was used to convict Jeffery Todd Pierce of rape and robbery in 1986. Due to DNA testing, though, Pierce was able to prove his innocence in 2001. Pierce’s exoneration triggered a massive investigation into Joyce Gilchrist’s trial testimony and lab results. Gilchrist was ultimately fired by the Oklahoma City Police Department crime lab in 2001 (see Luscombe and Bower, 2001).

⁷⁰ *State v. Magouirk*, 539 So. 2d 50, 61 (La. Ct. App. 1989) (special agent testified that “over . . . 12 years . . . I’ve looked at hair for about 10,000 different divisions, I’ve only had two occasions out of the 10,000 where I had hairs from two different people that I could not tell apart. Again, it’s not a fingerprint, but it’s normally a strong association.”); *Bivens v. State*, 433 N.E. 2d 387, 389 (Ind. 1982) (hair expert testified that on only two occasions out of 1500 did hair samples from two different individuals have identical characteristics); *State v. Hazley*, 428 N.W. 2d 406, 411 (Minn. Ct. App. 1988) (“Although hair analysis cannot conclusively identify a hair as belonging to a particular person, the technician who performed the analysis testified that in analyzing 2400 hairs per year for 16 years, she had never found a coincidental identical match.”).

⁷¹ The FBI’s comparative bullet lead analysis has since been called into serious question (see National Research Council, 2004; Finkelstein and Levin, 2005; and Imwinkelried and Tobin, 2003).

A marked feature of much information acquired in the course of ordinary experience is that, although this information may be accurate enough within certain limits, it is seldom accompanied by an explanation of why the facts are as alleged. Thus societies which have discovered the uses of the wheel usually know nothing of frictional forces, nor of any reasons why goods loaded on vehicles with wheels are easier to move than goods dragged on the ground. Many peoples have learned that advisability of manuring their agricultural fields, but only a few have concerned themselves with the reasons for so acting. The medicinal properties of herbs like the foxglove have been recognized for centuries, though usually no account was given of the grounds for their beneficent virtues. Moreover, when "common sense" does attempt to give explanations for its facts . . . the explanations are frequently without critical tests of their relevance to the facts. Common sense is often eligible to receive the well-known advice Lord Mansfield gave to a newly appointed governor of a colony who was unversed in law: "There is no difficulty in deciding a case—only hear both sides patiently, then consider what you think justice requires, and decide accordingly; but never give your reasons, for your judgment will probably be right, but your reasons will certainly be wrong."

As Nagel's passage implies, it is the yearning for explanations that are at once methodical and manipulated or controlled by factual evidence that generates science and legitimate scientific inferences.

When forensic examiners or reconstructionists are trained to use or rely on common sense or experience as a proxy for empirical research, this eventually blunts an examiner's intellectual and analytical growth. Nagel (1961, p. 5) offers an informative example:

Few who know them are capable of withholding admiration for the sturdy independence of those farmers who, without much formal education, are equipped with an almost endless variety of skills and sound information in matters affecting their immediate environment. Nevertheless, the traditional resourcefulness of the farmer is narrowly circumscribed: He often becomes ineffective when some breaks occur in the continuity of his daily round of living, for his skills are usually products of tradition and routine habit and are not informed by an understanding of the reasons for their successful operation. More generally, commonsense knowledge is most adequate in situations in which a certain number of factors remain practically unchanged. But since it is normally not recognized that this adequacy does depend on the constancy of such factors—indeed, the very existence of the pertinent factors may not be recognized—commonsense knowledge suffers from a serious incompleteness. It is the aim of systematic science to remove this incompleteness, even if it is an aim which frequently is only partially realized.

Forensic examiners who depend heavily on their experience or common sense to answer critical questions presented to them will generally be unable to think outside the box when they are presented with novel questions. Their inability to think beyond the four corners of their own experience stems from the fact that they have rarely been forced to engage in a form of critical thinking that would have shed light on the fundamental reasons and explanations that make up their particular area of expertise or science. These forensic examiners "suffer from a serious incompleteness" because they are usually incapable of connecting the dots that comprise their own area of expertise or science. Reinforcing this sentiment is Thornton and Peterson's comment regarding experienced-based testimony (as quoted in Cooley, 2004b, p. 403):

[E]xperience-based testimony dissociates the witness from science and the scientific method. Accordingly, *once science has been eradicated from the forensic scientist*, then he or she has no justifiable function to perform in the courtroom, and no business being there. . . . *If there is no science, there can be no forensic science.*

Furthermore, Ian W. Evett (1996, p. 121), a well-known and respected forensic scientist, stated the following about using one's "experience" to substantiate a particular conclusion:

Believing something to be so just because of something called "experience" is, in my view, essentially unscientific. And the toughest fights I have had have been with those who could call on many years' experience to justify their position! I believe that we have to be very wary of this thing called "experience." I believe . . . that it is fundamentally unscientific for one scientist to attempt to finish a debate with another by citing length of experience. The statement "when you've been doing the job as long as I have" always strikes me as unconvincing. How do we know that the person who has been doing the job for 30 years is any better than he was after five years? I'd only be convinced if I could see some evidence from performance in regular proficiency tests.

Evett (1996, p. 121) goes on to note that, according to his research, the claim that accuracy increases with experience is illusory:

Once I was involved in running a collaborative study to evaluate performance in identifying human hairs where . . . the participants were asked to match up unknowns with control samples from individuals. They were asked to attach numerical weight to their conclusions so it was easy to devise a simple scoring system of positive marks for correct identifications, negative marks for an incorrect identification, and zero score for no opinion. Participants also recorded their length of experience. Was there an association between performance and experience? Yes. The less experienced participants performed better! In [a] fingerprint study . . . there was [likewise] no association between number of identifications and length of experience.

In the end, although experience has its place in science, it does not define it. Science attempts to recognize and identify the underpinnings of natural phenomena through systematic empirical testing. It endeavors to complete the incomplete by identifying relationships between seemingly unrelated variables. These newly identified relationships add clarity to previously recognized explanations or create entirely new elucidations that have the potential to bring lucidity to areas of science once characterized as eternally incoherent. Regardless of whether it is the former or latter, the hunt for explanations (or wholeness) is what separates science from common sense or experience.

CASE EXAMPLES

The Misinterpreted Burn Pattern Cases

Todd Willingham's capital conviction, death sentence, and execution provide an excellent example of how experience-based testimony can lead to wholly inaccurate results, which can produce the "quintessential miscarriage of justice . . . the execution of a person who is entirely innocent" [*Schlup v. Delo*, 513 U.S. 298, 324–25 (1995)]. In 1991, Willingham's three daughters were killed in a fire that engulfed their house. Willingham was charged with capital murder after fire investigators concluded an accelerant had been used to start three separate fires inside the one-story, wood-frame home. Their findings were based on what they described as more than 20 indicators of arson (Mills and Possley, 2004).

At trial [*Willingham v. State*, 897 S.W.2d 351, 354 (Tx. Ct. Crim. App. 1995)], an expert witness for the State testified that

the floors, front threshold, and front concrete porch were burned, which only occurs when an accelerant has been used to purposely burn these areas. This witness further testified that this igniting of the floors and thresholds is typically employed to impede firemen in their rescue attempts.

The fire/arson expert's testimony was introduced to establish that Willingham "poured a combustible liquid on the floor throughout his home and intentionally set the house on fire, resulting in the death of his three children" (*Willingham v. State*, 897 S.W. 2d 351, 354). Specifically, one of the fire experts testified, "The fire tells a story . . . I am just the interpreter. I am looking at the fire, and I am interpreting the fire. That is what I know. That is what I do best. And the fire does not lie. It tells me the truth" (Deputy State Fire Marshal Manuel Vasquez as quoted in *Willingham v. State*, 897 S.W. 2d 351, 354). This same expert not only claimed that of the 1200–1500 fires he had investigated, nearly all had been arson, but also made the extraordinary claim that he had never been wrong in any of these prior cases (*Willingham v. State*, 897 S.W. 2d 351, 354). Due in large part to the expert's testimony, Willingham was ultimately convicted and sentenced to death.

Although Willingham steadfastly proclaimed his innocence, he was executed in February 2004. Immediately before being put to death, Willingham angrily stated (as quoted in [Mills and Possley, 2004](#), p. 1), "I am an innocent man, convicted of a crime I did not commit. . . . I have been persecuted for 12 years for something I did not do." Remarkably, an increasing number of individuals, particularly fire science and arson experts, truly believed Willingham was not misstating the truth when he uttered his final words. For instance, at the *Chicago Tribune's* behest, three of the country's top fire scientists (Gerald Hurst, John Lentini, and contributing author of this textbook John DeHaan) were asked to review the arson testimony presented during Willingham's trial ([Mills, 2005](#); [Mills and Possley, 2004](#)). All three experts were extremely critical of the arson testimony because much, if not all, of the testimony was based on nothing more than pure conjecture that was developed causally through years of experience investigating suspicious fires. According to Lentini ([National Public Radio, 2005](#)):

Their training was faulty and their judgment was faulty as a result of their poor training. *They relied entirely on experience.* They relied on what their mentors had taught them. And unfortunately, what the mentors taught them *had no basis in science*—crazed glass, spalled concrete, shiny alligator blisters. All of these have been over the years written down as indicators of a fire that moved too fast or burned too hot. And you can be totally confused about where the fire started, and you can also be totally confused about how the fire started.⁷²

⁷² Gerald Hurst, a Cambridge University educated chemist, commented (as quoted in [Mills and Possley, 2004](#), p. 1), "There's nothing to suggest to any reasonable arson investigator that this was an arson fire. . . . It was just a fire." Louisiana fire chief Kendall Ryland, another expert hired by the *Chicago Tribune*, said that when he attempted to recreate the conditions the original fire investigators described, he could not. When he could not, he said (as quoted in [Mills and Possley, 2004](#), p. 1) that it "made me sick to think this guy was executed based on this investigation. . . . They executed this guy and they've just got no idea—at least not scientifically—if he set the fire, or if the fire was even intentionally set." Edward Cheever, one of the fire marshals who aided in the original investigation in 1991, acknowledged that Hurst's criticism was entirely legitimate. According to Cheever (as quoted in [Mills and Possley, 2004](#), p. 1), "At the time of the Corsicana fire, we were still testifying to things that aren't accurate today. . . . They were true then, but they aren't now." Cheever's claim that the arson indicators were "true" in 1991 is disingenuous and mischaracterized in such a way to minimize the accountability or negligence of the initial arson investigators who concluded that the fire was purposely set. Scientific "truth" can only be uncovered through empirical research; if no such research was performed, then the suspected indicators cannot be considered "true" or "false"—rather, they can only be described as untested hypotheses awaiting verification. Any legitimately trained fire scientist or engineer in 1991 would have known this critical distinction between hypotheses and empirically generated scientific truths.

As Lentini, Hurst, and DeHaan stressed repeatedly, most of the beliefs about arson indicators, the very same indicators that led to Willingham's execution, were arrived at without the benefit of empirical testing.⁷³ Eventually, however, fire scientists tested these beliefs—by burning down buildings in which they had simulated both intentional and accidental fires—with the goal being to determine whether the indicators correlated with the manner in which the fires began. The results of the simulated fires led to the startlingly and unsettling discovery that many of their experienced-based beliefs about arson indicators were entirely without merit.⁷⁴

Remarkably, even after Hurst, Lentini, and DeHaan voiced their grave concerns about the arson testimony, Chief Deputy State Fire Marshal Doug Fogg, who testified that the fire was purposely set by Willingham, once again turned to his experience to substantiate his investigation and testimony. In a December 2004 interview with the *Chicago Tribune*, Fogg professed, "Fire talks to you. The structure talks to you. . . . You call that years of experience. You don't just pick that knowledge up overnight" (Mills and Possley, 2004, p. 1).

Although Fogg's comments are undoubtedly discouraging, a glimmer of hope has surfaced for other defendants, particularly capital defendants who have been unjustly convicted and, worse, sentenced to death based on these dubious theories about fire dynamics. The scientific research cited by Hurst, Lentini, and DeHaan in Willingham's case has played a significant role in exonerating two death row inmates, Ernest Willis and Kenny Richey, whose initial convictions and death sentences were also tainted by what can properly be called "arson witchcraft."

In Ernest Willis' case, Willis was convicted and sentenced to death in 1987 for purposely setting a 1986 fire that led to two deaths [*Willis v. State*, 785 S.W. 2d 378 (Tex. Crim. App. 1989)]. After unsuccessfully attacking his conviction for nearly 20 years based on his "actual innocence," Willis was granted a writ of habeas corpus in August 2004 [*Willis v. Cockrell*, 2004 U.S. Dist. LEXIS 15950 (W.D. Tex., Aug. 9, 2005)].⁷⁵ Once granted, the state of Texas had two options: It could appeal to the Fifth Circuit Court of

⁷³ As Professor Moenssens and colleagues (1995, pp. 459–460) wrote a decade ago:

Many of the arson indicators that are commonplace assertions in arson prosecutions are deficient for want of any established scientific validity. In many instances, the dearth of published material in the scientific literature substantiating the validity of certain arson indicators should be sufficient grounds to mount a challenge to the general scientific acceptability of such indicators. It is clear, from the cases, however, that arson indicators are given a talismanic quality that they have not earned in the crucible of scientific validation.

Similarly, two other fire/arson experts have written (Brannigan and Torero, 1999, p. 60):

The debate over whether fire patterns could be reliably interpreted has simmered over a number of years. The major problem has been a serious lack of high-level research. The entire arson field has a low level of qualification. In the typical case, an arson investigator is a fire officer with a very limited technical education. Unlike some other areas of forensic science, fire pattern research was rarely funded, and educational programs were limited to in-service training of fire personnel.

⁷⁴ The "old investigators' tales" that were not substantiated included wide V's versus narrow V's (which were misinterpreted to reflect the "speed of fire"); crazing of window glass (which was considered incorrectly to indicate rapid cooling; it actually indicates rapid heating); char blister and speed of fire (large, shiny blisters were believed to signify a rapid fire, whereas small blisters were thought to denote a slower fire); window sooting/staining (considered previously to suggest the type of fuel that had burned); and color of smoke and flame (likewise considered to imply the kind of fuel that was burning) (see *Federal Emergency Management Agency, U.S. Fire Administration, 1997; Lentini, 2002*).

⁷⁵ Mr. Willis' writ of habeas corpus was not granted on his "innocence" claim based on the faulty arson testimony presented at trial. Under Fifth Circuit law, a standing claim of "actual innocence" is not a cognizable claim for

Appeals or it could retry Willis. The Texas Attorney General's capital crimes section decided against appealing to the Fifth Circuit, whereas Pecos County District Attorney, Ori White, declined to re prosecute Willis after he reviewed reports completed by Gerald Hurst and another arson expert. As in Willingham's case, Hurst and the other expert concluded that the State's theory that the burn patterns were caused by a liquid accelerant equated to "voodoo" science. Hurst opined (as quoted in [McCollum, 2005](#), p. 98) that the State's fire expert's testimony was "worse than merely absurd; it [was] unconscionable."⁷⁶ The other expert similarly found that "there [was] not a single item of physical evidence . . . which support[ed] a finding of arson" (as quoted in [McCollum, 2005](#), p. 98).⁷⁷ Thus, after spending nearly 20 years on Texas' death row, Willis walked away a free man in October 2004 ([Gold and Hart, 2004](#), p. A14).

Like Willis, Kenny Ritchey was granted a writ of habeas corpus by the Sixth Circuit Court of Appeals [*Richey v. Mitchell*, 395 F.3d 660 (6th Cir. 2005)]. Prior to the Sixth Circuit's grant, Richey had spent 16 years on Ohio's death row after being convicted of starting a fire that killed 2-year-old Cynthia Collins in 1986 [*State v. Richey*, No. 12-87-2, 1989 WL 156562 (Ohio Ct. App. Dec. 28, 1989)]. Assistant State Fire Marshall Robert Cryer initially concluded that a malfunctioning electric fan accidentally caused the fire. During the trial, nevertheless, Cryer opined the fire was set intentionally. Cryer changed his preliminary opinion for two reasons. First, the crime lab reported traces of accelerants in the victim's living room carpet (*State v. Richey*, No. 12-87-2, 1989 WL 156562, n.6). Second, the "burn or pour patterns on the cement floor beneath the carpet and on the wooden porch . . . led him to conclude that the fire was arson related" (*State v. Richey*, No. 12-87-2, 1989 WL 156562, n.6). Several facts, though, surfaced after Richey's conviction that raised serious questions about the validity of the crime lab tests.⁷⁸ First, the State failed to produce any physical evidence linking Richey to the fire.⁷⁹ Furthermore, top fire scientists, retained by Richey's post-conviction attorney, opined that "no evidence exists that meets with the best scientific practice to prove there were traces of either petrol or paint stripper used in the house" (the attorney paraphrased his

relief in federal habeas proceedings. See *Willis v. Cockrell*, 2004 U.S. Dist. LEXIS 15950 *42-47 (W.D. Tex., Aug. 9, 2005)]; see also *Lucas v. Johnson*, 132 F.3d 1069, 1074 (5th Cir. 1998) (holding that "the existence merely of newly discovered evidence relevant to the guilt of a state prisoner is not a ground for relief on federal habeas corpus."); *Robison v. Johnson*, 151 F.3d 256, 267 (5th Cir. 1998).

⁷⁶ Hurst added (as quoted in [Gold and Hart, 2004](#), p. A14), "I couldn't find any trace of evidence that this was arson. It was a joke. It kind of blew me away." Hurst also noted (as quoted in [Gold and Hart, 2004](#), p. A14), "All of their indicators [that it was arson] are basically old wives' tales by today's standards. . . . Those were the bad old days of fire investigation, and it's just really unfortunate that he wound up on death row because of it."

⁷⁷ According to District Attorney Ori White (as quoted in [Gold and Hart, 2004](#), p. A14), "[Willis] simply did not do the crime. . . . The justice system actually worked in this case. But admittedly, it worked very slowly. I'm sorry it wasn't quicker. I'm sorry this man was on death row for so long and that there were so many lost years."

⁷⁸ For instance, at some point subsequent to the fire, the carpet was removed from the victim's residence by the manager of the apartment complex and was taken to a dump site. Investigators retrieved the carpet from the dump site 36 hours after the fire. Moreover, samples from the carpet were not taken until 2 or 3 weeks later. Finally, in the course of obtaining the samples, the carpet was laid out in the sheriff's department parking lot.

⁷⁹ *Richey v. Mitchell*, 395 F.3d 660, 686 (6th Cir. 2005) notes:

[Richey's] experts' attacks on the State's evidence would have been all the more powerful given the absence of corroborating physical evidence. Neither Richey's clothing, boots, or bandage revealed the presence of accelerants. No empty canisters of flammable liquids were found at or around the scene. And the owner of the neighboring greenhouse—from which the State theorized Richey stole the accelerants—was unable to determine whether anything was missing.

experts' opinions, quoted in [Macgregor, 2003](#), p. 16). In addition, the experts cast significant doubts on Cryer's testimony. For instance, during the trial, Cryer opined that given the depth and breadth of the burn patterns, Richey probably used a quart of accelerants. According to the fire scientists, at least 10 gallons would have been required to create the patterns Cryer described ([Macgregor, 2003](#)).⁸⁰

Developing and Enforcing Standards

Perhaps the most important issue in forensic science is the establishment of professional standards. An assessment is needed of standards of practice in the collection, examination, and analysis of physical evidence. —[Lee \(1993, p. 1124\)](#)

[F]orensic science require[s] adherence to standards of operation and of performance. —[Thornton and Peterson \(2002, p. 18\)](#)

Developing and enforcing practice standards are crucial to reconstruction because the scientific method is premised in part on the value of replication.⁸¹ Standards must therefore be clearly articulated and represent the consensus of opinion among a profession's members ([Thornton and Peterson, 2002](#), p. 18). Regrettably, other than those published in the current work (see Chapter 4), the reconstruction and forensic science communities have yet to establish standardized protocols for an assortment of forensic techniques ([Robertson, 1999](#)).

Reconstructionists are disadvantaged when it comes to the lack of standards because reconstructions can only be performed once identifications, comparisons, associations, and individualizations have been determined. That is, many of the forensic subspecialties that focus on identification, association, and individualization lack empirically derived standards. For instance, fields such as odontology ([Pretty and Sweet, 2001](#)), hair and fiber identification ([Stafford-Smith and Goodman, 1996](#)), firearm and tool mark identification ([Miller and McClean,](#)

⁸⁰ The Sixth Circuit's opinion highlights further inadequacies surrounding Cryer's work product and opinion [[Richey v. Mitchell](#), 395 F.3d 660, 686 (6th Cir. 2005)]:

Had counsel made the effort to find a qualified expert, rather than blindly hiring DuBois, the expert would have had the expertise and wherewithal to undermine the State's evidence that the fire was caused by arson. Custer and Armstrong [Richey's postconviction fire science experts] highlighted a litany of irregularities in the State's scientific evidence. First, Custer revealed alternative explanations for the circumstances that led Cryer to finger arson as the culprit, and surmised that the fire was more consistent with an accidental outbreak. Second, Armstrong opined that "there is no evidence of an identifiable ignitable liquid in any of the samples from the fire scenes." Moreover, the blunders that Armstrong highlighted—the State's failure to use accepted methodology, use control groups, and eliminate other explanations, to name a few—would likely have led the fact finder to adopt the defense's understanding of the science.

In November 2005, the U.S. Supreme Court vacated the Sixth Circuit Court of Appeals' opinion because the Sixth Circuit failed to determine whether Richey defaulted his ineffective assistance of counsel claim by failing to raise certain facts in state courts [[Bradshaw v. Richey](#), 126 S. Ct. 602 (2005)].

⁸¹ [McNamee and Sweet \(2003, p. 382\)](#) state, "Establishing a consensus of a standard protocol . . . aids in the unity and reliability of [any] profession." [Derry \(2002, p. 204\)](#) notes, "[Scientific] judgments are made within the context of agreed upon methodological standards that allow us to employ nature as a reliable . . . guide." As one commentator explained ([Dribben, 1994, p. 110](#)), "It is this replication of results that is the heart of science."

1998),⁸² and fingerprinting (Epstein, 2002) have yet to identify, through empirical research, specific protocols or criteria that can assist forensic examiners in determining whether individuality has been attained.⁸³ Note, however, that both firearms and fingerprints have large computerized databases at their disposal. What both need is someone versed in statistics to analyze data and develop meaningful identification/individualization criteria. This has yet to occur. Accordingly, reconstructionists risk taking some of the factual basis for their analyses on faith that good science has actually been performed.

Additionally, reconstructionists are hampered by the lack of standards that govern (or at least should govern) death and crime scene investigations and evidence collection. With respect to death investigations, as the National Institute of Justice (1999a, p. 1) admits, "There is no 'system' of death investigation that covers the more than 3000 jurisdictions in this country. No nationally accepted guidelines or standards of practice exist for individuals responsible for performing death-scene investigations."

As many cases have demonstrated, "even the most sophisticated forensic instrumentation cannot remedy errors made during the identification, collection, preservation, and transportation of evidence from the scene to the forensic laboratory" (Hanley and Clark, 1999, p. 27). Thus, contrary to popular belief, the "seemingly simple task of collecting evidence from a crime scene . . . requires a scientific approach and scientific knowledge" (DeForest, 1998, p. 1). Without any investigative or evidence collection standards, as forensic scientist Dr. Peter DeForest (2005) notes, the collection and preservation of physical evidence are severely jeopardized because it is left to the tendencies of questionably trained and educated crime scene technicians.

A complete lack of standards from evidence collection to identification and individuation provides reconstructionists and other forensic practitioners substantial discretion in selecting the methods of analysis they wish to use. When unfettered discretion is coupled with the absence of empirical testing, a significant likelihood exists that reconstructionists and forensic examiners will fail to embrace the most accurate and discriminatory tests available. Even worse, the lack of operational norms and proficiency testing may lead rogue forensic examiners to endorse radical techniques or interpretations (for articles concerning Drs. West and Robbins, see footnote 27). Courts, lawyers, and unsuspecting innocent defendants may fall prey to these untested interpretations or techniques simply because the relevant forensic community has failed to delineate the appropriate standards for demonstrating proficiency and governing interpretations.

Not only must the reconstructionist and forensic communities develop practice standards, they must also ensure that these standards are enforced continually. For example, consider the so-called "one dissimilarity doctrine" in fingerprinting (Thornton, 1977a, p. 89). According to this generally accepted doctrine (or standard), even if only one indisputable dissimilarity is observed between two prints, the prints cannot be attributed to the same finger or individual

⁸² Miller and McClean (1998, p. 20) state, "AFTE has not established specific criteria for a tool mark identification, and describes it as 'based on the examiners' training and experience.'"

⁸³ With no standardized criteria, forensic experts often disagree among themselves whether a match has been identified properly or sufficiently. For example, there have been various cases in which forensic dentists have been at odds whether a particular mark on a victim was, in fact, a bite mark or not. See *Davis v. State*, 611 So.2d 906 (Miss.1992) (state and defense experts disagree about whether mark was human bite mark); *People v. Smith*, 63 N.E.2d 879 (N.Y. 1984) (same); *State v. Kendrick*, 736 P.2d 1079 (Wash. App. 1987) (same); *Kinney v. State*, 868 S.W.2d 463 (Ark. 1994) (same); *State v. Holmes*, 601 N.E.2d 985 (Ill. App. 1992) (same); Sperry and Campbell (1990).

(Thornton, 1977a, p. 89). Although well recognized by the fingerprint community as a necessary tool to prevent false-positive identifications, according to fellow Federal Defender Robert Epstein (Epstein, 2002, p. 640), “it is effectively ignored in practice.”⁸⁴ For instance, according to Thornton, once a fingerprint examiner trawls over the prints and comes across what he or she believes to be an adequate quantity of corresponding points of similarity to make an inculpatory identification, the examiner will simply disregard any dissimilarities by explaining them away as being either a manifestation of distortion or an artifact. As Thornton (1977a, p. 89) wrote:

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

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

Reconstruction conclusions work in much the same way: A theory not supported by all of the facts and evidence must be abandoned. However, in practice, reconstructionists often pick and choose from the evidence that supports their conclusions and may explain away or outright ignore that which does not. Developing and enforcing articulable practice standards that address this and other issues is a good start. In the author’s estimation, adherence to those standards discussed in Chapter 4, as well as the ethical canon suggested in Chapter 2, would be a welcome sign that the reconstructionist is making honest efforts to perform solid, reliable work.

The Need for Independent Case-Based Peer Review

There were aspects of Mr. Cawley’s testimony that undermined his credibility. . . . Mr. Cawley said that his peers always agreed with each others’ results and always got it right. Peer review in such a “Lake Woebegone” environment is not meaningful. –*United States v. Lewis* [220 F. Supp. 2d 548, 554 (S.D. WV 2002)]

Forensic examiners often claim on the witness stand that their results are accurate because a colleague (or peer) has reviewed the final report and has subsequently agreed with the methods and results contained within. In this fashion, the occurrence of peer review is used to create the impression that conclusions or identifications suffered a systematic critique that was designed specifically to ensure the accuracy of their conclusions.⁸⁵ This is not necessarily the

⁸⁴ Mr. Epstein was the first defense attorney to make an all-out *Daubert* attack on fingerprinting, as he spearheaded the litigation that led to one of the most comprehensive opinions regarding fingerprinting’s admissibility. See *United States v. Mitchell*, 365 F.3d 215 (3rd Cir. 2004).

⁸⁵ *United States v. Harvard*, 260 F.3d 597, 599 (7th Cir. 2001) (“Meager also testified that the error rate for fingerprint comparison is essentially zero. Though conceding that a small margin of error exists because of differences in

case because much of the forensic community embraces a form of peer review that can best be described as “formalistic” peer review.

Formalistic peer review is the type of peer review advocated by American Society of Crime Laboratory Directors (ASCLD, 2000) standard 1.4.2.16. This ASCLD standard states that the function of a laboratory’s peer review process is “to ensure that the conclusions of its examiners are reasonable and within the constraints of scientific knowledge.” Under formalistic peer review, the reviewer, in effect, simply functions as a shallow check on the procedures utilized by the initial examiner; making certain the report adequately documents and explains its findings and conclusions. The reviewing examiner is, in effect, simply ensuring that the initial examiner’s report contains all the necessary formalities (e.g., what techniques were used and whether the examiner documented his or her findings thoroughly to explain the conclusion). This form of peer review should not be mistakenly interpreted or presented as an independent verification of the initial conclusions’ accuracy (Risinger et al., 2002).

Often, this form of peer review is presented inappropriately to prosecutors, courts, and defense attorneys as a process that ensures the accuracy of the initial examiner’s conclusions. This is intellectually dishonest because this form of peer review is easily susceptible to subconscious context effects (i.e., observer effects; see Chapter 3). For instance, even if the peer reviewer(s) is not exposed to contaminating information, like the initial examiner may have been, the reviewer(s) knows the original examiner’s conclusions, which, as mentioned, is a strong impurity that can influence the reviewer’s evaluation. What we have under this fact pattern, then, is an examiner (albeit a second one) who is made privy to an expected outcome before he or she evaluates an ambiguous stimulus. Thus, from a practical perspective, we have one examiner going to another examiner and saying, “Look, I found 13 points of similarity and concluded that the crime scene fingerprint without question came from the defendant’s right index finger; all need you to do is review my identification so I can take this information to the district attorney.” Under this fact pattern, we are again at square one because the initial examiner’s conclusions will, without question, influence (consciously or subconsciously) the reviewing examiner’s conclusion(s). In short, the reviewing examiner is, without question, vulnerable to a specific kind of observer effect—“confirmation bias.”

To complicate matters even more, consider the scenario in which the initial examiner is the reviewing examiner’s superior or supervisor who presumably has more experience than the reviewing examiner. In this scenario, the reviewing examiner’s ultimate conclusion will be impacted by two irrelevant, yet powerful, factors—the initial examiner’s conclusion and rank. The latter factor (i.e., the initial examiner’s rank or title) may cause the reviewing examiner to minimize or withhold any criticisms or concerns regarding the initial examiner’s conclusion or identification for fear that any criticisms may harm his or her future advancement. Moreover, the less experienced reviewing examiner may internalize legitimate concerns or shortcomings regarding the initial examiner’s results. For example, a less experienced reviewing examiner may feel very strongly that the more experienced fingerprint examiner misidentified various points of correspondence. Thus, from the less experienced examiner’s review, there are only 6 points of similarity rather than 13. However, rather than being candid with the more experienced fingerprint examiner, the less experienced reviewing examiner may convince himself or

individual examiners, he opined that this risk is minimized because print identifications are typically confirmed through peer review.”); *United States v. Rogers*, 26 Fed. Appx. 171, 173 (4th Cir. 2001) (unpublished opinion) (“The possibility of error was mitigated in this case by having two experts independently review the evidence.”).

herself that the reason he or she is unable to identify all 13 points of similarity is his or her lack of experience. ASCLD and its stable of certified crime labs continue to claim that formalistic peer review ensures accuracy. However, given these influences and scenarios, it is clear that this is not the case. The reviewers involved are too easily tainted or otherwise vested in the outcome.

CASE EXAMPLE

The Brandon Mayfield Misidentification

Consider the FBI's fingerprint misidentification with respect to the train bombing in Madrid, Spain. On March 11, 2004, a bomb exploded in a Madrid train station that killed 191 and injured approximately 2000 people (Sciolino, 2004). Spanish authorities discovered a bag of detonators in close proximity to the site of the explosion with a fingerprint on it that did not match any in their databank (Schmidt and Harden, 2004). Spanish authorities forwarded the print to several law enforcement agencies, including the FBI. After searching its fingerprint database, the FBI located a possible match to the prints of Mr. Brandon Mayfield, an attorney in Portland, Oregon (Schmidt and Harden, 2004).

From the outset, there were disconcerting and curious aspects about the FBI's professed match. For instance, Mr. Mayfield had converted to Islam, his wife was Egyptian, and he represented one of the "Portland Seven," a group of Muslim men convicted of terrorist conspiracy, in a child custody case. However, there was no evidence that Mr. Mayfield had been out of the United States in many years (Schmidt and Harden, 2004). Nevertheless, three highly qualified FBI examiners (current and retired) concluded that the print was a "100 percent positive identification" and so informed the Spanish authorities on April 2, 2004 (FBI, 2004; Stacey, 2005b). Mr. Mayfield was arrested on May 6, 2004.

The FBI's identification of Mr. Mayfield was incorrect. Spanish authorities eventually came across an Algerian suspect named Ouhnane Dauod whose prints "matched" the prints found on the bag more closely (Schmidt, 2004). The final piece of evidence came when the Spanish authorities "found traces of Daoud's DNA in a rural cottage outside Madrid where investigators believed the terrorist cell held planning sessions and assembled the backpack bombs used in the attack" (Tizon et al., 2004, p. A13). Mr. Mayfield was ultimately released after spending 2 weeks in jail and received a rare apology from the FBI (Heath and Bernton, 2004).

In the aftermath of the Mayfield misidentification, an international review committee was commissioned to determine how and why three highly trained FBI fingerprint examiners mistakenly linked the fingerprint to a wholly innocent person. The committee's report, which ironically was written by an FBI employee, Robert Stacey of the FBI's Quality Assurance and Training Unit, rather than the committee itself,⁸⁶ offered a variety of explanations why Mr. Mayfield was wrongly inculpated. A primary explanation offered by the FBI was that the reviewing examiners fell prey to "confirmation bias (or context effect)." Specifically, the FBI's report noted that (Stacey, 2005b):

⁸⁶ As Professors Thompson and Cole (2005, pp. 42–43) have noted correctly, having the agency that actually made the mistake write the official "audit" report pertaining to their own lapses or errors raises legitimate concerns as to whether Mr. Stacey and the FBI were entirely forthright about the extent of the problems they identified in the report pertaining to the FBI's fingerprinting methodology and its examiners. Thompson and Cole insightfully analogized this fact pattern to a bank that is being audited: "By analogy, imagine a bank audit in which the conclusions are written by one of the bank's managers rather than the auditors themselves."

the power of the IAFIS match, coupled with the inherent pressure of working an extremely high-profile case, was thought to have influenced the initial examiner's judgment and subsequent examination. This influence was recognized as confirmation bias (or context effect) and describes the mind-set in which the expectations with which people approach a task of observation will affect their perceptions and interpretations of what they observe.

The apparent mind-set of the initial examiner after reviewing the results of the IAFIS search was that a match did exist; therefore, it would be reasonable to assume that the other characteristics must match as well. In the absence of a detailed analysis of the print, it can be a short distance from finding only seven characteristics sufficient for plotting, prior to the automated search, to the position of 12 or 13 matching characteristics once the mind-set of identification has become dominant. This would not be an intentional misinterpretation of the data, but it would be an incorrect interpretation nevertheless.

Once the mind-set occurred with the initial examiner, the subsequent examinations were tainted. Latent print examiners routinely conduct verifications in which they know the previous examiners' results without influencing their conclusions. However, because of the inherent pressure of such a high-profile case, the power of an IAFIS match in conjunction with the similarities in the candidate's print, and the knowledge of the previous examiners' conclusions (especially since the initial examiner was a highly respected supervisor with many years of experience), it was concluded that subsequent examinations were incomplete and inaccurate. To disagree was not an expected response.

Additionally, this erroneous individualization was not made by an examiner alone, but by an agency that for many years has considered itself, rightfully so, as one of the best latent print units in the world. Confidence is a vital element of forensics, but humility is too. It was considered by the committee that when the individualization had been made by the examiner, it became increasingly difficult for others in the agency to disagree. This is supported because the Latent Print Unit immediately entered into a defensive posture when the Spanish National Police issued its statements that the FBI was wrong.

"Independent" peer review in the identification sciences involves having another examiner who is entirely unaware of who the original examiner is and the original examiner's conclusions.⁸⁷ In these circumstances, the reviewing examiner cannot be persuaded by related extraneous information or expectations. Independent confirmation, in effect, involves evaluating all of the underlying documentation to determine whether the reviewing examiner can recreate the initial examiner's conclusions. If the reviewing examiner cannot replicate the initial conclusions, then the validity of the original examiner's conclusions must be called into question. Again, it needs to be stressed that independent confirmation is a blind-testing procedure in that the reviewing examiner has no active knowledge with respect to any superfluous data or anticipated outcomes.

Consequently, reconstructions based on identifications and associations developed through formalistic peer review may be presented with an unearned level of confidence and certainty. This is to be avoided. Furthermore, reconstructionists who seek to bolster their own findings through peer review have an obligation to understand, and make clear to the court, its actual nature and limitations.

The Responsibility of Professional Associations

There is a real need for tightening of requirements for membership in professional forensic societies to make member quality more significant than member quantity. —*Midkiff (2004, p. 77)*

⁸⁷ That means nonmatches and supposed matches be submitted routinely, as otherwise they would know that someone else had made a match.

Reconstructionists and other forensic examiners have an individual measure of responsibility, but so do those professional organizations that confer credentials upon them. According to the (past) president of the AAFS, Kenneth E. [Melson \(2004, p. 1\)](#), “While forensic science organizations, like the (American) Academy (of Forensic Sciences) and some certifying organizations, have ethics codes, there is no universally recognized applicable, and enforceable code of professional responsibility for forensic scientists.” With no “universally recognized” ethical standards, identifying and sanctioning unethical behavior have been left to the professional organizations that have conferred forensic credentials and established codes of ethics (e.g., American Academy of Forensic Science, American Board of Criminalistics, California Association of Criminalists, International Association of Identification, and Association of Crime Scene Reconstruction). These professional organizations have the ability to send harsh and swift admonishments to their members when they engage in unethical behaviors (e.g., purposely misrepresent their qualifications, testify beyond the realm of their expertise, provide contradictory testimony in various cases, or knowingly fabricate evidence).

At a time when the criminal justice system’s view of forensic science is fairly low, these professional organizations have the extraordinary ability to change how the justice system perceives forensic evidence and forensic examiners. Immediately reprimanding or, in extreme cases, exiling unethical individuals would give the refreshing appearance that the forensic science community is genuinely interested in policing itself. Likewise, it would demonstrate to forensic watchdogs that the organization is extremely concerned with the fact that its members are competent, objective, and ethical. Actions such as these would perhaps even begin the slow process of reconciliation because, as it stands currently, the relationship between forensic science and the criminal justice system is not what it used to be (i.e., courts are no longer turning a blind eye to questionable science). In short, professional organizations must not bury their heads in the sand when it comes to enforcing their high ethical standards. As one past president of the AAFS stressed emphatically ([Joling, 1976, p. 746](#)):

Ethical principles cannot be ignored. Indeed, they must not be ignored! The misapplication of forensic science is a possibility and is part of the realities of human frailty. Indifference to these actualities can only result in the immediate disrespect for the entire discipline and the forensic science organization that umbrellas that discipline. A wrongful act can be condoned by inactivity, silence, “stonewalling,” or by ignoring professional ethics. Flagrant disregard for truth and justice can be noted by disinterest as well as by active participation in its propagation.

Unfortunately, forensic science organizations seem to be taking a back seat when it comes to enforcing their own ethical codes by turning a blind eye to behavior that is inappropriate under any fact pattern. In his chapter in *Richard Saferstein’s Forensic Science Handbook*, Charles [Midkiff \(2004, pp. 77–78\)](#), a retired ATF forensic examiner, stated the following about the lack of ethical oversight in forensic science professional organizations:

When faced with a threatening situation, the box turtle retracts its head, closes its trap door, and sits quietly until sufficient time has passed for the threat to have receded. When faced with a threat such as dealing with charges to serious ethical violations by one of their members, forensic organizations seem to find the turtle model appropriate. The turtle is aware that he is unlikely to outrun the threat, so he doesn’t even try. He sits patiently and waits, hoping against hope that when he slowly opens his shell, the ogre will be gone. Ethics committees of forensic societies and even the certifying boards much prefer to sit and wait as well. Even when they initiate action, it moves even more slowly than the turtle, and the delay is sufficiently lengthy that the miscreant, aware he is a target, simply neglects to pay his dues and renew his membership. He doesn’t even have to write a letter of

resignation. At the next encounter of members of the ethics committee, we may hear, "Whew! He's gone. Now nobody can expect us to do anything; why he's not even a member anymore." After all, we don't have any authority to take action against nonmembers. If the organization truly believes in swift justice, maybe a bit of it would be useful. Retention of an identified fraud among the membership is hardly a public relations success for the organization or the field. There is a need for teeth in ethics policies of forensic professional organizations and for those policies to be put to work promptly when a fraud is exposed.

CASE EXAMPLE

The author received discovery materials detailing a litany of gross ethical misconduct by a well-known reconstructionist and bloodstain expert. The expert's unethical behavior was detailed as follows.

In numerous cases, the expert gave contradictory opinions about whether expectorated blood from the nose or mouth can make high-velocity impact spatters. The expert's opinion always favored the prosecution's theory.

The expert repeatedly misrepresented whether he had ever worked for the defense. In some cases, he testified he had previously worked as a defense expert; in other cases, he testified he had not.

In various cases, the expert testified he received graduate training at the University of Virginia (UV) (this information was also on his resume). This was materially untrue, as UV never had a "graduate school in police management and administration."

In various cases, the expert testified he did postgraduate work at Cal State Fullerton (CSF) (this information was also on his resume). This again was materially untrue because CSF does not have any record that he ever attended CSF.

In certain cases, the expert testified he was a "forensic scientist" and that he clearly understood elementary chemistry and physics because he took college-level courses in chemistry in physics. On other occasions, however, the expert testified he had no education in physics or chemistry.

In one case, the professed "forensic scientist" testified he did not understand the fundamentals of Newtonian physics, viz., $\text{force} = \text{mass} \times \text{acceleration}$ (without a firm grasp of physics, one cannot be a competent bloodstain analyst).

In one case, the expert testified that he had conducted bloodstain research with real blood. In a later case, however, the expert testified he had never carried out any bloodstain research and that all his experience was "real-life" experience.

One well-respected forensic pathologist stated the following about the expert after reviewing his analyses and opinions in a particular case:⁸⁸

In my opinion, [the expert] misrepresented facts and evidence. He overinterpreted and reached conclusions on scientific evidence that were pure conjecture yet he led the jury to believe that he was more than just certain of his opinions, that he was in some cases one hundred and ten percent sure about facts which had various possibilities as to their interpretation and probative values to the case. I read a number of sworn testimonies given by [the expert] in the Utah case. I was so appalled by his testimony that it was all that I could do to continue to read what he was saying. All I can say is that in the 20 years that I have practiced as a forensic pathologist which includes dealing with and being involved in cases from all over the country and other countries as well, my exposure to [the expert] was one of the most frightening things which has occurred to me in my career.

⁸⁸ Quoting chief medical examiner for Fulton County (Atlanta) Georgia, Joseph Burton, M.D. This quote was extracted from a relief from judgment motion in *Michigan v. David E. Duyst*, S.Ct. No. 124548, Cir. Ct. No. 00-9779-FC (motion on file with the author).

Considering these factual claims, it is not surprising that an individual filed an ethics complaint with the AAFS against this expert, as he is an AAFS fellow and prominent member. In a letter to the individual who filed the complaint, the AAFS stated:⁸⁹

[The AAFS] did receive a more detailed response from Hon. Haskell Pitluck, Chair of the Ethics Committee, which was distributed to the members of the executive Committee prior to our meeting last month. The matter was thoroughly discussed (in Executive Session) at our recently completed meeting, and after considerable debate, it was decided that no further action on the part of the Executive Committee or the Board of Directors was warranted.

The Executive Committee saw two major issues in this case—one involving entries on the C.V. of the accused, and the other involving testimony given by the accused. Both issues hinged on whether or not the actions on the part of the accused could be proven to be deliberate. In the first case, the accused agreed to correct the offending portions of their C.V. while claiming no impropriety. The Ethics Committee was subsequently provided with a copy of the corrected version. Obviously, should the accused continue to provide uncorrected copies of their C.V., or make the same representation as before the hearing, there would no longer be an issue of intent.

The second issue is a somewhat different matter. After having reviewed the materials provided to me, I was also troubled by some of the testimony given. However, as you know, this is basically opinion testimony, and under our current Bylaws, it is not unethical to be ignorant. Also, as Haskell pointed out in his memo these issues were subject to cross-examination at the time of trial. Barring any positive proof that the testimony was deliberately intended to misrepresent the facts of the case, there is really nothing that the Ethics Committee can do at this time.

The AAFS sent the expert a cease-desist notification. The ethics committee ruling seems at odds with its Code of Ethics and Conduct (CEC) which states:

Every member ... shall refrain from providing any material misrepresentation of education, training, experience, or area of expertise. Misrepresentation of one or more criteria for membership in the AAFS shall constitute a violation of this section of the code.

Consider this reasoning: There can be no question that ignorant practice will invariably result in an incompetent work product. In this case, if the examiner demonstrates that he is ignorant of the fundamental sciences (e.g., physics and chemistry) that comprise his field of expertise (i.e., bloodstain interpretation), then it stands to reason he is not an expert at all. If he is not an expert, then he is ethically bound to refrain from offering expert services to anyone—defense or prosecution. That he continues to testify with AAFS approval runs counter to the AAFS's CEC and its overall objective.

Additionally, under the CEC, "Every member of the American Academy of Forensic Science shall refrain from exercising personal or professional conduct adverse to the best interests and purposes of the Academy." The suggestion that repeated incompetence does not constitute "conduct adverse to the best interests and purposes of the Academy" hardly seems defensible.

Moreover, according to the AAFS (bylaws, section III of the Preamble), its objective is

to promote education for and research in the forensic sciences; to encourage the study, improve the practice, elevate the standards, and advance the cause of the forensic sciences; to promote interdisciplinary communications; and to plan, organize, and administer meetings, reports, and other projects for the stimulation and advancement of these and related purposes.

The failure of the AAFS to enforce its own ethical guidelines is as frustrating as it is disappointing. This being the case, those on the AAFS ethics committee, as well as those in other forensic

⁸⁹ American Academy of Forensic Science memo on file with author.

professional organizations, should perhaps recall the words written three decades ago by the AAFS's (then) president (Joling, 1976, p. 745):

The day has arrived when the Academy can no longer hide its scientific light under a bushel basket. We have been and are now within the public domain. As time passes more and more of our members will be involved in matters of great public debate, controversy, and importance. We cannot remain isolated as a national organization while having our members intimately involved in scientific determinations and judicial utilizations of our individual and collective expertise. Consequently, the American Academy of Forensic Sciences has present national obligations—and it will continue to exert an influence locally, statewide, and nationally in the future. As a result, we can no longer escape into scientific seclusion, but rather we must face our greatly increased role of responsibility in the advocacy of issues which have public overtones. Invidious, unusual, or paramount problems of public as well as private concern for the rights of individual members of society or society as a whole have been placed upon our doorstep—and they will be placed there again.

CONCLUSION

As this book, in general, and this chapter, in particular, clearly demonstrate, every field in forensic science is under siege. Attacks are coming from not only the defense bar but also prosecutors, judges, and other critical criminal justice advocates who, until recently, believed faithfully and blindly in the forensic scientist's "special knowledge" and infallible interpretations. Consequently, the forensic science community (reconstructionists included) is at a critical crossroads. Forensic professionals can do one of two things: (1) They can stand tall, admit to the community's obvious problems and shortcomings, and then work to solve them or (2) they can continue to disregard the mounting evidence of incompetence, poor science, and fraud by portraying all those who cast a critical eye on the forensic sciences as ignorant outsiders who do not have the faintest clue of how forensic science is truly practiced.

If forensic professionals continue to travel the second course, there is no question that their courtroom role will continue to be embattled and continue to suffer decline. Preferably, forensic professionals will choose the former rather than the latter. By critically evaluating those factors that have precipitated the decline of forensic science and by developing the means to change them, forensic practitioners may begin to regain their "professional chastity."

This textbook has highlighted a number of causal factors leading to the decline of forensic science—the most important being access to high-quality forensic and scientific education (or the lack thereof). Forensic science and crime scene reconstruction reform must therefore begin with education, and this textbook can be an important part of that process. As the various contributors to this text have identified, there is much room for improvement in the forensic sciences and in the field of crime reconstruction. Taken all at once, the task may seem too daunting, even overwhelming. Taken one problem at a time, over time, and by a community of concerned practitioners, it is perhaps an attainable objective.

In any case, various courts have shown that they notice, and expect, more from forensic examiners than has been asked in the past—more in the way of demonstrating competency and proficiency, more in the way of demonstrating objectivity, and more in the way of showing one's work. The true forensic reconstructionist will not only meet these expectations when

possible but also work to exceed them. In this way, he or she will show that the court has not been misled in qualifying him or her as an expert witness.

SUMMARY

Although reconstructionists and other forensic examiners are influential players in the criminal justice system, their roles at trial and subsequent expectations regarding their findings have evolved rapidly during the past 20 years, principally in the past decade.

The winds of change have been accelerating steadily during this time, as an increasing number of legal actors (e.g., defense attorneys, judges, and scientists) have started to investigate and question the accuracy of forensic methodologies, as well as the nature of testimony regarding evidence interpretations. There are at least eight reasons why this tidal wave of scrutiny has come crashing down on the forensic community, including the following:

- The advent of DNA technology
- Noticeable correlation between forensic misidentifications and wrongful convictions
- Crime lab crisis
- Escalating discovery of forensic fraud
- Escalating discovery of forensic incompetence
- The media's impact on potential jurors
- Increased forensic awareness of criminal defense attorneys
- Daubert* revolution in regard to the admission of expert testimony

Reconstructionists must be equipped with the requisite technical and scientific comprehension to survive in the 21st-century courtroom. The reconstruction community needs to embrace various related reforms, from a defense attorney's perspective. Implementing these reforms would go a long way to blunt the intense scrutiny being directed at the forensic and reconstruction communities because they would help substantiate the reliability, validity, and proficiency of interpretive forensic conclusions in the eyes of the criminal justice system. These reforms include education and training, research, developing and enforcing practice standards, the need for independent case-based peer review, and the responsibilities of professional organizations.

QUESTIONS

1. Provide two reasons why the forensic community has been scrutinized by the legal community.
2. What were the "DNA wars"?
3. Explain the legal challenges to fingerprint evidence.
4. Provide two examples of forensic fraud.
5. Explain the difference among the *Frye*, *Daubert*, and *Kumho* rulings with respect to expert admissibility.

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Forensic Examination Reports¹

W. Jerry Chisum, Brent E. Turvey and Jodi Freeman

Key Terms

Brady v. Maryland; Cherry picking; Due process; Forensic examination report; *Melendez-Diaz*; Peer review

When forensic scientists complete their examinations, they are generally expected to provide an account of any findings. This is best accomplished by first writing a report, and later through depositions and testimony as necessary.² A **forensic examination report** is a detailed description of the evidence and materials examined, the examinations performed, the methods used, the results achieved, and any conclusions that may subsequently be derived.

Report writing is an essential skill in most professions, especially those of a scientific nature. However, the majority of forensic examination reports do not meet acceptable scientific standards. In fact, it is common for such reports to “contain only identifying and agency information, a brief description of the evidence being submitted, a brief description of the types of analysis requested, and a short statement of the results,” and “[t]he norm is to have no description of the methods or procedures used, and most reports do not discuss measurement uncertainties or confidence limits” (Edwards and Gotsonis, 2009, p. 3–6). In other words, most forensic examination reports do not explain how results were achieved or interpretations rendered, and tend to leave readers with a false sense of overconfidence regarding any findings that are presented.

There can be several reasons for this. First, there are the *inept*: Many forensic scientists are poorly trained and lack good writing skills; their deficiencies are a genuine reflection of what they believe to be adequate practice because nobody has ever corrected them. Second, there are the *fearful*: These examiners fear revealing too much about what they did or what their findings mean within a given case; theirs is a genuine concern about revealing ignorance, hurting their employer’s case, or being wrong. Next are the *equivocal*: In these instances, examiners hold determinations close to the vest so as to preserve their ability to change them later. In such cases, reports are late, short, and the

¹ This chapter is, in part, adapted from material originally developed for Turvey and colleagues (2010).

² Depositions and testimony are discussed in Chapter 20: Reconstruction Court Presentation and Testimony.

terminology is either confusing or nonspecific. More commonly, however, forensic examiners simply do not have the time, or do not wish to take the time, to make a full reporting.

Whatever the case, not one of these reasons provides a legitimate justification for deficient forensic reporting. Even claiming ignorance of practice is an unrepentant proclamation that one is not an expert, and therefore should not be conducting forensic examinations. As explained by Dr. John Thornton (Kirk, 1974, pp. v–vi):

When the liberty of an individual may depend in part on physical evidence, it is not unreasonable to ask that the expert witnesses who are called upon to testify, either against the defendant or in his behalf, know what they are doing.

The purpose of this chapter is to help alleviate the epidemic of substandard reporting that currently plagues the forensic community. While the forensic reconstructionist is featured, it is universal in its application to any endeavor where scientific results are being rendered for court-related purposes. It provides a practical foundation regarding the necessary philosophy of forensic reporting and a basic outline for how such reports should be prepared.

COMMUNICATION

The goal of a forensic examination report is to communicate findings in a clear and logical manner. This cannot be achieved with imprecise, sloppy, or poorly crafted writing. It is therefore incumbent upon the forensic scientist to learn not only the science and skills associated with their work, but also how to write without making basic errors.

There are actually fundamental rules for writing that everyone should know and follow: They are collectively referred to as *grammar*. Many police and forensic reports contain serious grammatical errors that can lead to misunderstanding on the part of any reader. Forensic scientists must learn how to structure a sentence and when to end it; how to structure a paragraph and when to end it; and how to craft these into a cohesive report of findings. Often, taking or retaking basic writing courses is helpful in this regard.

Spelling errors are also frequent. Forensic scientists should have and demonstrate a command of proper spelling with respect to everyday language, terms specific to their area of expertise, and any terms from associated disciplines (e.g., forensic pathology, law, and investigations). For example, they should know that “homicide” is not spelled “homocide.” They should also avoid phonetic spellings, slang, and abbreviations that have become a regular part of e-mail and text communications. When in doubt about the spelling or a particular term, look it up in the dictionary and write it out in full.

Spelling errors can be alleviated, in part, by the use of spell checking programs that are a built-in feature of most writing software. Sometimes, however, the word is spelled correctly, but it is the wrong word (e.g., to, too, and two; there and their; bear and bare). Also, there are words that are similar but mean very different things (e.g., affect and effect). Forensic scientists must know the difference—just because something is recommended by the spell-checker doesn’t mean that it is the right word for the context.

These errors and others like them not only lead to misinterpretations, but also reflect poorly on the education and professionalism of the writer; the care that the writer has for his or her

work product; and the care that supervisors have for the quality of reports written under their supervision. Again, the forensic scientist must learn to write.

PROFESSIONALISM AND DISCLOSURE

Forensic scientists are concerned with helping secure justice, not necessarily a prosecution or a defense. Subsequently, they have an ethical responsibility to ensure that their findings are wholly and effectively communicated to any intended recipients, including investigators, attorneys, and the court (Gannett, 2011).^{3,4} There is no better mechanism than writing it all down, which is perhaps the most accepted form of professional communication. This requires the forensic scientist to be competent in the task of intelligible writing.

The suggestion that report writing has a particular value when rendering forensic conclusions is not at all new. Dr. Hans Gross wrote, for example, of the critical role that forensic examination reports play in investigative and forensic contexts. Specifically, he wrote that just looking at evidence and forming opinions are only the beginning. He argued that there is utility in reducing one's opinions to the form of a report to identify problems in the logic of any theories (Gross, 1906, p. 439):

So long as one only looks on the scene, it is impossible, whatever the care, time, and attention bestowed, to detect all the details, and especially note the incongruities: but these strike us at once when we set ourselves to describe the picture on paper as exactly and clearly as possible. . . .

The experiences of the authors concur with those of Dr. Gross. The act of preparing opinions in a written format, gathering references, forming supportive argumentation, and rendering deliberately crafted conclusions is a valuable step in the analytical process. It allows errors and omissions in any of these areas to be realized and helps identify breaks in the logic of misinformed interpretation. It also provides the forensic scientist with a record of the examination that should be sufficient to refresh their recollection from the stand should their memory of any pertinent specifics falter.

DUE PROCESS, BRADY VIOLATIONS AND THE CONFRONTATION CLAUSE

In the performance of casework, forensic scientists are bound to accept the law and any related rulings of the court in their approach, analyses, and interpretations. However, only so long as these external mandates do not interfere with good scientific practice. For instance, they must not generally assume the guilt of a defendant as part of their analysis, as this is the very

³ Gannett (2011) cites multiple professional forensic organizations with comprehensive ethical codes requiring that members (p. 25) "fully explain results and conclusions, including qualifications and limitations." This is also explained in Edwards and Gotson (2009).

⁴ Despite film and television depictions of courtroom dramas, it is rarely the case that a jury will be given any investigative or forensic reports to review directly. Generally, a juror's notes and memory of courtroom testimony must suffice during deliberations. That is, if they are allowed to take notes, which is not a given. Every judge has his or her own view on such matters, and it is therefore different in not just every courtroom, but every case heard within.

issue to be decided at trial. Even in postconviction work, where guilt is a legal reality, this may be an issue under review. In other cases, however, guilt will have been conceded by a defendant in accordance with corroborating evidence, and such an assumption may be appropriate or even required by the court. The other issues for the forensic scientist, at this point, involve due process and *Brady v. Maryland*.

Due Process

Scientists employed by the prosecution have a very specific burden with respect to their findings and what is referred to as **due process**. The 5th and 14th Amendments to the U.S. Constitution provide that the government may not deprive its citizens of “life, liberty, or property without due process of law.” This provision is essentially a fairness requirement. Ideally, citizens may only be tried and punished for crimes alleged by the state under the most impartial and unprejudiced conditions. Any condition or treatment that tends to bias a judge, jury, or the process as a whole in favor of the state is considered a violation of due process.

Common due process violations include things such as inadequate defense counsel, inadequate access to legal counsel or private experts, failure to admit proffered experts, and failure to disclose exculpatory evidence or witnesses. In reality, the government has more money, more resources to draw from, and often benefits from a presumption of guilt held by ignorant and even partial jurors (and jurists). Under these conditions, due process is an ideal rather than a reality.

To abide the mandates of due process, scientists employed by the government must conduct forensic examinations in such a way as to be transparent in their methods and findings. As explained in [Edwards and Gotsonis \(2009, pp. 3–6\)](#):

As a general matter, laboratory reports generated as the result of a scientific analysis should be complete and thorough. They should describe, at a minimum, methods and materials, procedures, results, and conclusions, and they should identify, as appropriate, the sources of uncertainty in the procedures and conclusions along with estimates of their scale (to indicate the level of confidence in the results). Although it is not appropriate and practicable to provide as much detail as might be expected in a research paper, sufficient content should be provided to allow the nonscientist reader to understand what has been done and permit informed, unbiased scrutiny of the conclusion.

Some forensic laboratory reports meet this standard of reporting, but most do not. Some reports contain only identifying and agency information, a brief description of the evidence being submitted, a brief description of the types of analysis requested, and a short statement of the results (e.g., “The green, brown plant material in item #1 was identified as marijuana”). The norm is to have no description of the methods or procedures used, and most reports do not discuss measurement uncertainties or confidence limits. Many disciplines outside the forensic science disciplines have standards, templates, and protocols for data reporting. Although some of the Scientific Working Groups have a scoring system for reporting findings, they are not uniformly or consistently used.

Forensic science reports, and any courtroom testimony stemming from them, must include clear characterizations of the limitations of the analyses, including associated probabilities where possible.

In other words, forensic scientists must not withhold, conceal, or distort their examinations, methods, and related findings. Reports must be written in a clear fashion so as to be within the intellectual grasp of the layman, while also containing sufficient detail to accurately convey what they did, what they found, and what it means.

Brady v. Maryland (1963)

In the United States, this level of accountability is intended to comply with a well-known and often ignored (or misunderstood) legal standard passed down from the U.S. Supreme Court regarding evidence and its discovery to the defense: *Brady v. Maryland* (1963). By working within

the mandates set forth in *Brady*, forensic scientists are meant to help create equal access to the government's findings, prevent what is generally referred to as "trial by ambush," and seek to avoid miscarriages of justice. As explained in [Gershman \(2006, pp. 685–686\)](#):

Brady's holding is familiar to virtually every practitioner of criminal law: "[T]he suppression by the prosecution of evidence favorable to an accused upon request violates due process where the evidence is material either to guilt or to punishment, irrespective of the good faith or bad faith of the prosecution."

This principle, according to the Brady Court, reflects our nation's abiding commitment to adversarial justice and fair play toward those persons accused of crimes. As the Court observed: "Society wins not only when the guilty are convicted but when criminal trials are fair; our system of the administration of justice suffers when any accused is treated unfairly." Indeed, by explicitly commanding prosecutors to disclose to defendants facing a criminal trial any favorable evidence that is material to their guilt or punishment, Brady launched the modern development of constitutional disclosure requirements.

As experienced forensic practitioners are well aware, the high-minded language offered in *Brady* requiring timely disclosure of potentially exculpatory evidence stands in contrast to its interpretation and application. It was intended as a clear standard set forth for reasonable minds to appreciate and follow. However, the adversarial nature of the criminal justice system, and the general lack of accountability for even blatant prosecutorial misconduct,⁵ has left *Brady* without the teeth it needs. This was in fact the conclusion offered in [Gershman \(2006, pp. 727–728\)](#):

Reflecting on the evolution of *Brady v. Maryland*, one is struck by the stark dissonance between the grand expectations of Brady, that the adversary system henceforth would be transformed from a "sporting contest" to a genuine search for truth, and the grim reality that criminal litigation continues to operate as a "trial by ambush." The development of the Brady rule by the judiciary depicts a gradual erosion of Brady: from a prospective obligation on prosecutors to make timely disclosure, to the defense of materially favorable evidence, to a retrospective review by an appellate court into whether the prosecutor's suppression was unduly prejudicial. The erosion of Brady has been accompanied by increasing prosecutorial gamesmanship in gambling that violations will not be discovered or, if discovered, will be allowed, and tactics that abet and hide violations. Finally, the absence of any legal or ethical sanctions to make prosecutors accountable for violations produces a system marked by willful abuse of law, cynicism, and the real possibility that innocent persons may be wrongfully convicted because of the prosecutor's misconduct. Indeed, more than any other rule of criminal procedure, the Brady rule has been the most fertile and widespread source of misconduct by prosecutors; and, more than any other rule of constitutional criminal procedure, has exposed the deficiencies in the truth-serving function of the criminal trial.

The original language in *Brady* has been expanded by the Supreme Court to cover any and all potentially exculpatory information in control of the prosecution, the police, and their agents. This includes government-operated crime labs, as well as private labs and private experts contracted into government service. Unfortunately, ignorance regarding *Brady* remains even in these informed circles, as explained in [Giannelli and McMunigal \(2007, pp. 1517–1518\)](#):

⁵ As explained in [\(Rudolphi and Possley 2010\)](#): "In the vast majority—548 of the 707 cases—courts found misconduct but nevertheless upheld the convictions, ruling that the misconduct was harmless—that the defendants received fair trials notwithstanding the prosecutor's conduct. Only in 159 of the 707 cases—about 20 percent—did the courts find that the misconduct was harmful; in these cases they set aside the conviction or sentence, declared a mistrial or barred evidence. The Misconduct Study shows that those empowered to address the problem—California state and federal courts, prosecutors and the California State Bar—repeatedly fail to take meaningful action. Courts fail to report prosecutorial misconduct (despite having a statutory obligation to do so), prosecutors deny that it occurred, and the California State Bar almost never disciplines it."

The U.S. Supreme Court has extended *Brady* to cover exculpatory information in the control of the police. Some courts have explicitly included crime labs within the reach of *Brady*. In one case, the Supreme Court of California noted that a laboratory examiner “worked closely” with prosecutors and was part of the investigative team. The court concluded that the “prosecutor thus had the obligation to determine if the lab’s files contained any exculpatory evidence, such as the worksheet, and disclose it to petitioner.” [In re Brown, 952 P. 2d 715, 719 (Cal. 1998)]

In another case, a court wrote that an experienced crime lab technician “must have known of his legal obligation to disclose exculpatory evidence to the prosecutors, their obligation to pass it along to the defense, and his obligation not to cover up a *Brady* violation by perjuring himself.” [Charles v. City of Boston, 365 F. Supp. 2d 82, 89 (D. Mass. 2005)] While the expert should have been on notice about perjury, it is less clear that the *Brady* obligation would be known to lab personnel—without the prosecutor tutoring the lab. How often do prosecutors discharge this duty? Many lab examiners have never heard of *Brady*.

In some jurisdictions, the defense can make these requests directly to the crime lab. In others, the prosecution directs its forensic personnel not to communicate with the defense without its permission. It all depends on the structure of the lab system, the strength and character of the scientists it employs, and the bias of any leadership involved. If the goal is science communicated without bias, then no government lab should ever have a problem speaking with, or disclosing findings to, attorneys representing the accused.

Withholding Discovery

Withholding discovery material until the eve of trial is so common that it is almost considered standard practice in some jurisdictions. Yet it is an utter violation of *Brady*. One of the authors (Turvey) worked a case in Mississippi requiring a shooting incident reconstruction. In the simplest terms, there were two victims: a husband and wife fired upon by a third party. The husband was shot and killed, and the wife was injured (it is not, however, clear that she was injured as the result of a gunshot). As the author noted in his reconstruction report for the case, the murder of the husband occurred in late April of 2006. The reports of those investigators present indicated that the autopsy was conducted shortly after. However, the autopsy report itself was not disclosed to the defense until a few days before the trial. This occurred despite repeated requests for what is an essential component of any reconstruction effort in a homicide.

There is no legitimate reason for withholding forensic findings and related reports, but given the unwillingness of the judiciary to punish prosecutors for this kind of behavior (Rudolphi and Possley, 2010), it is unlikely that it will fade any time soon.

Inconclusive Is a Result

Another common *Brady* violation, often committed out of nothing more than ignorance, is related to the forensic practice of labeling a finding or report “inconclusive.” There are forensic practitioners employed by the government, from fingerprint analysts to DNA technicians, who erroneously believe that inconclusive or indeterminate findings are not an actual result. Therefore, they feel comfortable withholding the existence of such tests and related findings by virtue of failing to write them up in a report, or failing to disclose those kinds of reports to the defense.

Consider the discussion and examples provided in Giannelli and McMunigal (2007, pp. 1515–1516):

a. Timing of Disclosure

Brady is a trial right, not a pretrial disclosure rule. Nevertheless, exculpatory evidence must be disclosed in time for defense counsel to make use of it. Here, as with the discovery rules discussed above, delayed disclosure may place a defendant in an untenable position. In *Ex parte Mowbray*, [943 S.W.2d 461 (Tex. Crim. App. 1996)] a murder case, the prosecutor used a blood spatter expert to refute the defense suicide theory. According to the prosecutor, his case “depended upon” this evidence. Prior to trial, the prosecution retained another expert, Herbert MacDonell, considered the premier expert in the field. After reviewing the crime scene, the physical evidence and the photographs, MacDonell concluded months before trial that “it was more probable than not that the deceased died from a suicide rather than a homicide.” Yet the defense did not receive his written report until ten days before trial and then only after the trial judge threatened sanctions. MacDonell never testified. The court wrote, . . . State’s counsel early on recognized the potential lethal effect of MacDonell’s testimony on their theory of the case, and beginning in November and continuing until May they engaged in a deliberate course of conduct to keep MacDonell’s findings and opinions from Applicant’s counsel until the last days before trial. Even then they caused Applicant’s counsel to believe MacDonell would be a witness and available for cross-examination.

b. “Exculpatory” Requirement

Brady does not apply unless the evidence is exculpatory. Consequently, labeling a laboratory report as inconclusive may relieve the prosecution of the disclosure requirement. For example, in one case an inconclusive handwriting report “was not exculpatory, but merely not inculpatory.” [United States v. Hauff, 473 F.2d 1350, 1354 (7th Cir. 1973)] Similarly, a report showing that hair from a rape defendant was not found at the scene of the crime was deemed a “neutral” report. [Norris v. Slayton, 540 F.2d 1241, 1243–44 (4th Cir. 1976)] However, as one court correctly understood,

[S]uch a characterization [as neutral] often has little meaning; evidence such as this may, because of its neutrality, tend to be favorable to the accused. While it does not by any means establish his absence from the scene of the crime, it does demonstrate that a number of factors which could link the defendant to the crime do not. [Patler v. Slayton, 503 F.2d 472, 479 (4th Cir. 1974)]

Similarly, in *Bell v. Coughlin*, [820 F. Supp. 780, 786–87 (S.D.N.Y. 1993)] the prosecution failed to turn over FBI ballistics test results to the defense. The lab positively matched a cartridge shell (B3) to the .45 caliber pistol but reported that no conclusion could be reached with respect to the two bullets (J/R2 and J/R4) in its possession. Thus, although the results of the FBI tests may be characterized as mixed, they clearly contained exculpatory material.

In a research facility, it may very well be standard procedure to discard undesirable or unhelpful results—although it would be scientifically dishonest to conceal such a practice when publishing related research. However, in a forensic context, this practice is referred to as **cherry picking**: selectively reporting (and thereby emphasizing) only desired results or information rather than the entirety of examinations performed and results achieved. Specifically, this practice violates due process because:

1. The concealment of any examination performed on any item of evidence represents a break in the *chain of custody* for that item to those third parties involved in reviewing subsequent reports (i.e., judges, juries, attorneys, and independent forensic examiners). The defense in particular has a right to know of every individual who handled an item of evidence, what he or she did with it or to it and where, and in what order.
2. The execution of any examination on an item of evidence has a potential impact on its volume and quality (destruction, consumption, contamination, etc.). The nature of any impact on the evidence must be made clear to the police, court, and all of the attorneys involved in a case.
3. The failure to notify the police, court, or attorneys involved in a case regarding the existence of inconclusive examinations assists with concealing the causes behind such results. This can include errors in examination procedure, problems with the evidence itself, or individual examiner proficiency. Unless the cause of an inconclusive result has been unequivocally established, the impact on the interpretation of any subsequent or related results is unknown and potentially limiting.

4. The failure to investigate and report the cause of inconclusive results potentially conceals the error rate and/or the individual examiner proficiency rate related to a particular test. If these are unknown, then the scientific reliability of that test is not known. This may in turn create a false illusion of competence and proficiency in the mind of forensic examiners, their superiors, and the court.

Inconclusive findings are relevant to the reconstruction of a crime, the nature and extent of examinations performed, the evidence they were performed on, the quality of any testing, the competency of the examiner, and the legal proceedings that hinge upon the weight the court places on evidence of every kind. They are a result, just not one that is expected or necessarily desired.

Therefore, the forensic scientist must know what tests were conducted on which evidence in order to determine the context of the result. Inconclusive means different things under different circumstances. It may suggest an error in testing methodology, an inadequate sample or control, or be a reflection of a poorly trained examiner miscommunicating his or her findings.

The failure to disclose inconclusive results is a violation of due process and could be viewed as an obstruction to justice—which is in fact a criminal charge. This is, however, unlikely, as the police and prosecutors very rarely sanction their own experts for conduct it benefits from. Thus, such misconduct by government-employed scientists often goes unrecognized or uninvestigated.

CASE EXAMPLE

Det. Matthew Christian

Consider the following case example of *Brady* in action, which highlights the differences between the agendas and the cultures of law enforcement and science. Note that police investigators in particular seek to build cases in order to prosecute their suspects. To accomplish these goals, they can lie to suspects about the existence of evidence or witnesses during initial interviews. In some states they are also allowed to fabricate false reports and produce false evidence without fear of sanction; in other states it is a crime. The laws and policies governing police conduct in this regard vary drastically from agency to agency, and also with respect to jurisdiction.

Matthew Christian is, as of this writing, a detective with the San Jose Police Department in California. He fabricated a report from the district attorney's crime lab with a phony lab analyst's name that "confirmed" the presence of semen on a blanket related to an alleged sex crime.⁶ He then used this fabricated report during a suspect interview to gain an inculpatory statement.

Unfortunately, Det. Christian forgot about his deception and put the "ruse report" into his case file alongside a real lab report that contradicted it. The district attorney proceeded to trial thinking she had hard physical evidence—denying several defense requests about the contradictory lab results. When asked about it on the stand during a preliminary hearing, Detective Christian falsely testified as though the fake lab report and analyst were real and the findings had been inculpatory. The fake lab analyst was even put on the district attorney's witness list. Only when the defense was finally able to speak

⁶ In San Jose, California, the crime lab is a division of the district attorney's office. It is, in fact, called "Santa Clara County District Attorney's Criminalistics Laboratory." Detective Christian used the district attorney's seal and official documents in making his phony report.

with the lab did they discover that the confirmatory report was a fake. This information was forwarded to the district attorney, who had not verified the report.⁷

In December of 2006, all charges were dropped against the accused (Griffy, 2007a). Detective Christian remains on active duty with the San Jose Police Department. The use of ruse reports remains standard practice. Without the cover of *Brady* and the tenacity of alert defense counsel, the detective's error and his related misconduct might not have been revealed until during trial—after the damage had already done by forcing the accused to appear in front of a jury.

Currently, *Brady* is only as good as the investigators, scientists, and prosecutors who follow it; the judges who enforce it; and the defense counsel who understand and raise it as an issue. The general absence of prosecutorial sanctions for *Brady* violations has put the criminal justice system on the honor system in this regard. Scientific experts in their employ, therefore, have a tremendous responsibility to self-govern with respect to their evidence and its discovery. Their failure to comply, despite the cheers of some prosecutors and the indifference of some trial courts, has repeatedly been the cause of reversal at the appellate level.

Caveat for the Defense

The prosecution and their employees must follow different rules of conduct than those of the accused. This has to do with the forensic landscape: the laws of discovery (a.k.a. disclosure) are not the same for both sides. Forensic examiners employed by the prosecution (which holds the burden of proof) must document their involvement in every case and write reports regarding their findings or face very serious penalties. However, those who work for defense attorneys are bound by the attorney–client privilege and may subsequently be asked by their clients to refrain from writing a report of their findings for any number of legitimate reasons. The reconstructionist should weigh this request carefully, as they are entitled to decline and write a report anyway.

In cases where the forensic scientist agrees to refrain from making a written report of findings, to help maintain the state's burden and preserve the defendant's right to conduct their own investigation without fear of penalty, they should take scrupulous notes during their examinations. These notes can be shared with the court and opposing counsel upon request to demonstrate methodology and the soundness of findings. They can also serve to assist with courtroom testimony, in place of a comprehensive report.

It is only on the rare occasion that the authors have agreed to refrain from writing reports of findings in forensic casework. Each instance was ultimately a mistake that cost something in terms of organization and credibility, as it was conceded that such practice is indeed substandard, from a scientific standpoint. Such are the hazards of working in the legal realm.

⁷ In 1990, the same police department had been warned by the judiciary to cease the practice of creating phony lab reports. However, in 2002, “detective Juan Serrano [of the San Jose Police Department] described the use of ruse crime lab reports as ‘standard procedure’ at that time” (Griffy, 2007b).

Melendez-Diaz (2009)

Ake v. Oklahoma (1985) is a landmark U.S. Supreme Court decision which holds that, because the government has overwhelming access to manpower, money, and forensic experts, the defense must be given parity for the adversary system to function fairly. The ruling is of course an ideal. The reality is that not every lawyer and court understands and invokes *Ake* appropriately or consistently, as explained in Findley (2008, pp. 929–931):

... [T]he government has significantly greater access to forensic science services and experts than do most criminal defendants. Crime laboratories exist to provide such services to prosecutors; no corresponding institutions exist for defendants. And, because most defendants are indigent, their ability to hire experts is dependent on public funding of legal services to the indigent, which is abysmally inadequate in virtually every jurisdiction. Because funding for indigent defense is so inadequate, defense services are rationed in ways that put innocents at risk; rationing disfavors expensive, substantive innocence claims (such as expensive litigation about the validity of forensic evidence), and instead favors more inexpensive procedural constitutional claims. While the Supreme Court in *Ake v. Oklahoma* recognized a constitutional right to publicly funded experts for the indigent, exercise of that right is dependent on the willingness of a local judge to order the expenditure of scarce local resources, and on a cumbersome case-by-case, expert-by-expert process for requesting funding. Any risk of failure of that case-by-case process to provide adequate expert services falls on the defendant, and courts have tended to apply *Ake* narrowly. That system comes nowhere close to providing the level of forensic sciences assistance that is needed, or that is available to the prosecution.

Ake changed the forensic landscape in the United States dramatically by requiring the state to fund expert forensic analyses for indigent defendants. It reminded the criminal justice system to live up to that part of its promise of due process. *Ake* also increased the demand for independent forensic expertise of every relevant type and directly acknowledged the legitimacy of private forensic practice as a necessary agent of balance within the criminal justice system.

Similarly, the U.S. Supreme Court ruling in *Melendez-Diaz* (2009) further corrects imbalance in relation to government-employed forensic scientists. In essence, it reasserts that the accused have the right to confront any and all evidence and witnesses against them (Shelton, 2009). This right to confrontation includes forensic scientists who have written reports to be used as evidence against them at trial.

Forensic scientists testifying about evidentiary tests and findings at trial have not always been the same examiners who performed analyses in the case in question. Because of time and budget constraints, crime labs have been known to send supervisors or, in some cases, any warm body available on the day to satisfy the need for expert testimony during trial.⁸

In anticipation of this practice, certain crime labs have a history of doing one of two things. Federal agencies have, for example, engaged in the practice of preparing forensic laboratory reports such that it is unclear who actually performed examinations and who wrote the report. In these instances, reports were drafted by a particular unit or section without a specific name attached to them. Another, more common, practice has been to prepare forensic laboratory reports

⁸ This has also been a useful tool when a crime lab has an analyst who does not present well in court or who has competency or similar disqualifying problems. Sending someone else hides and protects such analysts from real courtroom scrutiny while allowing them to continue to perform examinations. This also resulted in some jurisdictions being dominated by the testimony of the most effective criminalists; those who could go into court and win over a jury by virtue of their credentials and/or skill with oral presentation.

with everyone's name on them: multiple supervisors, multiple analysts, and multiple peer reviewers. Either practice would allow a crime lab to send just about any crime lab analyst available from the section that generated the report to satisfy the ever-changing schedule of required courtroom testimony.

However, when the lab did not send the actual analyst who performed the actual testing and wrote the actual report to testify, then the accused was essentially out of luck. There could be no meaningful inquiry into the nature, quality, and competence of the forensic testing. The available criminalist could testify only to generalities and could honestly deny any direct knowledge of the testing involved in the given case.

Pretrial evidentiary hearings could be even worse. Prior to trial, some legal jurisdictions have allowed police officers or detectives to bring crime lab reports to the stand and explain their meaning in the absence of testimony from a crime lab scientist. In these cases, oversimplification, misinterpretation, and misrepresentation of scientific findings by law enforcement officers become not just possible, but likely.

This practice has worked in favor of the prosecution for generations. It has allowed government crime labs to put their best foot forward and law enforcement agents to inappropriately copilot scientific testimony. However, as explained in [Liptak \(2009\)](#), *Melendez-Diaz* has made such practices impermissible:

Crime laboratory reports may not be used against criminal defendants at trial unless the analysts responsible for creating them give testimony and subject themselves to cross-examination, the Supreme Court ruled Thursday in a 5-to-4 decision.

The ruling was an extension of a 2004 decision that breathed new life into the Sixth Amendment's confrontation clause, which gives a criminal defendant the right "to be confronted with the witnesses against him."

... Noting that 500 employees of the Federal Bureau of Investigation laboratory in Quantico, Va., conduct more than a million scientific tests each year, Justice Kennedy wrote, "The court's decision means that before any of those million tests reaches a jury, at least one of the laboratory's analysts must board a plane, find his or her way to an unfamiliar courthouse and sit there waiting to read aloud notes made months ago."

Justice Antonin Scalia, writing for the majority, scoffed at those "back-of-the-envelope calculations." In any event, he added, the court is not entitled to ignore even an unwise constitutional command for reasons of convenience.

"The confrontation clause may make the prosecution of criminals more burdensome, but that is equally true of the right to trial by jury and the privilege against self-incrimination," Justice Scalia wrote. "The sky will not fall after today's decision," he added.

But that is not how prosecutors saw it. "It's a train wreck," Scott Burns, the executive director of the National District Attorneys Association, said of the decision.

"To now require that criminalists in offices and labs that are already burdened and in states where budgets are already being cut back," Mr. Burns said, "to travel to courtrooms and wait to say that cocaine is cocaine—we're still kind of reeling from this decision."

Mr. Burns said complying with the ruling would be particularly tough in large rural states with a single crime laboratory and in old cases where the analyst has died or moved away.

The decision came in the wake of a wave of scandals at crime laboratories that included hundreds of tainted cases in Michigan, Texas and West Virginia. William C. Thompson, a professor of criminology at the University of California, Irvine, said those scandals proved that live testimony from analysts was needed to explore potential shortcomings in laboratory reports.

"The person can be interrogated about the process, about the meaning of the document," Professor Thompson said. "The lab report itself cannot be interrogated to establish the strengths and limitations of the analysis."

... Cross-examination of witnesses, Justice Scalia wrote, "is designed to weed out not only the fraudulent analyst, but the incompetent one as well." He added that the Constitution would require allowing defendants to

confront witnesses even if “all analysts always possessed the scientific acumen of Mme. Curie and the veracity of Mother Teresa.”

The case arose from the conviction of Luis E. Melendez-Diaz on cocaine trafficking charges in Massachusetts. Part of the evidence against him was a laboratory report stating that bags of white powder said to have belonged to him contained cocaine. Prosecutors submitted the report with only an analyst’s certificate.

Jeffrey L. Fisher, a law professor at Stanford who represented Mr. Melendez-Diaz, said perhaps a third of all states follow procedures that comply with Thursday’s decision. What that will mean as a practical matter remains to be seen. Criminal defense lawyers may still stipulate that crime lab reports are accurate, fearing that live testimony will only underscore their clients’ guilt. Others may insist on testimony in the hope that the analyst will be unavailable. Still others will now be able to prove that an analyst’s conclusion was mistaken or inconclusive.

“The defense bar today gains the formidable power to require the government to transport the analyst to the courtroom at the time of trial,” Justice Kennedy wrote.

“The court’s holding,” Justice Kennedy wrote, “is a windfall to defendants, one that is unjustified by a demonstrated deficiency in trials, any well-understood historical requirement, or any established constitutional precedent.”

Melendez-Diaz (2009) provides that if a lab analyst performed evidentiary analysis and wrote the report of findings, then they alone may offer it as evidence against the accused in a legal proceeding.

Detractors of this ruling will groan that it places an inordinate and unbearable strain on over-taxed government crime labs and their employees. No agency has the time or travel budget required to send crime lab employees away for days at a time, to wait for testimony that may ultimately be unnecessary. Casework quality will suffer and backlogs will grow, they will argue.

The authors agree that there will be challenges. However, there are inexpensive work-arounds. The simplest and most cost-effective include expert forensic testimony via remote videoconferencing (e.g., Skype). The courts have accepted video depositions and phone testimony from experts and lay witnesses for years, as well as the “phone presence” of attorneys unable to be physically present with their clients during certain court proceedings. Testimony via remote videoconferencing is now becoming more accepted and common.^{9,10} Installing and enabling these systems would require a bit of a learning curve, but nothing beyond that which our children have already mastered by the time they enter junior high.

TERMINOLOGY

Because forensic scientists who conduct examinations and provide written reports of findings are all going to have to testify in court now, they are also going to have to start using consistent terminology. It has been said that language is a cumbersome engine for thought. No truer words have been spoken. This has certainly been the case in the forensic disciplines, where there has been little or no standardization of terms, let alone their intended meaning. Each agency, each lab, and each practitioner, it seems, uses its/his/her own language. The absence of formal

⁹ One of the authors (Chisum) testified on a videotape while the judge was on the telephone and the attorneys and court reporter were present. The testimony was played for the jury the next day. This same author has also testified from a deserted parking lot in Arkansas via cell phone to a courtroom in Colorado.

¹⁰ In 2009, one of the authors (Turvey) gave expert forensic testimony in a pretrial admissibility hearing from Australia to Massachusetts via Skype and found the experience effective with both respect to cost and the cause of justice.

scientific education as a requirement of forensic practice hasn't helped. As explained in [Edwards and Gotsonis \(2009, pp. 3–6\)](#):

... [M]any terms are used by forensic examiners in reports and in court testimony to describe findings, conclusions, and the degrees of association between evidentiary material (e.g., hairs, fingerprints, fibers) and particular people or objects. Such terms include but are not limited to "match," "consistent with," "identical," "similar in all respects tested," and "cannot be excluded as the source of." The use of such terms can have a profound effect on how the trier of fact in a criminal or civil matter perceives and evaluates evidence.

Yet the forensic science disciplines have not reached agreement or consensus on the precise meaning of any of these terms. Although some disciplines have developed vocabulary and scales to be used in reporting results, they have not become standard practice. This imprecision in vocabulary stems in part from the paucity of research in forensic science and the corresponding limitations in interpreting the results of forensic analyses.

Given these limitations, it is the onus of forensic scientists to use plain language in report writing and to *operationalize* all significant terms used. They have a responsibility to become familiar with and write at the level of their intended audience, and they must define any key terms as they are being used to relate findings. This text, its glossary of terms, and the works it references should provide the forensic scientist with a grounded frame of reference to begin with.

Without precise definitions, and in the absence of forensic examiners to explain their word usage, the meaning of forensic reports is too often found in the eye of the beholder during closing arguments. In most instances, this involves a stakeholder in the outcome (i.e., an attorney or a partisan jurist) rather than a neutral party, making misinterpretation and misunderstanding a predictable, yet avoidable, hazard.

LOGICAL FALLACIES IN CRIME RECONSTRUCTION

If it was so, it might be; and if it were so, it would be; but as it isn't, it ain't. That's logic. –*Tweedledee, in Lewis Carroll's Through the Looking Glass, and What Alice Found There, London: Macmillan (1872)*

Perhaps the most revealing indicators of the absence of analytical logic and the scientific method in a crime reconstruction are the logical fallacies in forensic examination reports. The fallacious reconstructionist is not necessarily being intentionally deceptive. Rather, some reconstructionists lack the intellectual dexterity to know whether and when their reasoning is flawed. Regardless of motive or intent, logical fallacies are impermissible and can render any subsequent forensic conclusions erroneous.

Forensic practitioners of all disciplines would therefore do well to learn more about fallacies in logic and reasoning in order to avoid them in their own work as well as identify them in the work of others.¹¹ Common logical fallacies in crime reconstruction, and the forensic sciences in general, include, but are certainly not limited to, the following.

¹¹ Thornton has also provided a similar and complementary cautionary discussion of logical fallacies in Chapter 3: Crime Reconstruction: Ethos and Ethics.

Suppressed Evidence or Card Stacking

This is a one-sided argument that presents only evidence favoring a particular conclusion and ignores or downplays the evidence against it. It may involve distortions, exaggerations, misstatements of facts, or outright lies. It is, in essence, cherry-picking evidence from that which is available to support a conclusion, while ignoring anything that is contrary. This is an act of omission that can only be identified in the peer review process or as part of independent review.

Appeals to Authority

This occurs when someone offers a conclusion based on the stated authority or expertise of themselves or others. This kind of reasoning can be fallacious when the authority lacks the expertise suggested; when the authority is an expert in one subject but not the subject at hand; when the subject is contentious and involves multiple interpretations with good arguments on both sides; when the authority is biased; when the area of expertise is fabricated; when the authority is vague or unidentified; and when the authority is offered as evidence in place of defensible scientific fact.

- “I know this is a fact because I’ve been doing this for 25 years.”
- “I know I’m right because of my training.”

It is common for forensic experts of all kinds to offer their years of experience as evidence of competence. However, experience and competence are not necessarily related. Although knowledge, skill, and ability are *potential* benefits of age and experience, not everyone acquires them or the humility to apply them correctly. As explained in [Thornton \(1997\)](#), summoning experience instead of logic and reasoning to support a finding is an admission to lacking both (p. 17):

Experience is neither a liability nor an enemy of the truth; it is a valuable commodity, but it should not be used as a mask to deflect legitimate scientific scrutiny, the sort of scrutiny that customarily is leveled at scientific evidence of all sorts. To do so is professionally bankrupt and devoid of scientific legitimacy, and courts would do well to disallow testimony of this sort. Experience ought to be used to enable the expert to remember the when and the how, why, who, and what. Experience should not make the expert less responsible, but rather more responsible for justifying an opinion with defensible scientific facts.

In other words, the more experience of quality and substance one has, the less one will need to tell people about it in order to gain their trust and confidence—the quality of one’s experience is only demonstrated through the inherent quality of one’s methods and results.

Appeal to False Authority

This is an appeal to an authority that, in particular, lacks expertise in the relevant subject. It involves either ignorance on the part of the examiner or deliberate misrepresentation. In crime reconstruction, a common example would be arguing or assuming that experience in finding, collecting, and/or packaging evidence (a.k.a. crime scene processing) is related to experience interpreting the meaning of evidence in its context (a.k.a. reconstruction) or that being a law enforcement officer necessarily implies forensic expertise or a scientific disposition. Such faulty

assertions and assumptions are common to the admission of “expert” reconstruction testimony by the courts.

“I work in crime scenes all day picking up evidence in the mud and the blood; of course I know how to interpret what it means.”

“I’m a cop; of course I know how to read a crime scene.”

As explained in O’Hara (1970, p. 667), the role of crime scene investigator and the role of evidence interpretation do not, and should not, intersect:

It is not to be expected that the investigator also play the role of the laboratory expert in relation to the physical evidence found at the scene of the crime. . . . It suffices that the investigator investigate; it is supererogatory that he should perform refined scientific examinations. Any serious effort to accomplish such a conversion would mutilate against the investigator’s efficiency.

. . . In general the investigator should know the methods of discovering, “field-testing,” preserving, collecting, and transporting evidence. Questions of analysis and comparison should be referred to the laboratory [aka scientific] expert.

In addition, although emphasizing cooperation between crime scene investigators and forensic scientists, Lee (1994) is in agreement with this separation of collection and interpretation duties. Crime reconstruction is outlined as a process of systematic evidence examination based on adherence to the principles of forensic science and the scientific method, something necessarily beyond the short course training of the average crime scene technician.

Appeal to Tradition

This kind of argument reasons that a conclusion is correct simply because it is older, traditional, or “has always been so.” It supports a conclusion by appealing to long-standing, institutional, or cultural opinions, as if the past itself is a form of authority.

- “One swab per hand, front and back, is the correct method for collecting gunshot residue (GSR) because that’s that way I was taught and that’s the way it’s always been done in this department/ agency.”¹²
- “I’ve been doing it this way for 25 years.”

Argumentum ad Hominem, a.k.a. “Argument to the Man”

This argument attacks an opponent’s character rather than an opponent’s argument. Because of its effectiveness, it is perhaps the most common logical fallacy. Even if true, it is important to note that arguments against character are not always relevant to the presentation of scientific conclusions, logic, and reasoning.

¹² Gunshot residue collection kits generally come with two scanning electron microscope collection tabs per hand (right and left; inside palm and back). Combining inside palm and back of palm transfer evidence onto one tab eliminates the ability to interpret whether the subject had GSR transfer only on the palm, only on the back of the hand, or both. This information can have significant interpretive value.

- “He’s wrong because he’s an arrogant jerk.”
- “She’s just saying that because she’s a woman.”

Emotional Appeal

This is an attempt to gain favor based on arousing emotions and/or sympathy to subvert rational thought. This is used very commonly to sway juries in cases involving traditionally sympathetic victims, such as an attractive woman or a young child.

- “You know in your heart the right thing to do.”
- “If you work for the defense, then you must hate law enforcement and want to let child killers go free.”

Circulus in Probando, a.k.a. Circular Reasoning

This is an argument that assumes as part of its premises the very conclusion that is supposed to be proven.

- At a bail hearing, prior to trial: “He’s a danger to society because he killed the victim, and therefore should not be granted bail.” Violation of the presumption of innocence. The very fact to prove at trial is assumed pretrial.
- At a bail hearing, prior to trial: “She shouldn’t be granted bail because she has shown no remorse for her actions.” Violation of the presumption of innocence—innocent people cannot show remorse for crimes that they did not commit.

Cum Hoc, Ergo Propter Hoc, or “with This, Therefore Because of This”

This occurs when one jumps to a conclusion about causation based on a correlation between two events, or types of events, that occur simultaneously. The examiner assumes that things found together must be related.

- “We found these knives in the house, so they must be related to the crime that happened in another room—despite any lack of any direct associative evidence.”
- “We found these condoms at the scene, so they must be related to the rape.”

Post Hoc, Ergo Propter Hoc, or “after This, Therefore Because of This”

Reasons that a causal conclusion exists based solely on the alleged cause preceding its alleged effect.

- “She was killed just after he arrived at the house, so obviously he’s involved in her death somehow.”

Hasty Generalizations

This sort of generalization forms a conclusion based on woefully incomplete information or by examining only a few specific cases that are not representative of all possible cases.

- “I don’t know all of the facts of the case, and haven’t spent more than a few hours examining the evidence, but I can provide a fairly detailed reconstruction of events.”
- “I’ve seen a couple of cases just like this before.”

Sweeping Generalization

This occurs when one forms a conclusion by examining what occurs in many cases and assuming that it must or will be so in a particular case. This is the opposite of a hasty generalization.

- “All cops are crooked.”
- “All scientists do is work with theories; they don’t have real-life experience.”

False Precision

False precision occurs when an argument treats information as more precise or reliable than it really is. This happens when conclusions are based on imprecise information that must be taken as precise in order to support the conclusion adequately.

- “This method of examination has an error rate of zero.”
- “I’m 100% certain of my findings.”
- “The point of origin of the blood drop is 15.78 inches above the floor and 7.852 inches west of the drop.”

It bears mentioning that presenting what appear to be precise statistics or numbers in support of an argument gives the appearance of scientific accuracy when this may not actually be the case. Many people find math and statistics overly impressive and become intimidated easily by those who wield numbers with ease. This is especially true with DNA evidence, whose astronomic statistical probabilities are often presented by those without any background in statistics and without full consideration of the databases that such probabilities are being derived from.

In the advent of varying DNA databases and subsequent statistics of impressive weight being read in court to bedazzled jurors, and the outright fabrication of statistics related to hair comparisons, the cautionary offered in [Kirk and Kingston \(1964\)](#) is more appropriate now than ever: “Without a firm grasp of the principles involved, the unwary witness can be led into making statements that he cannot properly uphold, especially in the matter of claiming inordinately high probability figures.”

A more specific criticism of forensic practices was provided in [Moennsens \(1993\)](#):

Experts use statistics compiled by other experts without any appreciation of whether the database upon which the statistics were formulated fits their own local experience, or how the statistics were compiled. Sometimes these experts, trained in one forensic discipline, have little or no knowledge of the study of probabilities, and never even had a college-level course in statistics.

Those using statistics to support their findings have a responsibility to know where they come from, how they were derived, and what they mean to the case at hand before they form conclusions, write them up, and certainly before they testify in court.

REPORT STRUCTURE

Apart from their relative permanence, written conclusions also provide forensic practitioners with the best chance to memorialize methods, interpretations, arguments, and the relevant underlying facts of a case as they understand them. However, forensic examiners are often bound by convention and policy. For example, those who work for government agencies will have specific policies to follow and forms to use when preparing their reports. These policies and forms vary widely with respect to relevance, content, and quality.

Regardless of any institutional constraints, all scientific reports must be comprehensive with regard to examinations performed, methods employed, findings achieved, and conclusions rendered in context. Consistent with the recommendations of the NAS report (Edwards and Gotsonis, 2009) and the mandates of good scientific practice, a written forensic examination report should include, but need not be limited to, the following information:

1. Name(s) of the examiner(s), name(s) of the reviewing supervisor(s), date(s) of examinations, and date of the final report, all under cover of signature(s).
2. A preliminary background section, describing the forensic scientist's relationship to and involvement in the case (including when they started and completed their examinations).
3. A chain of custody section, describing and detailing the evidence (material) that was examined, and how it came to them (or vice versa).
4. A descriptive section, in which the forensic scientist thoroughly describes his or her examinations and considerations of the facts and evidence.
5. A results section, in which the examiner lists any results and conclusions, including their significance and limitations.

Name, Date, and Signature

It is a safe bet that most of those reading this text were taught the need for providing both their name and date on every homework assignment, project, and pop quiz during the first days of primary school. It is a habit that we either learn or suffer the consequences for ignoring. For a variety of reasons, many forensic reports lack one or both elements.

In every forensic report, the examiner's name must be provided so that readers may be certain who did the work. Dates of various examinations must be provided so that readers may learn at which point they occurred within a given case, and their timing with respect to any other case activity or examinations. A dated signature line also is necessary so that readers may verify the author of the report and when it was completed or submitted.

Without this basic information, it is not possible for the readers to know who did what or when relative to anything else that happened. The lack of this information also allows for inaccurate suggestions that examinations were performed sooner or later than they should have been. In crime reconstruction, the timing of an examination can be everything.

For example, one of the authors (Turvey) worked a case involving an allegation of rape. One of the issues at trial was petechial hemorrhaging found in the victim's eyes during the sexual assault examination. This is consistent with manual strangulation, as reported by the alleged victim. However, it was learned that upon arriving at the hospital for a sexual assault examination she was first treated with a number of antibiotics and analgesics. She immediately vomited the entire package of medication that she had been given. The sexual assault examination and subsequent photos were taken after she vomited. Given that vomiting can cause petechial hemorrhaging, and that it was not seen or documented prior to the vomiting, petechial hemorrhaging could not be used to suggest strangulation on its own (for additional discussion, see Chapter 6: Evidence Dynamics).

Preliminary Background Section

The preliminary background section of a report provides the forensic examiner's involvement in the case. It should include who hired or employed the examiner, under what circumstances, and when he or she first became involved in the case. It is important to know which side was providing the examiner with information and whether the examiner's involvement was secured before or after certain events took place, such as an arrest or a previous conviction, as this indicates the level of information that would have been available to him or her at the time of the examination.

This section of the report may also include basic background information regarding the case, including the type of crime involved; the date, time, and location of the offense; and any relevant victim information not otherwise mentioned in the report. This information is meant to provide a quick thumbnail sketch of the case that is useful to those glancing at the report for its context and may also provide insight into potential biasing influences.

This background section has great utility to forensic examiners, who may use this information to refresh their memory while testifying on the stand with report in hand.

Chain of Custody Section

The chain of custody section of the report provides the materials examined, where they came from, and when. In this section, examiners make clear which facts and evidence they are relying on, and where they might be found, so that others may check their work if necessary.

At this point, it is necessary to distinguish between *legal* and *scientific sufficiency* of evidence. Legal standards have limited hold over scientific methods of examination. In other words, what is sufficiently reliable for legal purposes may not be sufficiently reliable for inclusion in a forensic examiner's report, and the opposite is also true. It is the forensic scientist's responsibility to know the difference to make it clear to the court when necessary. As Thornton explains (1994, p. 476):

Although there is a forensic science profession in the United States, and although many of us spend much of our time in courts of law, we have for the most part been passive spectators to the court decisions that deal with the admissibility of scientific evidence. In one sense, this is as it should be. It is the job of the law, and not of science, to determine how science is to be used in the courts. But in another sense, our passivity has served both ourselves and the legal system poorly. It is the job of science, and not of law, to determine what is good science and what is not.

Thornton further notes (1994, p. 483):

Every scientist understands that there are courts of law. By and large, they are accorded respect. I am not as certain that every lawyer understands that there are courts of science as well. They are not as easily identified because they do not exist in a particular point in space, nor is there one man or woman in a black robe that symbolizes the court, nor a marble anteroom outside smelling of urine and industrial strength disinfectant. Courts of science are constructs of the mind, which bring clarity and coherency to scientific and technical matters. They are built not of marble, but from the scientific method. Every scientist is expected to serve as his or her own presiding judge, and if a costume is necessary, it is a white lab coat instead of a black robe. But these courts have certain rules also, just as courts of law. And the scientist who declines to practice his or her profession by the rules of science will soon find that he or she has earned only the derision of his or her colleagues, and eventually finds that he or she cannot continue to practice at all.

Ultimately, forensic scientists must determine whether evidence is *sufficient* and *reliable* for their examinations. That is to say, is there enough evidence of sufficient quality to examine and are the results of the examination going to be reliable enough to carry any conclusions?¹³ The courts, at a later point, will determine whether or not this is admissible. One does not necessarily hinge on the other, nor should it.

Descriptive Section

In the descriptive section of the report, the forensic examiner should describe the types of examinations performed and the steps involved before results were achieved. This description may require a single sentence, a short paragraph, or several pages. Failure to provide this information deprives third-party reviewers of knowing precisely how evidence was handled by the examiner and potentially filtered or even altered.

Results

In the results section of the report, forensic examiners should describe the nature and extent of ANY findings subsequent to their examinations—not just the findings they like or can explain clearly, but ALL findings from EVERY examination performed.

In the presentation of findings, forensic criminologists will find themselves using statements that suggest varying degrees of confidence. They may even become accustomed to using vague terms or terms of art such as *probably*, *likely*, *identify*, *match*, *consistent with*, and *reasonable degree of scientific certainty* to qualify the probability of findings. Without proper limits, this language can be misleading to those it is intended to assist.

Conclusions expressed with confidence statements must be qualified and explained to the point of absolute clarity. Without a high degree of internal clarification, findings may be misunderstood, misrepresented, and misapplied. [Edwards and Gotsonis \(2009\)](#) provide the following general advisory (pp. 3–6):

Forensic science reports, and any courtroom testimony stemming from them, must include clear characterizations of the limitations of the analyses, including associated probabilities where possible. Courtroom testimony

¹³ For a more complete discussion, refer back to Chapter 5: Practice Standards for the Reconstruction of Crime.

should be given in lay terms so that all trial participants can understand how to weigh and interpret the testimony. In order to enable this, research must be undertaken to evaluate the reliability of the steps of the various identification methods and the confidence intervals associated with the overall conclusions.

When forensic scientists have given findings, written or otherwise, there must remain no question as to whether the findings are certain and no question as to how certainty was established. After all, the purpose of presenting findings is to clarify the evidence, not muddle it.

FACT CHECKING

Before preparing the final draft of a forensic report, forensic examiners should take care to check that facts relied upon are accurate and up-to-date. When they are working for the government, this means relying on supervisors, colleagues, and law enforcement investigators. However, when they are working privately, forensic examiners may rely on their clients (the attorneys) and their investigators, either of whom may have a more accurate or even encyclopedic knowledge of the case facts.

It is, therefore, proper to allow either clients or their investigators to fact-check the final draft of a report. They may even suggest questions that the forensic examiner has failed to answer. It is improper, however, for attorneys or investigators to suggest changes as to final conclusions or their meaning.

PEER REVIEW

Ultimately, the purpose of report writing is to make findings clear and to make a fixed record of them. A secondary goal for scientists is to allow for peer review. **Peer review** refers to the appraisal of work and research by others in the same discipline or profession. It can happen when a report is in draft form, when scholarly writing is in prepublication, so as to allow for refinement based on feedback, or can take place after a final report or publication is rendered. Textbooks and journal articles are critiqued regularly in like formats, whereas forensic reports must be peer reviewed as part of the adversarial process by experts retained by opposing counsel. With respect to report writing as it relates to peer review, [Edwards and Gotsonis \(2009\)](#) explain (pp. 3–6):

Although it is not appropriate and practicable to provide as much detail as might be expected in a research paper, sufficient content should be provided to allow the nonscientist reader to understand what has been done and permit informed, unbiased scrutiny of the conclusion. Good scientific practice invites peer review; it wants to suffer the crucible of peer examination and critique. In this way it becomes more informed of its own weaknesses and becomes better. Poor scientific practice avoids peer review and even chastises those who would deign to engage in it.

It is recommended that forensic examiners submit draft reports to one or more peers for review—to identify any shortcomings, failures in logic, or lapses in practice. When examiners are working for government agencies, a supervisor will likely perform this task. When they are engaged in defense work, peer review requires a trusted colleague. It should be done without

identifying information to protect attorney–client privilege, and always with the client’s permission. If the client says no, then it is incumbent on the forensic scientist to respect that answer.

However, it should be understood that the very act of writing the report and supplying it to the state affords the opportunity for peer review in some form. Therefore, forensic scientists participating in the criminal justice system should not be surprised to find their work under all manner of scrutiny. If a forensic scientist does not stand behind his or her methods and results and does not want them to be scrutinized by others, then he or she is in the wrong profession, as independent examination is a requirement of the justice system.

SUMMARY

When forensic scientists complete their examinations, they are generally expected to provide an account of any findings. This is best accomplished by first writing a report, and later through depositions and testimony as necessary. A *forensic examination report* is a detailed description of the evidence and materials examined; the examinations performed; the methods used; the results achieved; and any conclusions that may subsequently be derived.

Most forensic examination reports do not explain how results were achieved or interpretations rendered, and tend to leave readers with a false sense of overconfidence regarding any findings that are presented. This is generally a result of the following: inept examiners, fearful examiners, equivocal examiners, or lack of time. None of these reasons provides a legitimate justification for deficient forensic reporting.

In the performance of casework, forensic scientists are bound to accept the law and any related rulings of the court in their approach, analyses, and interpretations. Forensic scientists are also bound by *due process* and *Brady v. Maryland*. To abide the mandates of *due process*, scientists employed by the government must conduct forensic examinations in such a way as to be transparent in their methods and findings. By working within the mandates set forth in *Brady*, forensic scientists are meant to help create equal access to the government’s findings, prevent trial by ambush, and seek to avoid miscarriages of justice. Despite *Brady v. Maryland*, common *Brady* violations include withholding discovery and withholding inconclusive results.

All scientific reports must be comprehensive with regard to examinations performed, methods employed, findings achieved, and conclusions rendered in context. A written forensic examination report should include, but need not be limited to, the following information: name(s) of authors and supervisors, date(s) of examinations, and date of the final report, under cover of signature(s); a preliminary background section; a chain of custody section; a descriptive section; and a results section.

QUESTIONS

1. Define the term *forensic examination report*.
2. What is the goal of a forensic examination report?
3. List three common due process violations.
4. Explain how *cherry picking* violates due process.
5. Explain why it is important for forensic scientists to use consistent terminology.

6. Explain how *Melendez-Diaz* might change the way that forensic scientists write their reports?
7. It is proper to allow clients or their investigators to fact-check the final draft of a report and suggest changes as to the final conclusions or their meanings. True or false? Explain.

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Reconstruction Court Presentation and Testimony

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Forensic science should not be a game of charades, where opposing attorneys attempt to use the presence (or absence) of scientific evidence to their tactical advantage. Complete, competent, and impartial forensic-science investigations can be that “touchstone of truth” in a judicial process that works to see that the guilty are punished and the innocent are exonerated. This is only possible, however, if our government institutions provide the necessary resources. —*Peterson and Leggett (2007, p. 660)*

Key Terms

Admissibility; Availability heuristic; Belief perseverance; Evidence; Forensic fraud; Perjury; Recency effect; CSI effect; Ultimate facts; Ultimate issue

As discussed throughout this work, the defining quality of forensic scientists is courtroom testimony—the possibility that they will be called upon to present scientific findings, under penalty of perjury, in a court of law. They are given the trust of court and are allowed to offer not just the facts related to their examinations but also opinions. The forensic scientist assists the justice system, criminal and civil alike, as educator to attorneys, judges, and juries. Consequently, the forensic scientist has a responsibility to be competent, objective, and professional.

Much has been written on the subject of expert testimony in the courtroom. Much of it is theoretical, written by those dealing with the letter of the law and how things should work when everyone knows the rules and follows them. This is unhelpful to the practicing forensic scientist, as many “jurists” (e.g., judges, lawyers, legal scholars) are ignorant of the law as it relates to the use and admissibility of physical evidence. Still others can be dismissive, biased, or even hostile to its presentation.

Forensic scientists, especially those young to the profession, have a right to know the actual challenges facing them inside the theater of court. Primarily because one mistake in here can

¹ Some parts of this chapter have been adapted from [Turvey and Freeman \(2010\)](#).

signal the end of a career before it even begins. This chapter is written from that perspective—as a forensic scientist’s guide to the practical aspects of courtroom presentation and testimony.

PRETRIAL COURTROOM CONSIDERATIONS

Forensic scientists must be thinking about every decision in their personal and professional lives at all times, as though it will need to be explained under oath in front of jury at some point, because very likely it will. In doing so, they will maintain their professional credibility and be better prepared once they arrive in court.

Character

In court, forensic scientists can be taken at their word by the judge and jury when they are shown to be of good character. Opposing counsel may use any relevant history of lying, criminal behavior, biased affiliation, or bad judgment to cut into the weight of their credibility. For example, many criminal justice and forensic science programs accept students without a criminal background check or without disclosing the kinds of behavior that may prevent the hiring of graduates into the profession. As explained in [CCLRTF \(2009, p. 25\)](#):

Many crime lab applicants fail to pass a background check and are eliminated from the candidate pool. One Southern California public lab expressed dissatisfaction in the strict hiring standards of its agency, noting that candidates were disqualified for drug use that occurred 10 to 15 years before, despite present employment at another public crime lab. Nevertheless, the Task Force recognizes that background checks are necessary because of the sensitive and critical role criminalists play in the criminal justice system. Mistakes or lack of professional standards by forensics professionals can lead, in a worst-case scenario, to wrongful convictions. The Task Force suggests that candidates, as well as those still in college who wish to become forensic scientists, be better informed that any association with criminal activity or lack of personal responsibility could preclude them from future employment in a crime lab.

One problem is that different labs and agencies have varying standards for disqualifying applicants. One lab director stated that his agency would not permit his lab to hire an experienced, highly qualified candidate because the candidate had used drugs more than a decade before, even if the candidate was already employed by another crime lab. It was his experience that this rigid standard may cause applicants to provide false or misleading information, while disqualifying those individuals who provide honest information.

In addition, students often complete the education required to become analysts only to later learn that they are disqualified from employment in a lab, usually due to past misconduct. Informing students about the most common disqualifiers at the outset would eliminate the unnecessary training of students who may never be eligible to work in a crime lab.

This does not mean that the future forensic scientist cannot make mistakes, because everyone has. It means that they must maintain accountability, acknowledge mistakes, and be able to explain how they acted to make corrections. However, it also means that they must strive to avoid criminal activity and association altogether—from the very moment they turn 18—as failure to do so carries with it steep consequences.

Education

The forensic scientist has an obligation to avoid accepting any job title or professional designation that does not describe their formal education and training accurately. For example, a degree in business administration does not prove an adequate foundation for a forensic scientist

nor does an entirely distance or Internet-based degree program (although it can be a valuable component of any well-rounded education).

Forensic science is an applied scientific discipline. Prospective forensic scientists must choose their academic institutions with care and study from those who actually work in disciplines related to their teaching subjects. This will dictate not only how they are perceived by the community, but also the range of internship and employment opportunities available.

At the same time, forensic scientists must become aware of the limitations of their education, training, and experience and not accept tasks or casework outside of their established area of competence.

Every Case, Every Time

Forensic scientists must conduct every examination and prepare every written report of findings, in every case, as though it will be admitted as evidence in court. In doing so, they will not need to defend expedient, sloppy, or incomplete work to a judge or jury. Take the time, every time, and do it right.

Curriculum Vitae: The Professional Resume

The forensic scientist must keep and maintain an up-to-date curriculum vitae, referred to as a CV or a resume. The expert CV should contain the full name with relevant education, training, and experience sections. It should also provide relevant employment history, professional affiliations and activities, and publications. While a complete listing of cases in which the forensic scientist has testified is probably too onerous,² the subjects he or she has been court qualified in, as an expert, may need to be made clear. The reconstructionist, for example, should work to be qualified broadly in crime reconstruction and evidence interpretation.

Forensic scientists should update their CV frequently, each time they complete a new professional accomplishment or experience a professional change, such as a new qualification, employer, training seminar, or publication. Consequently, the CV itself must be dated; this date must be changed each time the CV is updated with new information. The CV should be given to every client or employer and resubmitted with each update.

Red flags telegraphing conflation or a lack of expertise include padding the resume with irrelevant media appearances, church affiliations, hobbies, or the listing of a degree (e.g., Bachelor of Science or Doctorate) without the corresponding subject area (e.g., forensic science, chemistry, animal physiology).

It should not need to be said that forensic scientists must be completely honest on their CV and avoid the inclusion of false or misleading information. However, resume falsification accounts for about one-third of known **forensic fraud**³ (Turvey, 2003). This most commonly

² Some jurisdictions require an explicit accounting of prior expert testimony (case name and number, year of testimony, county, and subject matter), anywhere from 3 to 10 years back. It is best to inquire about this and have it prepared before getting on the stand.

³ Forensic fraud refers to providing sworn testimony, opinions, or reports bound for court that contain deceptive or misleading findings, opinions, or conclusions deliberately offered in order to secure an unfair or unlawful gain.

includes fake degrees and certifications, falsified employment, and false history with respect to testimony. Providing false information on a resume can result in the termination of employment and contracts, overturned court decisions, and even criminal charges.

On the day of testimony, the forensic scientist should make sure that extra copies of his or her CV are available for the attorney, client, judge, opposing counsel, and him- or herself.

Pretrial Communication with Opposing Counsel

Opposing counsel may contact reconstructionists directly in order to discuss their findings before trial. This may even occur before their examinations have been completed. In any case, reconstructionists should agree to speak with opposing counsel only after the client has been notified, and then only with the client or a representative present. This is not a matter of bias, but rather a matter of ensuring that there are witnesses, and a record, of the conversation. This will prevent miscommunication and misrepresentation of the conversation to any third party.

Reports and Exhibits

Forensic scientists should prepare a report that references, and possibly includes, the evidence and exhibits relevant to their findings. This report must be provided, under signature, to attorney and clients in advance of any relevant court proceeding. On the day of testimony, as with the CV, the forensic scientist should make sure that extra copies of the report are available for the attorney client, the judge, opposing counsel, and him- or herself.

See Chapter 19: Forensic Examination Reports for further discussion.

The Pretrial Conference

A pretrial conference is a meeting among the forensic scientist, attorney and clients, and any interested investigators to discuss the nature and limits of examinations, related findings, and anticipated areas of testimony. This provides an opportunity for any questions that may have arisen since the findings were made, to discuss new findings regarding other examinations, or to relay any evidence-related decisions from the court. For example, it is common for the court to determine that certain evidence, findings, or testimony is inadmissible, either in whole or in part, due to issues entirely unrelated to the forensic scientist. As explained in [Cashman and Benak \(2007\)](#), discussing the preparation of an expert medical witness for the prosecution (p. 48):

Often attorneys don't use the same terms as medical professionals, so it is important to make sure both parties fully understand each other; there is actually a mutual education that occurs in the early phases of this important and ongoing relationship which benefits future cases, and inherently patient outcomes.

Providers should not worry about raising concerns or even disagreeing with attorneys if they are misstating or misinterpreting facts or conclusions. For a prosecuting attorney to effectively present the evidence, it is critical such matters such as misunderstandings or incorrect statements of facts be brought to their attention. Further, if a question by the attorney addresses an area that is beyond a medical professional's area of expertise, it's acceptable to state this during preparation and trial, as it is important not to represent material that has nothing to do with the provider's practice area.

The same should be true of any forensic scientist, irrespective of which side has called him or her to testify.

It is also an occasion for the attorney–clients to get to know the forensic scientist in person, review the professional resume, and raise any concerns the attorney may have about how the evidence may be presented. For example, the court may require a pretrial hearing to qualify the expert or determine the admissibility of the forensic scientist’s evidence. If this is the case, the forensic scientist should be capable of providing the attorney–client with the precise nature of his or her expertise and insight as to the relevance of the testimony to the case at hand.

The pretrial conference should involve a discussion of which exhibits will be needed in court to support the forensic scientist’s reconstruction and how they might be presented. The use of small photo prints should be avoided, as they are difficult to see and often rushed through by jurors. Enlarged photos and photo projections are preferred so that the forensic scientists can point to key areas of evidence. A laser pointer is most useful for this purpose. In some cases, it may be possible to give a computer presentation of the findings using PowerPoint, Keynote, or some other presentation software. This is highly preferred, but must be arranged in advance with the court.

The purpose of the pretrial conference is to settle the aforementioned issues, discuss the court’s rulings, and provide an opportunity to learn how certain questions and evidence may, or may not, be answered. This may appear as collusion to some, even though it is not the case. While certainly not a member of the prosecutorial or defense “team,” the forensic scientist has a professional responsibility to ensure that his or her clients are informed regarding issues of evidence and expertise. The attorney, after all, must argue these things to the court. The forensic scientist can only sit there and answer the questions that he or she is asked.

Attorneys who proceed directly into court with a forensic scientist, in the absence of a pretrial conference, run the risk of a ham-handed courtroom presentation that misleads, misinforms, or simply misses. There is little that is more frustrating than being on the stand, under oath, answering questions from an attorney who does not understand one’s resume, area of expertise, or the limits (or the importance) of one’s findings. Such circumstances are to be avoided if possible.

Pretrial Preparation

It is common for courtroom testimony to be required months or even years after forensic examinations have been made. It is likely that the forensic scientist will have examined many cases in the intervening period, some with similar characteristics. To avoid confusion, it is best to review any notes, reports, evidence, exhibits, and prior testimony the day before anticipated testimony in front of the jury. This will make the facts of the case, and the complexities of findings, fresh to the memory and easier to recall.

While rereading your notes and reports, it is a good idea to write down words that may present a problem for the court reporter. This includes uncommon names and scientific instruments. This piece of paper is then handed to the court reporter as you approach the witness stand, with your name on it.

Giving testimony without sufficient pretrial preparation is a fool’s errand. It can make even the most competent forensic professional appear disorganized, forgetful, and even careless.

COURTROOM RULES AND ETIQUETTE

Each courtroom in the United States is presided over by a judge (or magistrate for lesser crimes). Judges are the only person in the court who can speak to anyone, and everyone, at any time, and often in any manner that they see fit. Judges' manner and tone, intentional and otherwise, can improperly telegraph their personal agenda or preferences to the jury. Most judges are professional and objective, dispatching their duties without prejudice and within the law.

However, some judges may be biased either for or against the prosecution before a trial begins. This can be the result of general intolerance and impatience with attorneys resulting from a strained relationship, as they tend to see the same legal players playing the same legal games despite numerous advisements from the bench. This can also be the result of an improper identification and alignment, as many judges are former prosecutors or defense attorneys; they can forget their role and act as a back-up for the side that they favor.

Depending on the case, and child homicides are among the most political, forensic scientists must enter the arena of court anticipating the possibility of open hostility, not courtesy,⁴ although it may or may not be directed at them. They must learn to respond, always, with civility and professionalism. It is by such reactions that they will be quite literally judged.

Manner of Dress

Forensic scientists should dress in professional courtroom attire, not their work clothes. That is to say, they should not arrive in court wearing a lab coat, crime scene gear, or a t-shirt and jeans. That can look contrived and disorganized. The professional male wears a suit and tie; the professional female wears a business suit or a pantsuit. The manner of dress is intended to show respect for the court and to convey organization and reliability to the jury.⁵

Communication with Opposing Counsel during Trial

Opposing counsel may attempt to speak with the reconstructionist directly during trial. This can occur in the hallway before testimony, at breaks during testimony, and even after they leave the stand. There is nothing inherently wrong with this as long as the case is not discussed without the presence of the attorney–client. The reconstructionist can and will be questioned about anything that is said, even casual remarks.

⁴ One of the authors (Turvey) has experienced all manner of incivility and hostility from judges and opposing counsel alike, including unfettered prosecutorial bias, shouting, red-faced screaming, under-the-breath epithets, and even drunkenness on one occasion. Such behavior embarrasses every courtroom that allows it. It can also result in the overturning of verdicts on appeal, even years after the fact.

⁵ Many attorneys are keenly aware that members of the jury scrutinize their manner of dress carefully. Consequently, some adopt a particular courtroom “uniform.” Instead of dressing to their own tastes and means, some will dress up or down in their professional attire depending on their jury. This panders to the jury's perceived class and culture, creating the false impression that they share common socioeconomic origins and values. Sometimes it is effective, and sometimes it backfires.

It is recommended that communication with opposing counsel be the same as with everyone else in the courthouse: professional, courteous, and respectful.

General Advice

Many have written to advise expert witnesses on how best to present themselves in court. Ihle⁶ (2010) provides a comprehensive checklist, followed up by a useful discussion (p. 76):

It is important to prepare, even the experienced expert witness, for what the expert can expect of the court and what the court expects of the witness. Freckelton and Selby (2002) provide 10 points of advice to the expert witness before court:

1. If unfamiliar with giving expert testimony, go and watch someone else do it first.
2. Sit or stand in the witness box and address your answers to the jury or, if there is no jury, to the judge.
3. Dress appropriately.
4. Be aware of the impressions you are making. Take care not to appear arrogant, flippant, hostile, or evasive.
5. Listen to the questions carefully and ensure you understand them before answering.
6. Be as clear, precise, and confident in your answers as the strength of your views permit.
7. If you cannot answer a question, then say so and explain why. Offer to redress the situation if possible.
8. Make sure you are aware of the factual and legal issues that invite your involvement.
9. Convey your views with whatever visual aids you believe will best assist your giving of evidence.
10. Do not misconstrue any question asked as a request to take a particular stance on an issue.

While this is a helpful checklist, there is one tenet above all else which may best encapsulate the role of the expert and ensure the expert does not waste his or her and the court's time: *do not forget your audience*.

Whether before a jury or a judge sitting alone, the expert is called upon as a witness to assist the court. The reason is that the expert has specialized knowledge accrued through years of education, training, and experience which the judge or jury do not have. The expert has been called upon by a party to explain how that knowledge can enlighten those deciding the case. It is almost axiomatic that the subject matter of the expert evidence will involve at least some concepts which are complicated for the uninitiated to grasp. Accordingly, the message must be given in a palatable form.

Attending to this general advice is an excellent beginning for any forensic scientist.

The Ultimate Issue Doctrine

The ultimate issue is the legal question before the trier of fact (a.k.a. the judge or the jury). As explained in *Black's Law Dictionary* (Black, 1990), the **ultimate issue** is "that question which must finally be answered as, for example, the defendant's negligence is the ultimate issue in a personal injury action." That is to say, the ultimate issue relates to legal findings of guilt, innocence, or, in civil matters, liability. The ultimate issue is meant to be determined by the trier of fact based on consideration of the **ultimate facts**, defined in Black (1990) as "facts which are necessary to determine issues in cases, as distinguished from evidentiary facts supporting them." The judge decides what the ultimate facts of a case are, based on his or her deductions and good judgment as they relate to the evidentiary facts.

⁶ Mr. Ihle is a former student of one of the authors (Turvey), who, after graduating from law school, went on to become a Crown Prosecutor in Victoria (Australia). After working for several years in that capacity, he went into private practice and now serves as both appointed prosecutor and defense counsel on serious criminal matters.

The history of case law that prohibits forensic experts from intruding on the ultimate issue by directly answering these kinds of questions for the judge or jury is referred to as the *ultimate issue doctrine*. This holds that witnesses are prohibited “from giving an opinion on the ultimate issue in the case. The rationale underpinning the ultimate issue rule is that expert opinion should not be permitted to invade the province of the jury” (Moenssens et al., 1995, p. 75).

THE FEDERAL RULES OF EVIDENCE, WHICH ARE USED AS GUIDE FOR THE ADMISSION OF EXPERT TESTIMONY IN MOST LEGAL JURISDICTIONS, STATE (FRE, 2006, PP. 13–15):

Article VII. Opinions and Expert Testimony

Rule 701. *Opinion Testimony by Lay Witnesses*

If the witness is not testifying as an expert, the witness’ testimony in the form of opinions or inferences is limited to those opinions or inferences which are (a) rationally based on the perception of the witness, and (b) helpful to a clear understanding of the witness’ testimony or the determination of a fact in issue, and (c) not based on scientific, technical, or other specialized knowledge within the scope of Rule 702. (As amended Mar. 2, 1987, eff. Oct. 1, 1987; Apr. 17, 2000, eff. Dec. 1, 2000.)

Rule 702. *Testimony by Experts*

If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case. (As amended Apr. 17, 2000, eff. Dec. 1, 2000.)

Rule 703. *Bases of Opinion Testimony by Experts*

The facts or data in the particular case upon which an expert bases an opinion or inference may be those perceived by or made known to the expert at or before the hearing. If of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence in order for the opinion or inference to be admitted. Fact or data that are otherwise inadmissible shall not be disclosed to the jury by the proponent of the opinion or inference unless the court determines that their probative value in assisting the jury to evaluate the expert’s opinion substantially outweighs their prejudicial effect. (As amended Mar. 2, 1987, eff. Oct. 1, 1987; Apr. 17, 2000, eff. Dec. 1, 2000.)

Rule 704. *Opinion on Ultimate Issue*

- (a) Except as provided in subdivision (b), testimony in the form of an opinion or inference otherwise admissible is not objectionable because it embraces an ultimate issue to be decided by the trier of fact.
- (b) No expert witness testifying with respect to the mental state or condition of a defendant in a criminal case may state an opinion or inference as to whether the defendant did or did not have the mental state or condition constituting an element of the crime charged or of a defense thereto. Such ultimate issues are matters for the trier of fact alone. (As amended Oct. 12, 1984.)

Rule 705. Disclosure of Facts or Data Underlying Expert Opinion

The expert may testify in terms of opinion or inference and give reasons therefor without first testifying to the underlying facts or data, unless the court requires otherwise. The expert may in any event be required to disclose the underlying facts or data on cross-examination. (As amended Mar. 2, 1987, eff. Oct. 1, 1987; Apr. 22, 1993, eff. Dec. 1, 1993.)

Rule 706. Court Appointed Experts

- (a) Appointment—The court may on its own motion or on the motion of any party enter an order to show cause why expert witnesses should not be appointed, and may request the parties to submit nominations. The court may appoint any expert witnesses agreed upon by the parties, and may appoint expert witnesses of its own selection. An expert witness shall not be appointed by the court unless the witness consents to act. A witness so appointed shall be informed of the witness' duties by the court in writing, a copy of which shall be filed with the clerk, or at a conference in which the parties shall have opportunity to participate. A witness so appointed shall advise the parties of the witness' findings, if any; the witness' deposition may be taken by any party; and the witness may be called to testify by the court or any party. The witness shall be subject to cross-examination by each party, including a party calling the witness.
 - (b) Compensation—Expert witnesses so appointed are entitled to reasonable compensation in whatever sum the court may allow. The compensation thus fixed is payable from funds which may be provided by law in criminal cases and civil actions and proceedings involving just compensation under the fifth amendment. In other civil actions and proceedings the compensation shall be paid by the parties in such proportion and at such time as the court directs, and thereafter charged in like manner as other costs.
 - (c) Disclosure of appointment—In the exercise of its discretion, the court may authorize disclosure to the jury of the fact that the court appointed the expert witness.
 - (d) Parties' experts of own selection—Nothing in this rule limits the parties in calling expert witnesses of their own selection.
(As amended Mar. 2, 1987, eff. Oct. 1, 1987.)
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Careful readers will note that Federal Rule of Evidence (FRE) 704 all but abandons the ultimate issue doctrine, explaining that testimony “in the form of an opinion or inference otherwise admissible is not objectionable because it embraces the ultimate issue to be decided by the trier of fact.” Rather, the FRE requires that expert opinions be “helpful.” However, much subsequent case law retains the prohibition, with courts all across the United States unwilling to allow experts to give this kind of testimony, although there are exceptions ([Moenssens et al., 1995](#)).

The rules of evidence and related case law are essentially conflicted on the question of ultimate issue testimony from forensic experts. This pretty much guarantees that experts will be asked to violate it. In fact, it is customary in certain legal circumstances. Forensic scientists must take notice of whether and how their findings intrude on the ultimate issues before writing reports, let alone taking the witness stand.

Forensic practitioners routinely hold scientific findings or inferences within their respective fields that bear closely or directly on the ultimate issue. As explained in [Moenssens and colleagues \(1995, p. 76\)](#):

The problem regarding the ultimate issue limitation is simply that in complex cases involving issues beyond the abilities of a layman, a jury may need an expert's opinion on the ultimate issue in order to reach a fair verdict. Opinion on the issues of identity [i.e., DNA, fingerprint comparison, etc.], value, insanity, and intoxication, for instance, all border on what would be considered ultimate fact issues, yet they are generally held admissible.

Forensic practitioners should, of course, be able and willing to educate the court as to scientific opinions related to and bordering on the ultimate issue, but they must fully acknowledge their limitations.

Because scientific fact and legal truth do not abide by the same standards, forensic practitioners are necessarily barred from intruding on the ultimate issue when it involves a purely legal determination or subject matter that is beyond their area of expertise. The reasons for this are fairly straightforward: forensic scientists are not generally experts at rendering legal conclusions within the complex considerations of regional statutes and case law that bind the average jurist; while they may hold opinions on many issues, not all of these are necessarily expert opinions. If the ultimate issue relates to a question that is within the practitioner's area of expertise, then it is disingenuous for the court to bar the forensic practitioner from giving related testimony. However, this assumes that both the court and the practitioner are being careful to delineate the nature and scope of that expertise. This is not always the case. Some examples may be useful.

- A psychiatrist may be asked to give an opinion on the ultimate issue of competency or sanity in a pretrial hearing. As the interpretation of either is a question of mental character, this is properly within certain kinds of psychiatric and even psychological expertise. In such cases the ultimate issue of guilt is either conceded or irrelevant to the proceedings.
- A DNA analyst may be asked to give testimony regarding the nature and probability of a particular DNA "match" at trial. He or she may then be asked a follow-up question regarding the identity of the contributor of a particular DNA sample. These are properly within their area of expertise—assuming that the criminalist has sufficient education and training in probabilities and statistics. However, asking him or her to opine regarding the guilt or innocence of a particular person based on these findings would intrude on the ultimate issue in an improper fashion.
- An expert on crime reconstruction or rape investigation may be asked to give testimony on the existence of injuries related to sexual assault, or false reports of sexual assault, and related indicia. Then he or she may be asked whether the case at hand involves a rape or false report. If the expert has expertise and evidentiary findings that bear directly on this issue, as well as a related expert opinion, then there is no reason for the court to exclude it. Rather, the expert has a duty to refrain from delving into issues of ultimate legal guilt or innocence. He or she must stick with the scientific facts and make clear that he or she is not drawing any legal conclusions. This is analogous to a forensic pathologist testifying as to cause and manner of death and determining cause as a gunshot wound and manner as homicide (which is a crime, and subsequently an ultimate issue)—without naming the person responsible.

Suffice it to say that reconstructionists should be ever mindful of the ultimate issue and approach the question of whether and when they may violate it with great care. Sometimes they will be barred from doing so when it is clearly within their scope; sometimes they will be invited to do so when it is not. In either instance they must abide the rulings of the court—even when they disagree.

The Judge Decides What Is Relevant at Trial

The courtroom is a realm of laws, not science. Science is merely an occasional guest. Barring misconduct, a judge's authority over his or her cases must be respected and his or her will conformed to. The judge decides who the experts are, what evidence is admissible, and how and when court will proceed. If one seeks to engage in forensic practice, one must accept this reality and the many disappointments that will necessarily follow.

Consider the issue of *evidence*. **Evidence**, as explained in Black (1990), is "testimony, writing, material objects, or other things presented to the senses that are offered to prove the existence or non-existence of a fact." This is consistent with Lilly (1987, p. 2), which provides that evidence is "any matter, verbal or physical, that can be used to support the existence of a factual proposition." Evidence in a forensic context is not a scientific designation: it is a legal construct.

Consider that any fact or finding gathered in relation to a legal proceeding is considered evidence until a judge says it is not. For example, documentation of a factual event may exist, such as a taped interview, a written confession, or an exclusionary test result. However, a judge may determine that it is not admissible, for whatever reason, and that fact and related documentation may not be considered as evidence at trial.

As a direct result of this legal reality, the sum total of evidentiary facts under consideration by a judge or jury in a given case generally does not represent the entire picture of known facts or findings; rather, it is the court's interpretation and reduction of the evidence based on its determination of what is and is not admissible. According to Black (1990), **admissibility** "as applied to evidence. . . means that the evidence introduced is of such character that the court or judge is bound to receive it; that is, allow it to be introduced at trial." Trial judges have broad discretionary authority with respect to deciding the admissibility of any proposed evidence. It is, in reality, a complex and inconsistently applied legal heuristic whereby a judge determines which facts and circumstances may actually be introduced as evidence based on "material relevance." Such determinations may be standardized for certain kinds of proposed evidence or may require an evidentiary hearing.

However, the trial judge is not the final decider; any case may be overturned by a court of appeals, given sufficient cause from a judge that has improperly excluded evidence or experts seeking to present it.

Excluded Material

The judge is likely to have determined that certain evidence, areas of questioning, or sections of the reconstructionist's report are inadmissible. That is to say, they cannot be mentioned during testimony. The reconstructionist must respect these limiting instructions, when made aware of them, by avoiding broad or editorial answers that deliberately raise excluded issues.

However, the reconstructionist must also answer all questions truthfully. Sometimes, attorneys will open the door to excluded material by asking a question that leads directly down the forbidden path. Even when the reconstructionist is aware of the excluded nature of such testimony, he or she has little choice but to answer as honestly as possible. On these occasions, it is wise to look over and ask the judge for permission to answer, advising that the question leads to excluded areas and issues. Once the door has been opened by such a question, the judge may

direct the reconstructionist to answer, or not. This is a matter for the court to decide and, again, has nothing to do with competence of the reconstructionist or his or her ability.

When Giving Testimony

Giving effective courtroom testimony is a difficult skill and not one that is acquired by all who practice forensic science. Developing this skill is, in fact, not a sign of forensic expertise. Some of the best practitioners are, to be frank, terrible in court. And some of the worst are among the most convincing when on the stand.

As with any skill, it is best understood and mastered through observation, practice, and review.

Listen carefully to all questions. Really understand the question before answering because some are traps, designed to get the forensic scientists to agree to something in the question that is untrue or improperly assumed. Have the question repeated if necessary, no matter who is asking it.

If a question sounds like nonsense, it probably is. Sometimes attorneys just come up with things off the top of their heads or start down a coherent line of thought only to lose themselves, forgetting their place. Asking them to repeat the question for failure to understand it will help everyone in the room who is just as confused.

Do not anticipate questions or answer until the question is complete. This is an easy thing to forget, but testimony is not a conversation. When people in a courtroom talk over each other it is both rude and confusing, which may be the intention.

If the forensic scientist does not know the answer to a question, the only correct answer is “I do not know.”

If forensic scientist must refer to their CV or report in order to best respond to a question, they should first ask the court’s permission. Look directly at the judge and say “Your Honor, may I refer to my report in order to refresh my memory?” The answer should always be yes. If opposing counsel asks the forensic scientist to testify without referring to the written work, answer: “I would prefer not to rely on the frailty of memory in such a complex matter. It’s better to get it right.” Certainly, opposing counsel will not be delivering questions without the aid of their written work, unless they are egotists or fools.

Answer all questions slowly and deliberately⁷ so that all can hear. Do not let others quicken the pace or create urgency where there is none. Slow down the cadence of testimony at every opportunity.

The direction of testimony is important. Face the judge when answering questions pretrial or outside the presence of the jury. Face the jury during trial. If counsel or the court asks why you are doing this, explain that you are trying to make sure that the trier of fact hears your answer clearly. Do not move as though a robot; move and speak as though you are having an instructive conversation with the jury. The less stiffness in testimony, the better.

⁷ One of the authors (Turvey) enjoys a 15-year history of being chastised by court reporters for speaking too fast. It is to the point now where once on the stand, the author affixes a sticky note to the area in front of him that reads only “Slow Down.”

Conversely, the forensic scientist should not let anyone interrupt his or her answer to a question. If interrupted, the forensic scientist should ask to be allowed to finish his or her answer, for fear of misleading the jury. If the court does not allow it, at least a record of being interrupted has been made.

After each question, the forensic scientist should look first at opposing counsel to see if there is going to be an objection. Then turn casually to the jury before answering. This allows any objections to be made before testifying. Mistrials can be avoided by this simple pause.

If there is an objection during testimony, stop speaking immediately. Wait for the judge's rule on the objection and then continue only when directed to do so. Do not take the objection personally. Often they arise out of legal rulings and strategy that have nothing to do with the forensic scientist. If it is intended to be personal, delivered with an intentional slight, respond only with civility and then only when directed to do so.

The forensic scientist should remember that the three most important things with respect to courtroom testimony are

1. Telling the truth
2. Telling the truth
3. Telling the truth

Do not leave the witness stand, ever, unless given permission to do so by the judge. If the judge has not given permission, ask for it before rising up to leave. When excused by the judge, step down from the stand, exit the courtroom, and leave the courthouse unless otherwise directed by your client.

False Testimony and Perjury

It should not need to be said that intentional false testimony, and perjury, must be avoided. There is simply no excuse for either. For example, one of the authors (Turvey) testified as an expert in forensic science and crime reconstruction for the defense in a case in Nevada. A young DNA analyst for the prosecution testified, under oath, that no further items of evidence were being tested by the police crime lab. Subsequent to her testimony, she generated a lab report regarding evidence that was being examined even while she was on the stand. Consequently, the defense called her back to testify during their part of the trial. The author deliberately met with the DNA analyst outside of the courtroom to let her know what was coming. Apparently someone had told her that testifying in this manner was acceptable. She was under the impression that concealing the fact of ongoing testing was not a problem. Therefore, this was an example of ignorance and obeying an order—not necessarily perjury. The lesson here is not to take anyone's word that withholding facts under oath is acceptable—even if it is policy.

Perjury, it should be noted, is the act of lying or making verifiably false statements on a material matter under oath or affirmation in a court of law or in any sworn statements in writing. A criminal act, it is not sufficient for the statement to be false to also be considered perjury; it must be regarding a material fact—a fact relevant to the case. Consequently, not all intentionally false statements made under oath are considered perjury.

Those who intentionally give false testimony, especially in the form of perjury, should be sanctioned and excluded from giving evidence in court. Certainly evidence of such misconduct

should be admissible as evidence in any court where they seek to give testimony. Unfortunately, neither is universally the case.

JURY PSYCHODYNAMICS

Because the forensic scientist is trying to communicate with the jury, it is prudent to discuss how juries are known to think and reason. Many psychological facets and relationships have influence over decision making, and jurors deliberating as to guilt or innocence are not especially immune to their complexities.

Availability Heuristic

As defined in [Turvey \(2011\)](#), **availability heuristic** refers to the “tendency to answer a question of probability by asking whether examples come readily to mind. What we recall becomes what we believe will be likely.” This is how many people reason, including many jurors. They do not actively listen, they do not try to learn, and they have no interest in reaching beyond what they already know so they tune out when required to try. Their first point of reference for understanding and solving any problem is going to be experience and movies or television, and not necessarily in that order. When explanations go beyond their experience, they tend to be cynical and even mistrustful. The less education, intelligence, and critical thinking possessed by individual jurors, the more their decision making is influenced by their own subjective availability heuristic.

Primacy Effect

The **primacy effect** is a cognitive bias in which those ideas or arguments that come first are given more credibility than those that come later. In other words, whoever or whatever comes first is right: the first to present evidence and opinions; the first to make an argument; and the first to make his or her case. This creates a tremendous bias in favor of the side that presents their case to the jury first—namely, the prosecution.

The primacy effect is reduced when information is presented too quickly and is increased when information is presented slowly. This would seem to be highly relevant to how evidence and arguments should be presented to the jury, depending on the desired outcome. Evidence and legal arguments are two very separate things. Arguments can be based on evidence, but not necessarily. Some arguments are mere speculation without evidentiary foundation.

Recency Effect

The **recency effect** is a cognitive bias in which those items, ideas, or arguments that came last are remembered more clearly than those coming first. The more recently heard, the clearer something may exist in the juror’s memory. This is common when information is given in lists—the last thing heard is recalled, while those at the beginning and in the middle may be forgotten.

The recency effect is increased when too much information is presented too quickly and is reduced when coupled with other tasks. With respect to jury memory, allowing note taking could also reduce it.

Belief Perseverance

Belief perseverance is the tendency to prefer and shield personal or preexisting beliefs despite irrefutable evidence that they are incorrect. This is related to *confirmation bias*, which involves seeking out only those sources of information that support preexisting beliefs or theories and actively neglecting all contrary evidence or sources of information. This means that when someone has strongly held personal beliefs, it is likely that they will be immune to facts or evidence that disproves them. Jurors are no different, and it is therefore important for those beliefs to be revealed during the voir dire process when they are relevant to issues at trial.

The CSI Effect

All of the previously mentioned biases and influences contribute strongly to what has been referred to as **the CSI effect** and its impact on juror expectations and decision making. Named after the popular television franchise, this particular set of biases is caused by the portrayal of forensic science on fictional and pseudo-documentary programs such as *CSI*, *Forensic Detectives*, and *Forensic Files*. In these programs, forensic evidence is gathered, examined, and interpreted quickly by armed police investigators who convey moral umbrage and confront criminals directly with laboratory findings. As explained in [Cooley \(2007\)](#), religious viewers of such programs (p. 471) “come to believe or blindly assume three broad themes regarding the forensic science community: (1) crime labs are pristine scientific sanctuaries, which always have the most up-to-date forensic technology; (2) crime labs only employ the most skilled and imaginative “scientists” who make few, if any, errors; and (3) forensic scientists are actually practicing and engaging in legitimate science.”

The reality is that forensic evidence examination, testing, and interpretation are lengthy processes involving scientists, not police officers, many of whom work in less than ideal conditions with limited budgets and training, surrounded by many biasing influences—to say nothing of error rates for evidence testing being generally unknown. This means that, too often, there is no science in forensic science (see generally [Edwards and Gotsonis, 2009](#)).

The CSI effect can impact the juror in two ways. First, it can create unreasonable expectations for the prosecution—that physical evidence will always be collected, tested, and examined in every case, even when the resources don’t permit it or the facts of the case don’t require it. Second, it can create an unreasonable bias against the defense, as the evidence presented by the state’s forensic examiners may be presumed infallible or more certain than it actually is. This is especially problematic when attorneys and forensic scientists distort their arguments and testimony intentionally to meet the expectations created by the CSI effect, in essence leaving false impressions behind in the minds of jurors.

SUMMARY

The defining quality of forensic scientists is their anticipation of courtroom testimony—the possibility that they will be called upon to present scientific findings, under penalty of perjury, in a court of law. They are given the trust of court and are allowed to offer not just the facts

related to their examinations, but also opinions. The forensic scientist assists the justice system, criminal and civil alike, as educator to attorneys, judges, and juries. The forensic scientist has a responsibility to be competent, objective, and professional.

The professional credibility of a forensic scientist may be influenced even before stepping foot into the courtroom. Pretrial courtroom considerations that may influence professional credibility include, but are not limited to, the following: character, education, consistency, curriculum vitae, pretrial communication with opposing counsel, reports and exhibits, the pretrial conference, and preparation.

Similarly, the professional credibility of the forensic scientist may be influenced by factors once inside the courtroom, including manner of dress and communication with opposing counsel during trial. Forensic scientists must also enter the courtroom with an understanding of the *ultimate issue*, relating to legal findings of guilt, innocence, or, in civil matters, liability. The history of case law that prohibits forensic experts from intruding on the ultimate issue by directly answering these kinds of questions for the judge or jury is referred to as the *ultimate issue doctrine*.

The courtroom is a realm of laws, not science. The judge decides who the experts are, what evidence is admissible, and how and when court will proceed. The reconstructionist must respect these limiting instructions when giving testimony. Giving effective courtroom testimony is a difficult skill and is best understood and mastered through observation, practice, and review.

Because the forensic scientist is trying to communicate with the jury, it is important to understand how juries are known to think and reason. Many psychological facets and relationships have influence over decision making, and jurors deliberating as to guilt or innocence are not especially immune to their complexities. Potential juror influences include *the availability heuristic*, *the primary effect*, *the recency effect*, *blind perseverance*, and *the CSI effect*.

QUESTIONS

1. Provide two examples of pretrial courtroom considerations for the forensic scientist.
2. Explain the *ultimate issue doctrine*.
3. What is the most important thing that a forensic scientist should remember with respect to courtroom testimony?
4. Perjury must be regarding a _____ fact—a fact relevant to the case.
5. Explain two ways how the CSI effect can impact the juror.

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I

Crime Reconstruction Report: Sharp Force Homicide

Brent E. Turvey

The author examined the evidence in this case as part of a postconviction review of the evidence. He then gave expert testimony during an appellate hearing regarding all of the findings presented. All appeals to date have failed, with rulings that have openly ignored the physical evidence. David Thorne remains in prison as of this writing.

February 24, 2003

MEMORANDUM

FROM: Brent Turvey, M.S., Forensic Solutions, LLC, Ph# (907) 747-5121

TO: Jeffrey Pederson & William "Bud" Doyle, Attorneys for David Thorne

SUBJECT: *Ohio v. David Thorne*, Case #1999CRA00750

This document is a supplement to the original report generated by my office in this case dated January 2, 2003. It is prepared subsequent to a careful examination of the crime scene and autopsy photographs, which were provided my office after the completion of the original report. The purpose of this supplement is to compare statements regarding the crime and the crime scene to the physical evidence documented in the crime scene and autopsy photographs. All conclusions rendered in the original report are reasserted, and a review of this supplement without the original should be considered incomplete.

In advance of rendering these conclusions, this examiner finds it necessary to make the following statement and place it in bold type so that it will not be missed in a review of this supplement. **Perhaps the single-most important factor in the disposition of this case has been the chronic failure of professionals to actually read through and examine the case material to develop a genuine understanding of the case facts. This includes those charged with doing so for the prosecution of the defendant, and those charged with doing so on his behalf.** Without a full and genuine understanding of the case facts, it seems highly improbable that any jury could make informed decisions about the guilt or innocence of any defendant.

BACKGROUND

(Taken entirely from *Ohio v. David Thorne*, No. 2000CA00067, Nov. 20, 2000)

On September 15, 1999, a Stark County Grand Jury indicted David Thorne with one count of aggravated murder. The grand jury also added the specification David Thorne conspired to commit the murder for hire. At his September 16, 1999 arraignment, David Thorne plead not guilty to the charge.

David Thorne was charged with hiring Joseph Wilkes to kill his ex-girlfriend, Yvonne Layne. Ms. Layne was the mother of five children. David Thorne was the father of one of Ms. Layne's children, Brandon. Mr. Wilkes confessed he killed Ms. Layne in her home on March 31, 1999. Mr. Wilkes agreed to testify truthfully about the crime and David Thorne's involvement in the planning of the murder in exchange for a life sentence with possibility of parole after 30 years.

A jury trial commenced on January 18, 2000, at which time the following evidence was adduced.

On April 1, 1999, Tawnia Layne, the victim's mother, went to Yvonne Layne's home to take one of her grandchildren to school. When she arrived, Tawnia found her daughter's body. Yvonne's throat had been cut, and her body was lying in a pool of blood. Yvonne's five young children were awake in the house. Tawnia Layne called the police.

While there were two partial bloody footprints at the scene, there was little other physical evidence. The police were unable to recover any usable fingerprints. Although a knife was recovered from a nearby storm sewer, the knife had been wiped clean. As part of the investigation, the police discovered Yvonne had recently implemented paternity proceedings for her son Brandon.

As a result, David Thorne was ordered to pay child support in the amount of \$358 per month with weekly payroll deductions beginning in March 1999. By the time of his first payment, David Thorne owed more than \$700 in back support. The Alliance police learned of Mr. Wilkes through Rose Mohr. Ms. Mohr contacted the police to tell them she and her boyfriend, Chris Campbell, had spoken with Mr. Wilkes at the Carnation Mall in Alliance on the night of March 31, 1999.

According to Ms. Mohr, Mr. Wilkes told her and Mr. Campbell that he was in Alliance because he had been hired to kill a woman. Mr. Wilkes made statements that he had purchased a knife at Walmart and showed Ms. Mohr and Mr. Campbell the knife. Ms. Mohr remembered Mr. Wilkes saying he was hired for money to commit the murder "for a guy."

In contrast, Mr. Campbell recalled Mr. Wilkes stating that his "girlfriend" had paid for a room for him at the adjoining Comfort Inn, this girlfriend had dropped him off, and the girlfriend had asked Mr. Wilkes to commit the murder. (Note: This is taken from the court record, which has these statements transposed. According to our documentation, Ms. Mohr states that it was a girlfriend and Campbell states that it was a guy.)

In July 1999, Mr. Wilkes confessed to the murder and implicated David Thorne, claiming David Thorne paid Mr. Wilkes to kill Ms. Layne. Mr. Wilkes gave details: how David Thorne planned the murder; provided an alibi for himself; provided Mr. Wilkes with a place to stay before and after the murder; provided transportation to and from that location; and provided money to purchase the batting gloves and the knife used in the murder. Mr. Wilkes testified David Thorne wanted custody of his son Brandon and did not want to pay child support to Ms. Layne. Mr. Wilkes testified he rented a room at the Comfort Inn at Carnation Mall in Alliance on March 31, 1999. He then purchased batting gloves and later a knife at the Kmart in the mall, walked to Ms. Layne's residence, and committed the murder. He told the police he threw the knife in a storm sewer near the house and disposed of his gloves in a McDonald's dumpster.

The next morning, he claimed David Thorne picked him up at the hotel and took him to a friend's house. Mr. Wilkes hid his black nylon pants in the woods near his friend's house. He could not recall what he did with his shoes or his shirt.

After 5 days of testimony and deliberation, the jury found David Thorne guilty of aggravated murder and guilty of the specification David Thorne conspired to commit murder for hire.

CONCLUSIONS

After a careful review of the available case material, the following are our conclusions and their basis.

Conclusion #1: According to page 3 of the undated Coroner's Report, signed by PSS Murthy, MD sometime after the autopsy on 4/1/99, the victim, Yvonne Lane, received a "gaping incised wound to the neck extending from left to right and measuring 8×4 ". The Sternomastoid is severed The trachea is partly severed The left internal and external carotid artery and the jugular vein are severed."

It is this examiner's conclusion that the victim received this injury while standing very near the sliding glass door opposite the kitchen in her home, while facing it at least partially. Furthermore, that victim was attacked from behind. This conclusion is supported by the following facts, evident in the crime scene photos ([Figures 1-4](#)).



FIGURE 1



FIGURE 2



FIGURE 3



FIGURE 4

- A. There are strong, distinctive arterial spurt patterns in the crime scene, transferred from the victim to the following surfaces in generally the following sequence: the sliding glass window; the wood floor in front of the sliding glass window; the kitchen table; the wooden floor between the kitchen table and the couch; and the arm of the couch.
- B. The height of the arterial spurt patterns on the sliding glass window are most consistent with a standing victim.
- C. Arterial spurt patterns nearest the sliding glass door are the strongest and come from a standing victim, indicating that they are the first. As blood pressure drops, so does the strength and subsequent volume of any arterial spurting. As the blood pressure drops, so does the ability of the victim to stand upright.
- D. There is an empty space, or a void pattern, in the blood patterns in front of the sliding glass window. This indicates the precise location where the offender and victim were standing when the victim suffered the aforementioned injury.

Conclusion #2: The offender in this case sustained significant blood transfer from the victim, to the point that it was dripping off of his person. This conclusion is supported by the following facts, evident in the crime scene and autopsy photos.

- A. As already stated in *Conclusion 1D*, there is a void pattern in the blood patterns in front of the sliding glass window, indicative of the precise location where the offender was standing when the victim received the aforementioned injury. This void is created by the offender's body blocking the transfer of gushing blood from the victim onto the wall and floor.
- B. The bottom of the victim's right foot sustained dropped blood transfer as opposed to the smeared/contact blood transfer covering the bottom of the left foot. This must necessarily have come from blood dripping on to the victim while the bottom of her feet were exposed, very likely in the position she was found. The blood could not have been dripping off of her to land in this location ([Figures 5 and 6](#)).



FIGURE 5



FIGURE 6

- C. There is blood transfer on the skirt of the couch at ankle level just below the location where a bloody knife was apparently wiped off. There are also associated blood patterns on the carpet in the same area. The victim did not make it this far. This indicates that the offender had blood on his pants and shoes ([Figures 7 and 8](#)).



FIGURE 7



FIGURE 8

Conclusion #3: The victim appears to have been partially carried or partially dragged, by the offender, away from the sliding glass window the short distance in to the living room area where she was found. This conclusion is supported by the following facts, evident in the crime scene and autopsy photos.

- A. As already stated in *Conclusion 2B*, the bottom of the victim's right foot sustained dropped blood transfer as opposed to the smeared/contact blood transfer covering the bottom of the left foot. This indicates that the victim was not fully supporting herself with both feet as she traversed the blood continually spurting out on the floor in front of her.
- B. There is a long smear pattern in the spurting blood beginning in the area near the void pattern and ending at the victim's right calf. This pattern indicates that the victim's right leg was being dragged across the spurting blood. This indicates that the victim was being supported or dragged by someone when that transfer was made (Figure 9).



FIGURE 9

- C. There is a second long smear pattern inside of the spurting blood beginning in the void pattern and ending at the victim's right thigh. This indicates that the movement of the offender corresponds with the movement of the victim subsequent to her injury (Figures 10 and 11).



FIGURE 10



FIGURE 11

Conclusion #4: There is no evidence to support the conclusion that the offender was facing the victim at any time during the attack. This conclusion is supported by the following facts, evident in the crime scene and autopsy photos.

- A. As already stated in *Conclusion 1*, the victim was attacked from behind.
- B. There are no defensive injuries sustained by the victim.
- C. The distance traversed from the location where the victim was initially attacked (the sliding glass window) to the victim's final resting place in the crime scene (the floor in front of the couch) is very short. However, it does contain all of the arterial spurt patterns in the crime scene.
- D. There are no spiraled arterial spurt patterns, suggesting that the victim did not turn to face her attacker after receiving her neck injury.

Conclusion #5: The white dresser in the living room appears to have been pulled down over the victim, possibly to simulate a struggle, after the victim was already on the ground. Moreover, the TV appears to have been placed on her body, as opposed to having fallen on her body. This conclusion is supported by the following facts, evident in the crime scene and autopsy photos.

- A. The TV is too far away from the dresser upon which it had been resting with the cable box to have fallen into the location where it was found (Figures 12 and 13).



FIGURE 12



FIGURE 13

- B. There is no associated injury/bruising on the victim from having the TV land on her. Injuries of some kind would be expected at the location of impact from an object this heavy.
- C. The dresser is too close to the wall to have been knocked off balance by an impact to its base.
- D. The base of the dresser is still touching the wall, indicating that it was pulled forward from the top.
- E. There are no bloody handprints evident on the TV, cable, or dresser. Furthermore, this examiner has not read any reports or notes indicating the presence of blood on the TV, cable, or dresser. The victim's hands are covered in blood. The victim's body is covered in blood. If the victim had pulled or knocked the dresser over through bodily contact, there would be blood transfer (Figures 14 and 15).



FIGURE 14



FIGURE 15

Conclusion #6: Because of the amount of blood associated with the floor of the home where the body was found, and the fact that the body blocked access from one side of that floor to the other, it is unlikely that anyone, adult or child, could enter it without receiving blood transfer or changing the scene in some way.

Conclusion #7: An Alliance Police Department (APD) Narrative Supplement dated 7/16/99 by Det. Sampson provides the following summarized account of events by Joseph Wilkes:

When asked to describe what he did [to Yvonne Lane], Wilkes said, "We were sitting on the couch talking. I reached over, grabbed her hair and cut her throat. She tried to run out the door, the big glass door that slides, she turned around and asked me why, I told her David wanted me to, and she fell to the floor, I walked over by her and said I never did it and I walked out and ran."

An APD Narrative Supplement dated 7/21/99 by Det. Sampson provides a similar summarized account of events by Joseph Wilkes:

Due to Wilkes and Layne knowing each other, the two went to the living room and conversed while seated on the couch . . . While talking, Layne had turned her head away from Wilkes, like she was listening for one of the children. Wilkes has reached into his pocket and pulled out the knife, opened it and with one swift

move, grabbed Layne by the hair, pulled and cut the throat with the knife. Layne, after having her throat cut, bounded to her feet in an attempt to get away from her assailant. She runs towards the glass sliding doors but stopped. She turned around to face Wilkes and in her last dying breath asked "Why did you do that?" Wilkes, while looking Layne in the face, told her "David wanted me to." After that was said, Layne fell over to the floor and died in her living room.

These two summaries are consistent with the Summary of Oral Statements of Defendant (Joseph Wilkes) dated 10/5/99, signed by and agreed to by four different prosecuting attorneys.

These versions of events as provided by Joseph Wilkes are absolutely contradicted by the physical evidence in this case. Furthermore, these versions of events are by themselves unreasonable and unsupportable. This conclusion is supported by the following facts, evident in the crime scene and autopsy photos.

- A. As provided in *Conclusion #1*, the attack began at sliding glass door. It did not start at or on the couch. Had it begun on the couch in the position described by Mr. Wilkes, there would have been arterial gushing along the back of the couch and the wall above the couch, at the very least ([Figure 16](#))



FIGURE 16

- B. If the victim had run to the sliding glass door and tried to leave, there would be bloody handprints on its surface or on its handle. No such evidence exists.

- C. If the victim had run to the sliding glass door and tried to leave out of desperation and/or panic and/or fear, it defies reason that she would suddenly stop, turn around, and demand an explanation from her assailant. This would increase her danger of being injured again.
- D. Even if the victim had run to the sliding glass door and suddenly decided to turn around and speak to her assailant, she would not have been able to. She would have been light-headed from extreme blood loss, losing her vision and her balance. She would also have found it nearly impossible to speak through her severed trachea (Figure 17).



FIGURE 17

- E. The victim's neck injury released continual arterial spurts until she collapsed on the floor in front of the couch. As provided in *Conclusion #4D*, there are no spiraled arterial spurt patterns. This indicates that the victim did not turn to face her attacker after receiving her neck injury. She moved in a curved path from the sliding glass window to the living room.

It should be noted at this point that Mr. Wilkes signed an affidavit on July 18th, 2001, denying any involvement in the homicide of Yvonne Layne.

Conclusion #8: According to an APD Narrative Supplement dated 7/15/99, Joseph Wilkes offered to take police officers "to the location where he had discarded his bloody pants. The Adidas "swooshy" pants were located in a muddy creek bed, in a wooded area adjacent to 4641 Loomis Parkway in Ravenna, Ohio. According to a Canton-Stark County Crime Laboratory report for case no. 99-03469, lab no. 65339 dated 7/29/99, the same pants were examined and "No blood or trace evidence of value was detected."

Given the facts and conclusions provided in *Conclusion 2C* of this supplement, and the aforementioned crime lab findings, it is the conclusion of this examiner that these pants were not worn during the commission of the crime. Had the offender worn them, they would have been stained with blood, at least in the ankle area. This finding contradicts the statements of Joseph Wilkes.

II

Bloodstain Pattern Case Study

W. Jerry Chisum

Victim: Raymond
Defendant: Bill
Codefendant: Joe
Witness: Romona, Joe's girlfriend at the time

This was an old and cold case. That is to say it was 15 years old and wasn't being worked on. Then a new DA read the reports and decided he wanted to prosecute the two youths (at the time it happened) for murder.

He had a story from the ex-girlfriend Romona of one of the youths. According to her, the two had gone to see the victim twice one evening. The first time, he wasn't home. The second time she stated that Bill (not her boyfriend) had a gun and was a martial arts student. He put the victim in a bear hug and takes him down. Bill tells his partner Joe to get the gun and shoot the victim in the head. Then to shoot him again.

They took the gold necklace and gold bracelet that the decedent wore. They got blood on their clothing so they went to the beach and changed, getting rid of the gun. They gave the gold jewelry to Romona, which she took to her aunt in Tijuana. The aunt melted it so Romona could sell it.

Based on what was just described, the prosecution asked their crime lab experts, one from the county lab and one from the city lab, to examine the evidence. The DA did not like either of their reports so he hired an outside expert.¹ One that always testifies the way the prosecution wants.

The defendant states that they went to the home twice, but Ray didn't answer the door either time, so they left. That the girlfriend, who came forward only after she had a big fight and broke up with Joe 2 years after the murder. His field of martial arts is Muey Thai, the most violent of the martial arts. In Muey Thai there is no "bear hug" or holding someone down. It is a form of kick boxing and elbow smashing blows.

The outside expert's report supports the theory of wrestling and holding the victim down with his left arm across his chest when he is shot. The DA brings the case to trial. One of the authors (Chisum) was hired by the defense (Figures 1-3).

¹ The outside expert is a retired police officer who studied and worked for a while in bloodstain analysis, but is not used by his former department.



FIGURE 1 The crime scene: Placards # 9 and # 14 are 9-mm casings.

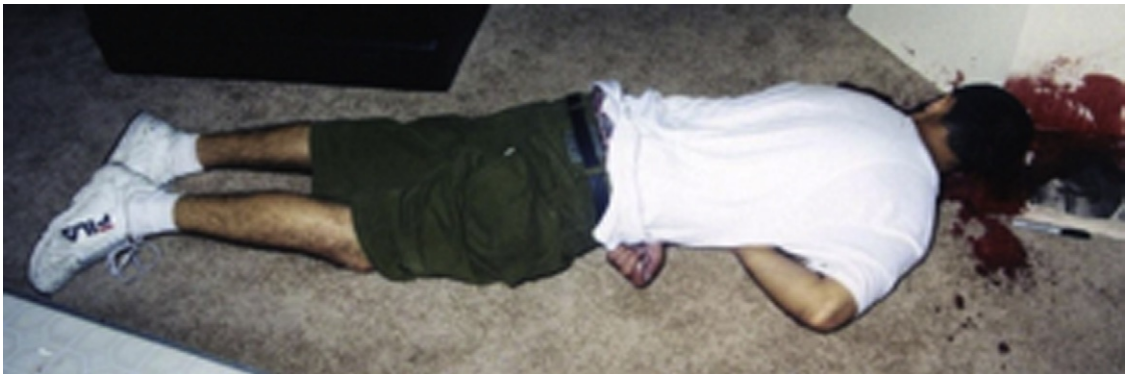


FIGURE 2 Note that the left hand is extended beyond the right side.

“The shot to the top of the head is 2 cm left of midline, 14.0 cm above left external auditory canal, 2 cm from top of head, downward back to front about 45°, right to left ~ 20°, gunpowder and soot under skin and in wound.”

2 SHOTS TO HEAD



FIGURE 3 Two shots to the head. The shot to the back of the head is a grazing shot, with only part of the bullet penetrating.

"The shot on the lower back of the head is midoccipital scalp, centered 1.0 cm to right of mid-line, 13.0 cm from top of head, 4 cm above the level of the external auditory canals, 3.0 × 7.0-cm graze defect, straight left to right and horizontal, no powder."

"Secondary injury from the lower shot, 2 cm from end of above defect, 1.0-cm laceration, exit wound, no powder, explanation: bullet split."²

"To split a bullet it must enter at a fairly low angle. A number of factors enter into the determination but a hollow point is more likely to split off some of the jacketing material than a round-nosed solid bullet. The angle of entry will change to a steeper angle as the bullet enters. Therefore, a straight line is not justified in a back of the head shot. A fragment of the bullet is imbedded in the magazine under the decedent's head."³

This case was being prosecuted based on the story by Romona (a jilted girlfriend) and the "wrestling" theory. While the bloodstains are important to interpret, you must examine every detail of the body carefully before it is moved or the stains may have another tale to tell. The bloodstains shown above on the wall and the newspaper appear to be consistent with the theory that he was shot twice in the head while he was down. But let's examine the rest of the body and then take a second look at the stains. Examine the figures before you read further. What do you see? How do you explain what you see?

In [Figure 4](#), you should have noted the shoestring on the left shoe stretched toward the right shoe. Both toes are pointed in the same direction. The shorts are "scrunched up" on the right side, but smooth and laying flat on the left, with the pants leg extended toward the right.



FIGURE 4 The lower part of the body. What do you see in this photo? How do you explain these observations, or do you need more information?

² From pathologist's autopsy report.

³ From my report.



FIGURE 5 The waist area.



FIGURE 6 The torso and head from the left side.

In [Figure 5](#), you should have noted the tucked portion of the t-shirt behind the belt.

In [Figure 6](#), you need to have noted that the blood on the face is smeared and is running counter to gravity. The blood has been carried by capillary action up the front of the arm; however, there is no connection of the blood to the top of the arm where the blood has soaked the chest.

There is a worm of blood on the right shoulder. The blood in front of the body is considerably darker than the rest of the blood. There are a couple of small drops of blood on the upper back.

In [Figure 7](#) there are several bloodstains. The wall, the newspaper, and the carpet have bloodstain patterns that must be explained. The wall actually has several different bloodstain patterns. You should have noted the splash pattern on the carpet, the forceful drops of blood on the wall in two areas, above the top of the head and to the far right, and the “curtain” pattern overlying the spatters. Note the directions of flows on the newspaper and the color and thickness of the bloodstains. Finally, the folded edge of the newspaper is resting on the baseboard, raising it about 2 inches.

The two experts from the crime labs would not support the prosecution. The prosecution hired the outside expert who stated in the first line of his report that it was obvious the body had not been moved. He also stated that it was equally obvious that someone used a wrestling type hold to pull the arm across the body. He stated that the victim was held while the other man shot him the first time; then he didn’t move and was shot the second time in the top of the head. The blood on the wall he stated was arterial spurting. The crime lab experts did not agree with his conclusions but found nothing to counter his statements.

What did you see that could counter these conclusions?

The first thing I noted were the pants, why would one leg be flat and the other wrinkled? Then the shoestrings, why are the ones on the smooth leg stretched out? The next thing I noted was that the blood on the chest could not get to that location as shown in [Figure 6](#). It cannot jump the space on the arm, and because the arm is pressed by the chest, it can’t flow between the chest to the arm. If it did, it would stain the top of the arm too. Therefore, the body has been moved before the photos were taken.



FIGURE 7 The newspaper in relation to the head and the stains on the wall.

The detective who responded to the scene stated that she took two firemen with her and they lifted the body to ensure that there was no gun under the body.⁴ Fifteen years later she states that they only lifted the body a little bit, but she couldn't remember if the lights were on at 9 pm. One fireman at the feet twisted the legs to help raise the body, resulting in the left leg being raised off the floor; the other put his left hand in the waist of the trousers (see [Figure 5](#)) and under the newspaper to hold the head steady. The arm, which was to the left side, draped across the front of the body. When they lowered the body, the arm was trapped. The shoestrings and pants show the rolling back down.

The splash stain on the carpet does not originate from either of the head wounds. It is consistent with the blood pouring off the corner of the newspaper if it is lifted. The flow of blood on the paper would defy gravity as it lies. The raised edge should only have splashed stains present. The wall stains are not arterial stains but a thin blood sheet pouring from the newspaper onto the wall; the top of the paper is bent down so that the blood runs at an angle in this area. The spatter underlying the curtain is from the hole in the top of the head when the second shot was fired into the head. This caused a hydraulic effect, causing the blood to squirt out to the first hole.

The stains on the face are because he was more face down on the floor until he was lifted. This caused some of the blood to run in the wrong direction.

As a final note, the blood in front of the body was very black, similar to the color we get when we add HCl to blood. In a photo (not shown) there are many white pieces in this blood consistent with the rice the doctor found in his stomach. The arm being across the body caused pressure on his stomach to disgorge some of the meal and blood that had accumulated.

To complete the reconstruction, he was kneeling when he was shot from behind. He fell face down. A coup de grace shot to the back of the head was fired at a low angle, causing the bullet to split.

The prosecution's expert started his hypotheses with a false assumption. Therefore, nothing he concluded is correct.

The point of this exercise is that careful observations of the body and surroundings need to be made and subtle incongruities need to be explained before you start explaining the bloodstains.

⁴ She knew better, this changes the scene. What difference does it make if there is a gun under the body? He has two holes in the head so suicide is not in question; the medical examiner can lift the body after it is documented to determine if there is a gun present.

III

Staged Crime Scene Analysis

Brent E. Turvey

The author witnessed the entire trial in this case and testified during the guilt phase regarding all of the findings presented save *Conclusion #1*: that law enforcement efforts to secure and process the crime scene were almost nonexistent, and consequently did not meet the minimum national standards for competent forensic practice. The judge explained that it was not permissible to admit testimony that was critical of law enforcement investigations or efforts. To explain, he stated: "This is not California, and it is never gonna be."

While under cross-examination, after being confronted with the evidence from the author's forensic examination, Terry Wayne Adams confessed to staging numerous aspects of the crime scene. However, and despite any absence of direct physical evidence, Robert Barnes was convicted for an undisclosed and undefined role in the crime. It was never directly argued in court that he was the shooter; only that he was present during the shooting.

FORENSIC EXAMINATION REPORT

To: Jim Gray, Attorney, P.O. Box 1682, 108 E. Canal St., Picayune, MS 39466
Ph# 601-749-2700; Fx# 601-798-8668

From: Brent E. Turvey, MS, Forensic Solutions, LLC, P.O. Box 2175, Sitka, Alaska
99835, Office (907) 747-5121

Date: February 3, 2006

Re: *Mississippi v. Robert Grant*

The purpose of this report is to review the forensic examinations and testimony relating to examinations of the evidence in the case of *Mississippi v. Robert Grant* (re: homicide of Arthur Joshua on July 16, 2004).

Sometime on the evening of July 16th, 2005, after 10:30 pm, Terry Wayne Adams, Wesley Jerome Williams, Roderick Shanker, Tishma Peralta, and Larry Bowens, a.k.a. "Skipper," allege that one or more individuals entered the Adams' residence at 123 Ed Reid Road in Lumberton, MS. They further allege that these individuals fired gunshots and stole items from a safe that was

kept on the premises. Mr. Adams claims to have been tied up or partially tied up, and Mr. Williams claims to have been hit twice in the head by a short length of 2×4 .

On December 28, 2005, this examiner received case material related to this matter from Attorney Jim Gray, including, but not limited to:

1. Pearl River County Sheriff's Department (PRCSD) Incident Report by A. Naquin dated 7/17/04
2. PRCSD Supplementary Report by Det. J. Kramer dated 7/17/04
3. PRCSD Supplementary Report by Det. J. Kramer dated 7/20/04
4. PRCSD Supplementary Report by Capt. E. Rocker dated 7/17/04
5. Photo Log 2004-07-0167
6. Untitled Evidence Log 2004-07-0167 listing exhibits 1–13
7. Evidence/Property Logs re: 2004-07-0167, discover pages 343–351
8. Autopsy Report for Joshua Arthur by Steven T. Hayne, MD dated 7/17/04
9. Evidence Submission forms by Steven T. Hayne, MD for toxicology screening of fluids and trace evidence analysis of clothes
10. Toxicology Report by ExperTox Inc. Lab, dated 7/21/04
11. Mississippi Crime Lab Evidence Submission Forms for evidence submitted by Capt. Eric Rocker received on 7/22/04
12. Mississippi Crime Lab Evidence Submission Forms for evidence submitted by Walter Gipson, Pearl River County CMEI, received on 7/30/04
13. Mississippi Crime Lab Drug Analysis Report dated 9/28/04
14. Mississippi Crime Lab Firearms/Toolmarks Report dated 4/27/05 (2 pages)
15. Mississippi Crime Lab Firearms/Toolmarks Report dated 4/27/05 (1 page)
16. Mississippi Crime Lab Trace Evidence Report dated 6/13/05
17. Mississippi Crime Lab Trace Evidence Report dated 8/5/05
18. Mississippi Crime Lab Latent Prints Report dated 9/22/04
19. Mississippi Crime Lab Bioscience/DNA Report dated 5/27/05
20. Mississippi Crime Lab Bioscience/DNA Report dated 6/30/05
21. Mississippi Crime Lab Bioscience/DNA Report dated 10/19/05
22. Forensic Test Results report from Reliagene dated 7/27/2005
23. Interview of Roderick Shanks at scene, 123 Ed Reid Road, by Det. J. Kramer on 7/17/04: 0400 hrs
24. Interview of Terry Wayne Adams at PRCSD by Det. J. Kramer on 7/17/04
25. Interview of Tishma Peralta at PRCSD by Det. J. Kramer on 7/17/04; 1711 hrs
26. Interview of Shannon Landry at PRCSD by Det. J. Kramer on 7/17/04; 2141 hrs
27. Interview of Shannon Landry at Lamar County Sheriff's Jail Facility by Det. J. Kramer on 7/18/04; 1631 hrs
28. Interview of Chris Thomas at 7 Carver Ave. by Det. J. Kramer on 7/21/04: 1215 hrs
29. Interview of Ronald Pinter at Investigations Office in Poplarville by Det. J. Kramer on 8/18/04

On January 12, 2006, this examiner traveled to Mississippi and examined evidence related to this case at the Pearl River County Criminal Justice Center in the presence of Capt. Eric Rocker, PRCSD; Investigator James Runnels of the ODA, 15th Circuit Court Dist.; and Attorney Jim Gray. On that date, this examiner examined and photographed Exhibits 4–6 (without removing

them from their clear plastic bag), 9, 12, and 13. This examiner identified a brownish hair approximately 2–3 inches in length on Exhibit 9 (blue pillowcase). This item was collected and packaged into a white envelope, labeled Item BT-1, and handed to Captain Eric Rocker.

On the morning of January 13, 2006, this examiner was present at pretrial interviews of Capt. E. Rocker and Det. J. Kramer in the courtroom at the Pearl River County Criminal Justice Center, conducted at the request of Attorney Jim Gray.

On the afternoon of January 13, 2006, this examiner visited the crime scene at 123 Ed Reid Road in Lumberton, MS. This examiner documented the exterior of the residence with measurements and photographs in the presence of representatives from the district attorney's office, a representative from the PRCSD, and Attorney Jim Gray.

On the evening of January 13, 2006, this examiner revisited the crime scene and documented the interior with measurements, photographs, and video in the presence of Investigator James Runnels of the ODA and Attorney Jim Gray.

FINDINGS

After a careful review of all of the facts and information provided, it is the opinion of this examiner that:

Conclusion #1: Law enforcement efforts to secure and process the crime scene were almost nonexistent, and consequently did not meet the minimum national standards for competent forensic practice with respect to adhering to the “fundamental principles of investigating a crime scene and preserving evidence that should be practiced in every case” (TWGCSI, 2000, pp. 1–2).

Conclusion #2: Because of the failure to meet minimum crime scene practice standards, many key items of potentially exculpatory physical evidence were not documented, collected, preserved, or tested.

Conclusion #3: The crime scene in this case appears to have been *staged* to suggest that the shooting occurred outside the residence.

Conclusion #4: The available physical evidence in this case is most consistent with the following scenario: a distant gunshot wound delivered by a shooter taller than the decedent, aiming from the area of the back door, while the decedent was standing inside the open front door of the residence at 123 Ed Reid Road.

DISCUSSION

Conclusion #1: Law enforcement efforts to secure and process the crime scene were almost nonexistent, and consequently did not meet the minimum national standards for competent forensic practice with respect to adhering to the “fundamental principles of investigating a crime scene and preserving evidence that should be practiced in every case” (TWGCSI, 2000, pp. 1–2).

These include, but are certainly not limited to, a failure to ensure that the following basic procedures were implemented:

- a. Failure of first responder (A. Naquin) to “Survey the scene for dangerous persons and control the situation” (p. 12). Had this occurred, the decedent's body may have been found

and the situation could have been elevated to homicide as much as 3 hours sooner. As it stands, the body was not located until just before 0300 hrs, by Det. Kramer, who was on scene for at least 2.5 hours before the body was located.

- b. Failure to define and control the scene boundaries and provide a means for protecting and securing the crime scene. "The number of crime scenes and their boundaries are determined by their location(s) and the type of crime. Boundaries shall be established beyond the initial scope of the crime scene(s) with the understanding that the boundaries can be reduced in size if necessary but cannot be as easily expanded" (p. 15). This is in light of:
 - Absence of a perimeter search by both initial responders (A. Naquin and J. Kramer)
 - Absence of security tape to identify the area as a crime scene
 - Absence of a security log to record entry and exit of any personnel
- c. Failure to ensure continued scene security and integrity through collection efforts as people and personnel entered and exited the scene (p. 23).
- d. Failure to identify all witnesses who were at the scene for the purpose of securing an interview (p. 14).
 - Larry Bowens was reported to be present during the alleged incident. However, there is no record of him ever being formally interviewed by investigators.
 - Wesley Jerome Williams was allegedly struck twice and injured by the decedent, Arthur Jacobs, who was reported to have been wielding a short length of 2 × 4. However, there is no record of Mr. Williams being formally interviewed by investigators with the other witnesses in this case.
- e. Failure to secure and separate witnesses to preserve the integrity of their statements (pp. 14–15).
- f. Failure to canvass surrounding areas (p. 20).
 - Responders A. Naquin and J. Kramer did not survey the outside of the scene for evidence (which would have included bloodstains, the decedent's body, the two bloody masks, and the blue pillowcase containing items from the house).
 - There is no record of anyone visiting or even documenting the existence of the second residence on the property to effect a search for evidence or witnesses.
- g. Failure to document the precise location and position of all the items at the scene as they were found (p. 16).
 - Although photographs of some items were taken, no measurements were taken of any items at the scene.
 - Investigative reports give no indication that attempts were made to establish whether items had been moved by anyone before they were photographed.
 - There is no photographic documentation or description of the safe that was allegedly robbed. Subsequently it was not processed as evidence.
 - No photograph of the rear porch/door light fixture to show where the bulb had been removed.
 - There is no sketch of the crime scene of any kind, smooth, rough, or otherwise. The dimensions of the scene and precise location of any evidence within and without were not documented by law enforcement investigators.
- h. Failure to document the scene in any adequate fashion (pp. 24–25).

- No measurements were taken of any evidence to note positions and relationships of evidence at the scene.
 - No scales were used to note the size of evidence, with the exception of an ABFO scale showing the length of the injury to Mr. Williams.
 - No video of the scene was taken.
 - Although Det. Kramer reported that he performed rudimentary trajectory analysis at the scene with short lengths of rod, no measurements, photos, or sketches of his examinations or conclusions were made.
 - Approximately 119 photographs were taken of the interior and exterior of the scene and vehicles belonging to persons related to this case, mostly close-ups without scale or context.
 - Approximately 20 of those scene photographs show the interior of the home. None of these show the front door where the suspects are alleged to have been let in by Mr. Williams. None of these show the safe that was allegedly robbed. None of these show the back steps or ground at the rear of the residence where the attackers allegedly fled.
 - There is no documentation by Det. Kramer as to the state of the residence (clean, messy, rifled through, items tossed around, drawers opened).
 - There is no documentation of the size and color of pillowcases available in the residence to determine whether or not one was missing.
- i. Failure to prioritize and plan out the collection of evidence. Failure to communicate between interior and exterior scene search/processing efforts (pp. 26–27).
- A. Naquin did not search the exterior of the residence for evidence or perform a walkthrough of the scene in any fashion.
 - Det. Kramer stated that he worked entirely on the interior of the home and did not search it for firearms. He also stated that he performed no search for evidence outside of the home until alerted to something in “the wood line” by a barking dog just before 0300 hrs. He had been onsite for at least 2.5 hours by that time.
 - Captain Rocker, who arrived at approximately 0300 hrs, stated that he concentrated his search efforts on the exterior of the residence. He further stated that he did not perform an examination or search the interior of the scene. He stated that he left that responsibility entirely up to Det. Kramer.
- j. Failure to collect and preserve evidence (pp. 27–28):
- Failure to document, collect, and preserve the safe alleged to have been robbed.
 - Failure to collect the 2 × 4 alleged to have been used by Arthur Jacobs when attacking Mr. Williams.
 - Failure to recognize, collect, preserve, and test potential bloodstain evidence pictured on the coffee table.
 - Failure to recognize, collect, preserve, and test potential bloodstain evidence pictured on the tennis shoes of one of the residents at the scene.
 - Failure to keep all of the items found in the blue pillowcase alleged to have been used by the attackers to collect valuables. All of the items in the pillowcase (especially the newspaper, paper, glassware, and currency) should have been kept as evidence and examined for latent prints and trace evidence. Instead, everything was returned to the residents of the home the next day, except the marijuana.

- Failure to formally establish the residence as a crime scene, secure it, and remove its occupants. The residence in this case was treated with disregard other than establishing a portion of the shooting incident, and as such the occupants were allowed to maintain custody of it through the law enforcement scene investigation, which was brief for a homicide.

The preceding is not intended as an exhaustive list. Rather it is meant to demonstrate that minimum national standards for competent forensic practice were not met with respect to crime scene processing efforts. This failure represents an overall disregard for adequate crime scene investigation and a disinterest in corroborating witness statements with the physical evidence.

Conclusion #2: Because of the failure to meet minimum crime scene practice standards, many key items of potentially exculpatory physical evidence were not documented, collected, preserved, or tested.

- a. Failure to process the interior of the scene as the location where the fatal shot occurred, with respect to processing the scene (the front door, the back door, front and back steps, the ceiling, and the carpet, etc.) for bloodstain patterns. This examination should have been extensive and would have revealed any high-velocity bloodstain patterns from gunshot wounds, low-velocity bloodstains from blood dripping off clothing and/or extremities, and any bloody drag marks that may have been left behind.
- b. Failure to search the interior of the crime scene for firearms of any kind.
- c. Failure to recover the projectile lodged in the wall above the bathroom. This examiner located and photographed the location where the projectile came to rest; however, it was not recovered, as this would have required a more invasive effort. It is the opinion of this examiner that this projectile should be recovered and ballistic examinations performed to confirm its association with the crime. The location of this projectile is known by Investigator James Runnels of the ODA, who initially located the likely resting place of the projectile.
- d. The safe that was allegedly robbed was not documented or collected. This should have been photographed, collected, and then processed for latent prints and other potential transfer evidence.
- e. The wooden 2 × 4 was photographed but not otherwise documented or collected. This should have been collected and examined carefully for latent prints, tissue, and hair/fiber evidence to confirm or refute its use as weapon against Mr. Williams at the hands of someone wearing dark gloves. Tissue should be found at the point of impact (given two strikes), and fiber from the assailant's gloves should be embedded in the dry, splintery surface of the wood where it was held.
- f. There was no search for binding materials allegedly used to bind Terry Wayne Adams.
- g. There was no search of the residence or property for a white garment from which Exhibits 12 and 13 (white masks with eyeholes and mouth holes) could have been cut to exclude the possibility that the garment actually came from the residence.
- h. Shannon Landry claims to have picked up Robert Grant from the crime scene in her car. The car allegedly owned by Shannon Landry, according to the photo log, was a red Geo Metro. She alleges that Robert Grant entered her vehicle wearing bloody coveralls, after having dragged Arthur Jacobs from near the residence to the tree line. She further alleges that he removed the coveralls while in her vehicle and threw them out the window. If this had

occurred, Robert Grant would have blood on his hands and interior forearms that should have transferred onto her vehicle at any one of several points of contact.

- There are four exterior photos and no interior photos of her vehicle.
- This vehicle was not taken into custody and processed for blood or trace evidence.
- Interior photos and processing efforts could have confirmed or refuted the presence of the victim's blood transferred onto any points of contact on the passenger's side.
- Bloody transfer from a third party into this region of her vehicle, on the interior and exterior, would be necessary for her version of events to be true.

Conclusion #3: The *simulated*, or *staged*, crime scene is that in which evidence has been altered purposefully by an offender to mislead authorities and/or redirect the investigation (Turvey, 2002, p. 249). Often, it is the owners or occupants of a residence that stage crime scenes in order to move investigators away from the obvious conclusion that they were in some manner responsible for the crime that was committed there.

The crime scene in this case was *staged* to appear as though the shooting death of Arthur Joshua occurred outside the residence. This is based on a careful consideration of the following inconsistencies in the evidence:

- a. According to the report by Det. Kramer, he "discovered that the back porch light had been removed." The light bulb was subsequently located near the back yard door by Capt. Rocker.
 - Removal of a porch light bulb by an offender is time-consuming and impractical. It is seen in movies and television but is uncommon in actual break-ins, especially when the residents are known to be home.
 - The light bulb that was collected (Exhibit 8) is pictured in photo #337, covered by grass. This would require someone placing the bulb into the grass and perhaps even combing grass over it. This is inconsistent with the bulb being dropped, tossed, or thrown. Again, this is time-consuming, impractical, difficult to do in the dark, and serves no purpose to a potential home invader aside from increasing their risk of discovery by occupants.
 - The back porch light is clearly visible in place, in photo #339. This is inconsistent with the light having been removed in the first place and requires reconciliation with Det. Kramer's statement in his report.
- b. According to the statement by Terry Adams, the attacker with the gun "started to try to tie up my hand and that's when my girlfriend and Skipper arrived back home and he broke out." He does not indicate that he was fully tied up, that his hands were behind his back, or that he was on the floor at any time. According to his girlfriend, Tishma Peralta, she found Adams "on the floor with his hands tied behind his back." She does not indicate what kind of material he was tied with or how he was able to get free.
 - There is no documentation of any binding materials found at the scene to confirm that Mr. Adams was tied up.
 - There is no documentation of any ligature marks or other injuries to Mr. Adams' wrists that would be present if his hands had indeed been bound behind his back.
 - According to the Trace Evidence reports by the Mississippi Crime Laboratory dated June 13, 2005, Terry Adams is the only person in the residence who tested positive for gunshot residue, on his left palm.
- c. Tishma Peralta claims to have seen two men invading the home. She states that one of them was wearing a white mask with big eyeholes through which she could see his black skin.

Ultimately, she states that she sees “the other dude” “run out” after “busting out the back door.” This was accomplished, according to her statement, with some force and difficulty. This is when she claims to hear the final gunshot. It is unclear where the shooter is standing in her version of events (inside or outside the residence). Notably:

- She does not describe the exit of the man wearing the white mask (Arthur Joshua).
 - If an assailant had to “bust out” or break out of the back door once he had already gained entry into the residence, this would indicate that it was closed and locked. It would certainly not be necessary to “bust out” of a door that one had used to gain entry. This statement by Ms. Peralta precludes use of the back door as a point of entry.
 - There is no documentation or indication that heavy force was used to break or “bust” the back door open from the inside. Upon close examination of photograph #53, the door appears to be undamaged from the inside.
- d. Wesley Jerome Williams alleges that someone entered through the front door and then struck him twice in the head with a wooden 2 × 4, telling him to get down on the floor. Only one injury was documented related to the attack on Mr. Williams—a minor reddening of the scalp in a single linear pattern consistent with at least one of the edges of the 2 × 4 (see photo #56). The following inconsistencies were noted:
- There is only one minor injury to Mr. Williams’ forehead, and no other reported injuries to his body.
 - There is an absence of swelling in the area of the injury, which would be expected with a heavy blow to the head using a 2 × 4, and the passage of time. At least an hour, if not more, had passed before this photograph could have been taken.
 - There is an absence of hemorrhage beneath the skin, which would be expected with a heavy blow to the head using a wooden 2 × 4.
 - On close inspection of the photograph, there is an absence of splinters transferred to Mr. Williams’ scalp, or injuries from splinters, which would be expected given the condition of the 2 × 4 and the severity of the blow.
- e. Two bloody white masks were recovered from the scene. Tishma Peralta did not report seeing an assailant that wore two masks. She reported the intruder that she saw, up close, was wearing a white mask with big eyeholes. Only one assailant is known to have been injured in this case, and consequently only one mask should have been found with blood on it. This inconsistent finding begs further examination and investigation.
- f. Only some of the items allegedly taken from the safe and placed into the blue pillowcase have value to a thief (the cash, the marijuana, perhaps the pipe/papers, coins, the wallet, and the GPS). However, the personal note, two drink coasters, a Crown Royale bag, a film container, and the set of glasses with glass tray have no value on the street. Taking these items makes little or no sense from the perspective of profit.
- It should be noted that content of the Crown Royale bag is not documented.
 - It should be noted that content of the film container is not documented.
 - It should be noted that there was apparently a white container recovered from the blue pillowcase with the contents undocumented.
- g. The glass contents of the blue pillowcase were wrapped carefully with newspaper prior to being placed inside. Advertisements on the newspaper used to wrap these items are consistent with advertisements on the newspaper from the table in the living room at the crime scene (see photo #54). This supports the conclusion that the items were wrapped

carefully at the scene. This activity was not described by any of the witnesses interviewed in this case.

- h. Tishma Peralta, Skipper, and Wesley Jerome Williams would have to be in the living room when the shot that killed Arthur Joshua was fired, ricocheted off the front door, and landed on the couch (detailed in *Conclusion #4*). There is no documentation that any one of these three individuals suggested this event to investigators. This omission is a logical break in the known sequence of events and must be resolved.
- i. The victim was shot through the lungs and trachea. His lungs would have collapsed and he would be spitting blood on the inside of his mask, making it difficult to stand, walk, or see. This makes an unassisted exit from the residence unlikely. His body would have to be carried or dragged from the inside of the residence to where it was ultimately found outside.

Conclusion #4: The available physical evidence in this case is most consistent with the following scenario: a distant gunshot wound delivered by a shooter taller than the decedent, aiming from the area of the back door, while the decedent was standing inside the open front door of the residence at 123 Ed Reid Road. Facts in support of this conclusion include:

- a. No projectiles were located outside of the residence.
- b. No shell casings were located outside of the residence.
- c. The third unknown bullet path mentioned by Det. Kramer in his report was described to this examiner by the current male juvenile resident of the home and established by this examiner at the scene in the presence of Investigator James Runnels of the ODA. This examiner documented the male juvenile's version of events on video #MVI_756 dated January 13, 2006. It is consistent with the known facts in the case.
 - Only three 9-mm projectiles were located in the crime scene after an exhaustive search by Det. Kramer.
 - As seen in photo #37, only three discharged 9-mm shell casings were recovered inside the crime scene and all were found in the same general area.
 - Two bullet paths led to the right of the back door, down the hall into the back room. One of these projectiles was recovered and one remains located in the wall above the bathroom, as noted previously. The firearm was pointed in that direction when discharged, and the shell casings ejected to the right. They apparently hit the wall and dropped to the floor. These bullet paths are described in Det. Kramer's report and are consistent with someone shooting at a low downward angle, not at a specific item or target.
 - The third and previously unknown bullet path leads into the living room from the area of the back door. The projectile (Exhibit 5) was fired into the living room area, ricocheted sideways off of the open front door approximately 2 inches from the top, and landed on the couch where it was eventually located, photographed, and collected by Det. Kramer.
- d. Available evidence suggests that the 9-mm projectile fired into Arthur Jacobs was fired at a distance.
 - No tattooing, smudging, or flame injury is noted on the skin or the clothing. For this entrance wound to be near contact, this would need to be evident. With this excluded, the only other possibility is a distant shot, as suggested by the autopsy report.
 - Pattern injuries around the gunshot entrance wound are similar to other pattern injuries on the rest of the body caused by postmortem insect activity (ant bites).

- e. Available evidence suggests that the 9-mm projectile fired into the living room (Exhibit 5) is most likely to have fatally wounded Arthur Jacobs.
- The 9-mm projectile that was fired into the living room (Exhibit 5) was determined to have blood on it, and according to the report by Reliagene dated 7/27/05, the partial DNA profile of the blood on Exhibit 5 is consistent with the DNA profile of the victim, Arthur Joshua.
 - It is unlikely that a distant gunshot wound would be possible outdoors, with little or no light for the shooter to see their target.
 - There is absolutely no physical evidence to support the conclusion that the shooting took place outside (no shell casing, high-velocity bloodstain patterns, projectiles, etc.).
 - Arthur Jacobs would be standing in the living room, in a path between the front door and the back door, in order to be inflicting any injuries on Wesley Jerome Williams. The ricochet impression in the open front door would be behind him. Tishma Peralta and Mr. Williams suggest this general location of Arthur Jacobs in their statements.
 - The projectile entered Arthur Jacobs at a downward angle, indicating a shooter that is taller than him.
 - According to the autopsy report, the projectile “is noted to course through the chest was fracturing the anterior [front] 1st left rib, perforating the left lung grazing the trachea . . . and then perforated the right lung before fracturing the lateral [side] 4th rib. The projectile is noted to course through the right upper extremity and is consistent with the extremity raised.” This means that the victim had at least one of his arms up when he was shot.
 - For the projectile to have exited the victim’s body with his right arm raised, it would have been on an upward angle, in response to ricocheting off of the fractured 4th lateral rib. Consistent with a ricochet as opposed to a straight trajectory, the autopsy report notes that the exit wound is “irregular.” This could easily put the projectile on a path consistent with striking the top of the open front door.
 - It bears mentioning that raised arms are not the norm for an aggressor, but are the norm for someone who sees a gun pointed at them from a known threat. This would not be possible outside in the dark.
 - There is a potential bloodstain pattern on the table in the living room, around and beneath the uncollected wooden 2 × 4, that was not recognized, documented, collected, or tested. See photo #54.
 - The Mississippi Crime Lab Bioscience/DNA report on the spent projectile in the living room (Exhibit 5) came back positive with respect for a screening test for blood. The sample was preserved for confirmatory DNA testing but never tested.

It should be noted that the gun used to commit this crime was not recovered. Consequently, the actual model and origin of the firearm that was used has not been established.

RECOMMENDATIONS FOR FORENSIC TESTING

As indicated in this report, a number of items beg further forensic testing to confirm or refute essential elements of this case. This examiner strongly recommends at least the following:

1. BT-1, a single hair collected from Exhibit 9, the blue pillowcase, should be examined by the trace evidence section to establish contact and possible ownership. If it is not a Negroid hair,

this excludes Arthur Jacobs and Robert Grant. It could also be used to suggest that the pillowcase was owned by someone else.

2. Exhibits 12 and 13, the bloody white masks with eye and mouth cutouts, should be DNA tested with respect to epithelial cells from saliva on the interior of the mouth holes to establish whether they were actually worn and used in the course of the alleged invasion.
3. Brown Coveralls recovered from HWY 13, Exhibit No. Unknown, should be examined for blood in the area of the exterior wrists and forearms to establish whether there is contact consistent with dragging Arthur Joshua.
4. Brown Coveralls recovered from HWY 13, Exhibit No. Unknown, should be DNA tested with respect to epithelial cells from sweat in the area of the interior wristbands to establish more precisely who has worn these coveralls.
5. The interior of the residence at 123 Ed Reid Road should be examined with a blood enhancement reagent to determine the location, nature, and origin of any bloodstain evidence to include high-velocity patterns, low-velocity drops, and drag marks. This includes examination of walls, ceilings, and carpet in the living room (both on the surface and underneath).
6. The interior of Shannon Landry's vehicle, the red Geo Metro, should be examined with a blood enhancement reagent to determine the location, nature, and origin of any bloodstain evidence to confirm or refute her version of events that evening.

Please do not hesitate to contact me with any questions.

Brent Turvey, M.S.

Forensic Science

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Glossary

- Abrasions** scraping away of a portion of skin or mucous membrane, resulting when the skin contacts a rough object with sufficient force.
- Accelerant** any fuel (solid, liquid, or gas) used to initiate or increase the intensity or speed of the spread of fire.
- Accompanying drop** a small drop produced as a by-product of drop formation.
- Action evidence** something that defines anything that happened during the commission of a crime.
- Administrative force** behavior focused on the delivery of a specific, purposeful amount of injury in order to accomplish a particular goal.
- Admissibility** “as applied to evidence . . . means that the evidence introduced is of such character that the court or judge is bound to receive it; that is, allow it to be introduced at trial” (Black, 1990).
- Altered stain** bloodstain with characteristics that indicate a physical change has occurred.
- Amputation** removal of part of the body.
- Angle of impact** acute angle (alpha), relative to the plane of a target, at which a blood drop strikes the target.
- Anoxia** deprivation of oxygen to the point of death.
- Antemortem** wounds that occur during the period of time before death.
- Area of convergence** area containing intersections generated by lines drawn through the long axes of individual stains that indicates the location of the blood source in two dimensions.
- Area of origin** three-dimensional location from which spatter originated.
- Arson** intentional setting of a fire with the aim to damage or defraud.
- Associative evidence** evidence that links two or more specific entities.
- Assumption of integrity** assumption that evidence left behind at a scene is guarded and vestal prior to the arrival of police investigators and other responders.
- Authority bias** tendency to accept the opinion of someone presumed to be an authority on the subject.
- Autoignition** occurs when the surface or gases generated by pyrolysis can be ignited by the external heat being applied.
- Availability heuristic** tendency to answer a question of probability by asking whether examples come readily to mind.
- Avulsion** occurs when a piece of tissue is suddenly lost from the body.
- Backspatter pattern** bloodstain pattern resulting from blood drops that traveled in the opposite direction of the external force applied; associated with an entrance wound created by a projectile.
- Ballistics** study of bullets in motion.
- Behavioral evidence** any physical, documentary, or testimonial evidence that helps establish whether, when, or how an action has taken place.
- Behavioral evidence analysis** an ideoductive method of crime scene analysis, crime reconstruction, and criminal profiling that requires the examination and interpretation of physical evidence, forensic victimology, and crime scene characteristics.
- Belief perseverance** tendency to prefer and shield personal or preexisting beliefs despite irrefutable evidence that they are incorrect.
- Bertillonage** form of personal identification based on a system of body measurements and photography of features used to identify criminals prior to the widespread use of fingerprinting.
- Bias** prejudice in favor of, or against, something. Generally used to suggest an unfair advantage or disadvantage.
- Bidirectional contact transfer** two-way contact transfer, with material from Surface A being transferred to Surface B, and material from Surface B being transferred to Surface A concomitantly.
- Blind spot bias** tendency not to compensate for one’s own cognitive biases, even when evidence to the contrary is present or perhaps even abundant.
- Bloodstain** deposit of blood on a surface.
- Bloodstain pattern analysis** examination of the shapes, locations, and distribution patterns of bloodstains for the purpose of interpreting the physical events that caused them.

- Bloodstain patterns** visible record of bloodshed at a crime scene.
- Blood clot** gelatinous mass formed by a complex mechanism involving red blood cells, fibrinogen, platelets, and other clotting factors.
- Brady v. Maryland** legal ruling from the U.S. Supreme Court that holds “the suppression by the prosecution of evidence favorable to an accused upon request violates due process where the evidence is material either to guilt or to punishment, irrespective of the good faith or bad faith of the prosecution.” It requires timely disclosure of exculpatory evidence by the prosecution to the defense.
- Bow effect** bullet deflecting off a soft-forgiving material such as soil, sand, or sod can exhibit scoring marks in a configuration resembling bow-wave-like patterns similar in appearance to waves passing around the bow of a boat.
- Bruises** injury producing a hematoma or diffuse extraversion of blood without rupture of the skin.
- Brutal force** physically aggressive behavior that involves the onset of one or more injuries that inflict tremendous damage, often until death results. However, brutal force does not always result in death nor is it necessarily intended to kill.
- Bubble ring** outline within a bloodstain resulting from air in the blood.
- Bullet wipe** material deposited around the margins of a bullet hole that appears as a dark-colored ring.
- Burn** damage caused by heat, fire, or chemicals.
- Cast-off pattern** bloodstain pattern resulting from blood released from an object due to its motion.
- Cessation cast-off pattern** bloodstain pattern resulting from blood drops released from an object due to its rapid deceleration.
- Chain of custody (a.k.a. chain of evidence)** record of each person, and agency, who has controlled, taken custody of, examined, tested, or had any other kind of contact with a particular item of evidence from its discovery to the present day.
- Cherry-picking** in forensic casework, selectively reporting and thereby emphasizing only desired results or information rather than the entirety of examinations performed and results achieved; reconsidering only those conclusions that are not preferred.
- Chisum trail** unique ricochet mark caused by the right or left edge of a flattened bullet remaining in contact with the surface after the main body of the bullet has lifted off the surface.
- Choke** constriction at the muzzle end of a *shotgun's bore*.
- Chop wounds** injuries that are the result of heavy instruments with a sharp edge. They go deep into the tissue, can be associated with bone fractures, and can have a combination of incised and lacerated characteristics. Examples include injuries inflicted by axes, hatchets, machetes, swords, and meat cleavers.
- Cognitive psychology** psychological science that studies cognition, the mental processes believed to underlie behavior.
- Colposcopy** process of using a colposcope during a vaginal and cervical examination.
- Comparative analyses** those that answer the question “Who or what does this belong to?”
- Conclusions** statements that the evidence is claimed to support or imply.
- Confirmational bias** interpretation of evidence partial to existing beliefs.
- Contextual bias** being influenced by factors that do not form a legitimate part of one’s technical work.
- Control-oriented force** physically aggressive behavior that restricts or prevents victim movement.
- Control samples** sample of known composition and history that can be compared with trace evidence to evaluate its significance or to assess the validity of the analysis conducted.
- Contusions** injuries (usually caused by a blow of some kind) in which blood vessels are broken, but the skin is not. They can be patterned (imprinted, not directional) or nonpatterned. They include bruises and hemorrhages, which can often be aged based on color. Differentiating postmortem and antemortem contusions is also an important consideration in reconstruction.
- Corpus delicti (“body of the crime”)** those essential facts that show a crime has taken place.
- Corrections** composed of those agencies charged with handling the probation, incarceration, managements, rehabilitation, treatment, parole, and execution of convicted criminals.
- Crime reconstruction** determination of the actions and events surrounding the commission of a crime.
- Crime scene** any area where a crime has taken place.
- Crime scene analysis (or crime analysis)** analytical process of interpreting the specific features of a crime and related crime scenes based on physical evidence.
- Crime scene investigation** process of establishing scientific facts of a case using physical evidence that has been gathered in relation to suspected criminal activity.

- Crime scene processing** function of recognizing, documenting, collecting, preserving, and transporting physical evidence.
- Crime scene type** relationship of the crime scene to the offense behavior.
- Criminalistics** division of forensic science dedicated to the recognition, examination, and interpretation of physical evidence using natural sciences, logic, and critical thinking.
- Critical thinking** indiscriminately questioning assumptions in arguments encountered in any context and from any authority.
- CSI effect** “phenomenon in which actual investigations are driven by expectations of the millions of people who watch fake whodunits on TV. It has contributed to jurors’ desire to see more forensic testimony from the stand” (Hempel, 2003, p. 13).
- Cybertrails** digital footprints left behind by victims and offenders as they move through the world, electronic and otherwise, often through third-party systems and providers. These digital footprints are evidence that investigators and forensic examiners can retrace and use to determine what we were doing, where, and when.
- Daubert v. Merrell Dow Pharmaceuticals, Inc.*** 1993 Supreme Court ruling superseding *Frye*, which holds that scientific testimony may be admitted if it is both relevant and reliable. The four prongs of relevance and reliability focus on error rate, peer review, testability (or falsifiability), and general acceptance.
- Deductive argument** one in which if the premises are true, then the conclusions must also be true. In a deductive argument, conclusions flow directly from the premises given.
- Defeminization** violent removal or destruction of female sexual areas (e.g., nipples, breasts, vaginal area).
- Defensive force** physically aggressive behavior intended to protect the individual administering it from attack, danger, or injury.
- Defensive injuries** injuries sustained while fending off an attack.
- Deflect** change in the direction of the bullet path by means of penetration or perforation of an object.
- Digital evidence** any data stored or transmitted using a computer that support or refute a theory of how an offense occurred or that address critical elements of the offense, such as intent or alibi.
- Directionality** characteristic of a bloodstain that indicates the direction blood was moving at the time of deposition.
- Directional angle** angle (gamma) between the long axis of a spatter stain and a defined reference line on the target.
- Directional evidence** anything that shows where something is going or where it came from.
- Drip pattern** bloodstain pattern resulting from a liquid that dripped into another liquid, at least one of which was blood.
- Drip stain** bloodstain resulting from a falling drop that formed due to gravity.
- Drip trail** bloodstain pattern resulting from the movement of a source of drip stains between two points.
- Due process** provision of the U.S. Constitution that requires citizens to only be tried and punished for crimes alleged by the state under the most impartial and unprejudiced conditions.
- Dumpsite (or disposal site)** crime scene where a body is found. Use of this term tends to suggest that the victim was killed elsewhere, but it is possible for a victim to be killed and disposed of at the same location.
- Ecchymosis** irregularly formed hemorrhagic area of the skin (i.e., a bruise); the color is blue-black, changing over time to shades of greenish-brown or yellow.
- Edema** local or generalized condition in which body tissues contain an excessive amount of tissue fluid.
- Edge characteristics** physical feature of the periphery of a bloodstain.
- Environmental wound patterns** these result from any item in the crime scene that comes into contact with the victim–offender in such a manner as to cause injury.
- Equivocal forensic analysis** review of the entire body of evidence in a given case, questioning all related assumptions and conclusions.
- Equivocal forensic scientists** examiners that hold determinations close to the vest so as to preserve their ability to change them later.
- Erythema diffused** redness caused by capillary dilation.
- Ethic** moral obligation to maintain the integrity of the processes.
- Ethos** moral, ideal, or universal element in something, as opposed to that which is subjective or emotional in its appeal.
- Evidence** anything that assists in proving or disproving any theory about any element of the crime. To include “testimony, writing, material objects, or other things presented to the senses that are offered to prove the existence or non-existence of a fact” (Black, 1990).
- Evidence dynamics** any influence that adds, changes, relocates, obscures, contaminates, or obliterates physical evidence, regardless of intent.

- Experimental force** force that fulfills nonaggressive, often psychological, and fantasy-oriented needs.
- Exploded sketch** combination of an *overview* with side-view *sketch*.
- Expiration pattern** bloodstain pattern resulting from blood forced by airflow out of the nose, the mouth, or a wound.
- Explosion** sudden conversion of potential energy (chemical or mechanical) into kinetic energy with the production of heat, gases, and mechanical pressure.
- Facts** verified and undisputed circumstances or information.
- Fallacies of logic** errors in reasoning that essentially deceived those whom they are intended to convince. They are brought about by the acceptance of faulty premises, bias, ignorance, and intellectual laziness.
- False allegations** any untruthful statement, accusation, or complaint to authorities asserting that a crime occurred, which in reality did not.
- Falsification** subjecting a theory to repeated attacks in order to disprove it—testing it against case facts or alternative theories.
- Fantasy** deliberate act of imagining a behavior, event, or series of events that one finds personally arousing or enjoyable.
- Fearful forensic scientists** examiners that fear revealing too much about what they did or what their findings mean within a given case; theirs is a genuine concern about revealing ignorance, hurting their employer's case, or being wrong.
- Finished sketch** one that is prepared for court; it is drawn accurately and to scale.
- Fire** sustained exothermic oxidation (combustion) of a fuel sufficient to produce readily detectable heat and light.
- Flaming combustion** combustion where gases or vapors mix with air and then are ignited.
- Flashover** when radiant heat from the ceiling layer causes ignition of all the exposed fuel surfaces in the room, leading to full room involvement.
- Flow pattern** bloodstain pattern resulting from movement of a volume of blood on a surface due to gravity or movement of the target.
- Forensic examination report** detailed description of evidence and materials examined; examinations performed; methods used; results achieved; and any conclusions that may be subsequently derived.
- Forensic fraud** providing sworn testimony, opinions, or reports bound for court that contain deceptive or misleading findings, opinions, or conclusions deliberately offered in order to secure an unfair or unlawful gain.
- Forensic generalist** particular kind of forensic scientist, broadly educated and trained in a variety of forensic specialties.
- Forensic identification scientist** one concerned with evidence identification and comparison (e.g., drugs, toxicology, DNA, tool marks, and fingerprints).
- Forensic science** application of scientific knowledge and principles to the resolution of legal disputes, whether criminal or civil.
- Forensic scientist** one that examines and determines the meaning of physical evidence in accordance with the established theories and principles of forensic science, with the expectation of presenting his or her findings in court.
- Forensic services** branch of the criminal justice system that deals with the examination and interpretation of evidence—physical, behavioral, and testimonial.
- Forensic specialist** particular kind of forensic scientist, trained in a specific forensic subspecialty, such as criminalistics, forensic toxicology, forensic pathology, or forensic anthropology.
- Forensic technician** one trained in the specific procedures related to collecting and even testing evidence found at or in association with crime scenes.
- Forensic victimology** scientific study of violent crime victims for purposes of addressing investigative and forensic questions.
- Forward spatter pattern** bloodstain pattern resulting from blood drops that traveled in the same direction as impact force.
- Fractures** cracking or breaking as the result of force applied to a localized area of bone.
- Fragment** when a bullet breaks up into smaller portions (typically resulting from impact with an object).
- Frye v. United States*** 1923 decision in which the court of appeals required a showing that methodology be generally accepted in the scientific community for admissibility.
- Gauge** size of a *shotgun's bore*.
- Glowing (smoldering) combustion** combustion where oxygen combines directly with the solid surface of the fuel, producing little or no flame.
- Goddefroy's method** examination of the rope used in hanging cases, where the fibers of the rope will lie in the opposite direction of that of the pulling. This is used to distinguish between suicide and homicide.

- “Grab” injuries** often characterized by two, three, or four contusions visible on one side of the victim’s arm, and one on the other, corresponding with the offender’s fingers and thumb.
- Hematoma** solid swelling of clotted blood within tissues.
- Historian reconstructionist** intuitive reconstructionist who, based on experience, will see the overall picture and form a theory of what happened.
- Howler** error in which the correct answer or conclusion is reached, but for the wrong reasons.
- Hymenal transection** complete or partial tear or laceration through the width of the hymenal membrane extending to (partial) or through (complete) its attachment to the vaginal wall; if the transection is nonacute and does not extend to the vaginal wall, it is called a cleft; hymenal transections may be associated with acute and nonacute injuries.
- Identification (or classification)** placement of any item into a specific category of items with similar characteristics.
- Identification sciences** those that answer the question “What is it?”
- Impact pattern** bloodstain pattern resulting from an object striking liquid blood.
- Incise wounds (cuts)** injuries that are the result of sharp instruments being drawn across the surface of the skin, even into the tissue, and are generally longer than they are deep.
- Individuation** assignment of uniqueness to an item.
- Inductive argument** one in which it is merely unlikely that the premises are true and the conclusion false. It is at best a prediction about what might be true. Often based on statistics, comparisons, or experience.
- Inferred evidence** anything that the reconstructionist thinks may have been at the scene when the crime occurred but was not actually found.
- Information bias** tendency to seek and develop information and factor it into a conclusion, even when that information does not exist or when it is irrelevant.
- In-group bias** tendency to give more credence to the position of others perceived to be members of their own group.
- Insect stain** bloodstain resulting from insect activity.
- Institutional bias** form of bias manifested by the policies, programs, or practices of an agency, an organization, or a group, whether public or private, or any of its personnel that benefit or promote the interests of one side in a courtroom dispute, while either denying or minimizing the interests of the other side.
- Intermediate crime scene** any crime scene between the primary crime scene and a *disposal site*, where there may be transfer evidence.
- Internet Protocol (IP) address** numerical label assigned to every device that connects to a computer network for both identification and location purposes; every computer on the Internet is assigned an IP address to enable delivery of data.
- Judiciary** composed of attorneys, judges, magistrates, courts, and other professionals that deal with the adjudication and exoneration or punishment of criminal defendants.
- Kumho Tire Co. v. Carmichael*** 1999 Supreme Court ruling that holds that *Daubert* “applies not only to testimony based on ‘scientific’ knowledge, but also to testimony based on ‘technical’ and ‘other specialized’ knowledge.”
- Lacerations** injury resulting from ripping, crushing, overstretching, pulling apart, bending, and shearing; lacerations result from blunt force. These are torn or jagged wounds that tend to have abraded and contused edges. They can be differentiated from sharp force injuries by the recognition of tissue bridging from one side of the laceration to the other (indicating shearing or crushing force). Adelson (1974) warns examiners to beware that bullets striking the skin tangentially, without penetrating, can mimic lacerations and incise wounds.
- Langer’s lines** natural anatomical grain of the skin surface.
- Latent evidence** evidence that cannot be seen with the naked eye and is best visualized and then photographed with technical assistance (e.g., powders; chemical reagents; alternative light sources such as ultraviolet or infrared).
- Law enforcement** agencies at the local, state, and federal levels that investigate reported crime, establish the facts, and determine whether a law has been violated.
- Law of parsimony** prohibits, without a proven necessity, the multiplication of entities, powers, principles, or causes; above all, the postulation of an unknown force where a known impotence can account for the phenomenon.
- Lead splash** caused by the impact spatter and vaporization of lead that deposits on the downrange side of nonperpendicular impact angles.
- Lethal force** physically aggressive behavior that is sufficient to kill.
- Limiting evidence** that which defines the nature and boundaries of the crime scene.
- Livor mortis** settling of blood by gravity to the lowest part of the body, provided there is no restriction to the area, such as pressure from a surface, binding, or material.

- Locard's exchange principle** when contact occurs between two items, there will be an exchange of both visible and microscopic material. Evidence of this exchange may be used to infer that contact between the two items occurred.
- Locational (or positional evidence)** shows where something happened, or where something was, and its orientation with respect to other objects at the location.
- Logic** science that evaluates arguments.
- Macroscopic evidence** evidence that may be viewed with the naked eye and photographed with limited technical assistance.
- Medical history** information about a patient gathered by a health care professional for purposes of making examinations, providing treatment, and rendering a diagnosis.
- Melendez-Diaz** legal ruling from the U.S. Supreme Court holding that defendants have a due process right to confront those scientists who have written forensic reports to be used against them in court; that, unless stipulated, a forensic report may not be introduced without the testimony of its author.
- Mental incapacity** temporary state of being incapable of rationally appraising the nature of one's own conduct.
- Microscopic evidence** trace amounts of evidence that cannot be visualized and discriminated easily with the naked eye and may even require the use of a magnification device to examine (e.g., a magnifying glass, a loupe, or one of many different kinds of microscopes).
- Mind mapping** method of linking seemingly random and unconnected thoughts to create a diagram of what one knows about a subject.
- Mist pattern** bloodstain pattern resulting from blood reduced to a spray of microdrops as a result of the force applied.
- Modus operandi (MO)** offender's method of operation, consisting of their habits, techniques, and peculiarities of behavior.
- Negativity bias** tendency to choose and evaluate things based on an inclination to avoid negative experience rather than the desire to advance a positive view.
- Negative documentation** record of areas where no injuries exist and of associated environments believed to contain none of the items responsible for injury.
- Observer effects** in forensic casework, any form of bias that occurs when results of a forensic examination are distorted or influenced by the context (e.g., environment, culture) and mental state of the forensic scientist, to include subconscious expectations and desires.
- Occam's razor** principle that states "entities should not be multiplied unnecessarily; or plurality should not be posited without necessity."
- Offensive wounds** injuries sustained while inflicting an attack.
- Omission bias** tendency to judge harmful actions as worse, or less moral, than equally harmful omissions or inaction.
- Outcome bias** tendency to gauge a decision by a conception of its eventual outcome instead of on the quality of the decision at the time it was made.
- Overhead projection diagram** diagram that provides a bird's-eye view of evidence item locations and projectile paths.
- Overkill** injury beyond that needed to cause death, involving the repeated infliction of injury subsequent to the application of lethal force.
- Oversimplification** when a complex situation is described in simplistic terms that neglect its complexity.
- Overview sketches** drawn as if looking down upon the crime scene.
- Ownership evidence** something that helps answer the "who" question with a high degree of certainty.
- Parent stain** bloodstain from which a satellite stain originated.
- Peer review** appraisal of work and research by others in the same discipline or profession.
- Penetrating wound** when something enters or forces into a body, but does not exit.
- Perforating wound** when a wound goes through the body, resulting in two or more holes as blood sources.
- Perimeter stain** altered stain that consists of peripheral characteristics of the original stain.
- Perimortem** an injury inflicted just before or just after death.
- Perjury** act of lying or making verifiably false statements on a material matter under oath or affirmation in a court of law or in any sworn statements in writing.
- Perspective sketch** drawing made to show three dimensions and perspectives.
- Physical match** palpable complement of separated items.
- Physical torture** intentional and repeated infliction of nonlethal injury to a victim. To satisfy the requirements of torture, the victim must remain alive and conscious during the initial infliction of the injury so that he or she can experience the pain that follows.

- Pickoff** handpicking of minute bits of evidence that is most effective when evidence is readily recognizable.
- Pinch point** occurs at the entry side of the oval-shaped hole and is useful in determining bullet direction of travel.
- Pool** bloodstain resulting from an accumulation of liquid blood on a surface.
- Postmortem** wounds that occur during the period after death,
- Practice standards** basic foundations and precepts that regulate the limits of evidentiary interpretation.
- Precautionary acts** behaviors that an offender commits before, during, or after an offense that are consciously intended to confuse, hamper, or defeat investigative or forensic efforts for the purposes of concealing the identity of the perpetrator or his or her connection to the crime, or even the crime itself.
- Precautionary force** physically aggressive offender behavior that results in wound patterns intended to hamper or prevent the recognition and collection of physical evidence and thereby thwart investigative efforts.
- Premises** statements that set forth the reasons or evidence for an idea.
- Primacy effect** cognitive bias in which those ideas or arguments that come first are given more credibility than those that come later.
- Primary crime scene** location where the offender engaged in the majority of his or her principal offense behavior
- Primary impact** location where a bullet first comes into contact with an object during its flight path.
- Projected pattern** bloodstain pattern resulting from the ejection of a volume of blood under pressure.
- Projectile paths** actual path(s) that projectile(s) has taken in a shooting incident scene that provides useful information regarding the location(s) and position(s) of participants and the location of any intermediate targets struck.
- Psychological evidence (or motivational evidence)** any act committed by the perpetrator to satisfy a personal need or motivation.
- Puncture** act of piercing or penetrating with a pointed object or instrument.
- Rape** nonconsensual sexual penetration.
- Recency effect** cognitive bias in which those items, ideas, or arguments that came last are remembered more clearly than those coming first.
- Reenactment** process in which participants mimic actions involved in a specific event or series of events.
- Restraint** any item found in the crime scene or brought to the crime scene used to physically control, limit, contain, or restrict a victim.
- Ricochet** change in the direction of the bullet path by means of impact with an object.
- Rituals** specific acts performed in an order that give them a particular meaning.
- Role-playing** process in which participants engage in animated, freeform hypothesis development and theory revision regarding the potential actions of individuals involved in an event or a series of events.
- Role strain** reference to the "difficulties and contradictions inherent in one's role." In private practice, forensic criminologists must abide by the often-incompatible principles of both science and law (Kennedy and Kennedy, 1972, p. 16).
- Rollover (or flameover)** flaming ignition of the smoke layer that produces very high temperatures that accelerate the radiant ignition of fuels throughout the room.
- Satellite stain** smaller bloodstain that originated during formation of the parent stain as a result of blood impacting a surface.
- Saturation stain** bloodstain resulting from accumulation of liquid blood in an absorbent material.
- Science** "an orderly body of knowledge with principles that are clearly enunciated," as well as being reality oriented and having conclusions susceptible to testing (Thornton, 1997, p. 12).
- Scientific knowledge** any knowledge, enlightenment, or awareness that comes from examining events or problems through the lens of the scientific method.
- Scientific method** way to investigate how or why something works, or how something happened, through the development of hypotheses and subsequent attempts at falsification through testing and other accepted means.
- Scientific principles** scientific theories that withstand the test of time and empirical study.
- Scientific theory** hypothesis that remains standing after a succession of tests or experiments fail to disprove it.
- Scientist** someone who possesses an academic and clinical understanding of the scientific method and the analytical dexterity to construct experiments that will generate the empirical reality that science mandates.
- Scientist reconstructionist** the reconstructionist who will see the pieces and traces of events and arrange them carefully into a whole.
- Secondary/tertiary/etc. impact** second, third, etc. location(s) where a bullet comes into contact with objects during its flight.

- Secondary crime scene** location where some of the victim–offender interaction occurred, but not the majority of it.
- Secondary transfer** exchange of evidence between objects or persons that occurs subsequent to an original exchange, unassociated with the circumstances that produced the original exchange.
- Selection bias** distortion of evidence arising from the manner in which evidence is collected.
- Self-serving bias** tendency to perceive oneself responsible for favorable outcomes but not responsible for unfavorable ones.
- Semen** fluid mixture of male bodily secretions that contains the sperm.
- Sequential evidence** anything that establishes or helps establish when an event occurred or the order in which two or more events occurred.
- Serum stain** stain resulting from the liquid portion of blood (serum) that separates during coagulation.
- Sexual assault** any nonconsensual sexual contact.
- Sexual homicide** any homicide with a sexual component, to include sexual assault.
- Sharp force** injuries caused by pointed, bladed, or edged objects and weapons such as an incise, a stab, or a chop.
- Shooting incident reconstruction** process of identifying specific events that occurred during a shooting incident.
- Shotgun bore** diameter of a shotgun barrel.
- Signature behaviors** acts committed by an offender that are not necessary to commit the crime but that suggest the psychological or emotional needs of that offender.
- Simulated (or staged) crime scene** one in which physical evidence has been purposefully altered by the offender to mislead authorities or misdirect the investigation.
- Socratic method** approach to knowledge building and problem solving based on discussion and debate.
- Solvent recovery** evidence recovery technique that uses a swab moistened with water as a means of recovering small bloodstains.
- Spatter stain** bloodstain resulting from a blood drop dispersed through the air due to an external force applied to a source of liquid blood.
- Splash pattern** bloodstain pattern resulting from a volume of liquid blood that falls or spills onto a surface.
- Spoliation** when evidence or scenes in custody are damaged, lost, defiled or destroyed. It is a negative, destructive form of evidence dynamics.
- Spoliation inference** evidence that is *spoliated* relevant to litigation.
- Squaring the vehicle** an approach to shooting incident reconstruction in which common reference points in the vehicle are used to plot the location of bullet defects and their associated bullet paths, relative to vehicle orientation.
- Stab wounds** injuries that are the result of being pierced with a pointed instrument. The depth of the injury into the tissue is usually greater than its width in the skin.
- Staging** specific type of precautionary act intended to deflect suspicion away from the offender, to suggest an alternate crime, or noncriminal series of events by manipulating the physical evidence.
- Swipe pattern** bloodstain pattern resulting from the transfer of blood from a blood-bearing surface onto another surface, with characteristics that indicate relative motion between the two surfaces.
- Tape lifting** evidence recovery technique that entails applying an adhesive tape to a surface of interest so that minute bits of evidence adhere to the adhesive when the tape is removed.
- Target** surface onto which blood has been deposited.
- Technician** one who is trained in procedures learned by routine and repetition.
- Temporal evidence** anything that specifically denotes or expresses the passage of time at the crime scene relative to the commission of the crime.
- Terminal point** location where the bullet comes to a final rest.
- Tertiary crime scene** any location where physical evidence is present but there is no evidence of victim–offender interaction.
- Therapeutic or diagnostic wounds** injuries inflicted by emergency medical service personnel during treatment.
- Trace evidence** small bits, or traces, of physical evidence that associate, or disassociate, a person with a crime.
- Transfer of form (pattern evidence)** when the form or pattern of one material is transferred to another.
- Transfer stain** bloodstain resulting from contact between a blood-bearing surface and another surface.
- Truth table (or veracity table)** table used to test the veracity of multiple theories inhabiting a case, with theories across the top and observations, clues, and physical evidence along the side.
- Ultimate facts** “facts which are necessary to determine issues in cases, as distinguished from evidentiary facts supporting them” (Black, 1990).

Ultimate issue “that question which must finally be answered as, for example, the defendant’s negligence is the ultimate issue in a personal injury case” (Black, 1990).

Unidirectional contact transfer one-directional contact transfer from the donor to the recipient, commensurate with a certain level of association.

Vanity reconstruction reconstruction based on presumed expertise from years of experience performing various tasks.

Vehicle orientation a vehicle’s position relative to the bullet path and the ground.

Void absence of blood in an otherwise continuous bloodstain or bloodstain pattern.

Wipe pattern altered bloodstain pattern resulting from an object moving through a preexisting wet bloodstain.

Wound pattern analysis recognition, preservation, documentation, examination, and reconstruction of the nature, origin, and intent of physical injuries.

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