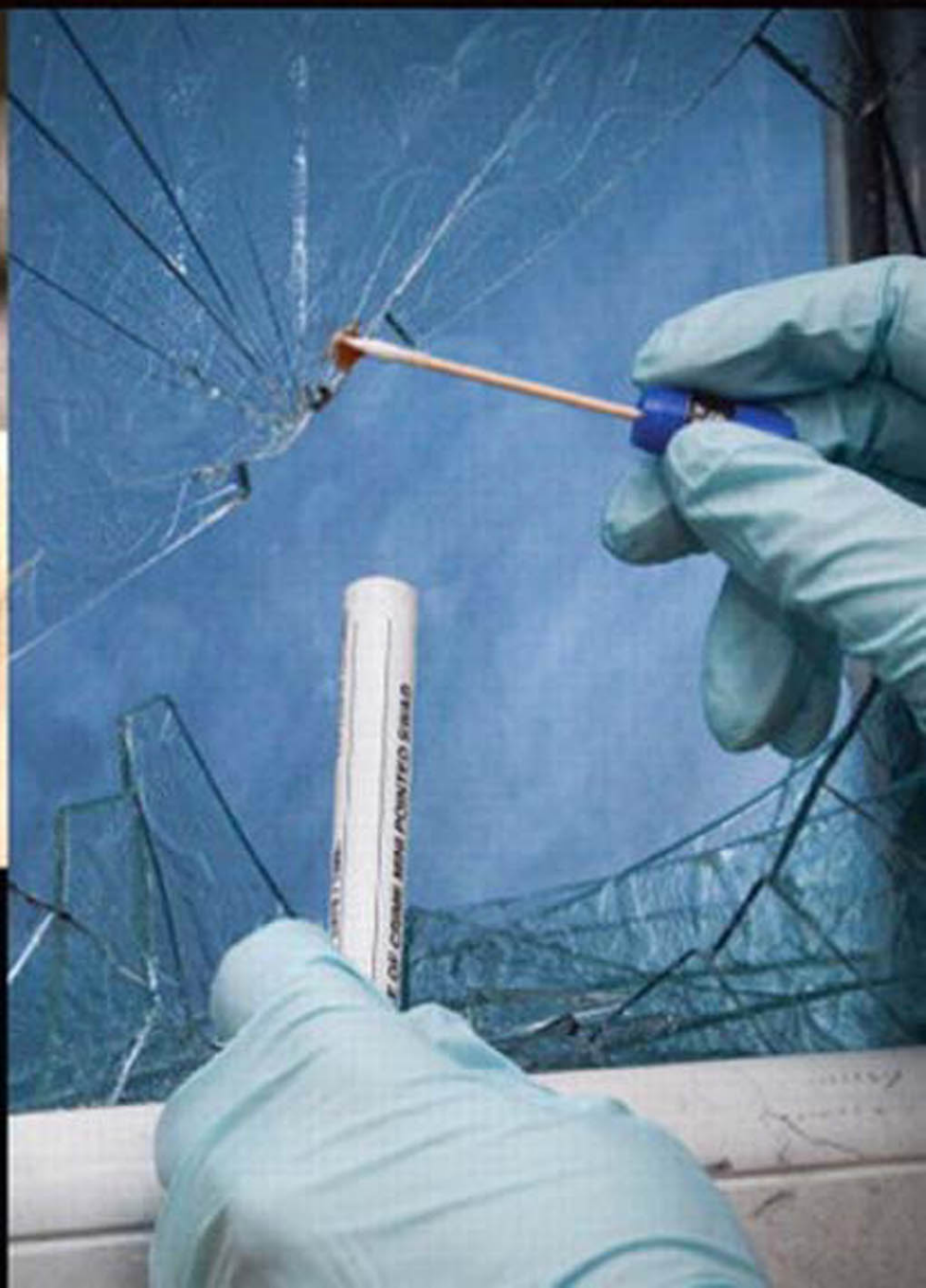
Eleventh Edition

CRIMINALISTICS

An Introduction to Forensic Science

Richard Saferstein



edition 11

Criminalistics
An Introduction to Forensic Science

Richard Saferstein, Ph.D.

Forensic Science Consultant, Mt. Laurel, New Jersey

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Library of Congress Cataloging-in-Publication Data
Saferstein, Richard
Criminalistics : an introduction to forensic science / Richard Saferstein, Ph.D., Forensic Science Consultant, Mt. Laurel, New Jersey.—Edition 11.
pages cm
Includes index.
ISBN-13: 978-0-13-345882-4
ISBN-10: 0-13-345882-2
1. Criminal investigation. 2. Forensic ballistics. 3. Chemistry, Forensic. 4. Medical jurisprudence. I. Title.

HV8073.S2 2015
363.25—dc23

2013045701

10 9 8 7 6 5 4 3 2

PEARSON

ISBN 10: 0-13-345882-2
ISBN 13: 978-0-13-345882-4

To the memory of Fran and Michael

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New to This Edition

- Chapters have been rearranged to integrate scientific methodology with actual forensic applications.
  - Chapter 12 in the 10th edition has been moved to the position of Chapter 4 in the 11th edition.
  - Chapter 16 has been moved to the position of Chapter 6.
  - Chapter 17 has been moved to the position of Chapter 8.
  - Material from Chapters 4 and 5 has been moved into Chapters 9 and 11.
  - Material from Chapter 13 has been moved into Chapter 10.
  - Chapter 8 has been moved to the position of Chapter 11.
  - Chapter 9 has been moved to the position of Chapter 12.
  - Material from Chapters 4, 6, and 13 has been moved to Chapter 13.
  - Chapter 10 has been moved to the position of Chapter 14.
  - Chapter 11 has been moved to the position of Chapter 15.
  - Material from Chapters 14 and 15 has been moved to Chapter 16.
  - Chapter 18 has been moved to the position of Chapter 17.
  - Chapter 19 has been moved to the position of Chapter 18.
- "Inside the Science" boxes highlight technological and scientific aspects of select chapter topics. Chapters that include one or more of these boxes also include end-of-chapter review questions relating to the box's content.
- New Application and Critical Thinking questions have been added to select chapters.
- Chapter 2, "The Crime Scene," has been revised to include expanded coverage of the collection and preservation of DNA evidence, as well as safety protocols required to ensure the well-being of CSI personnel at crime scenes.
- Chapter 5, "Death Investigation," is a new chapter that emphasizes the roles of the forensic pathologist, forensic anthropologist, and forensic entomologist in death investigation, paying particular attention to autopsy procedures and time-of-death determinations.
- Chapter 18, "Computer Forensics," has been reorganized and updated
- Chapter 19, "Mobile Device Forensics" is completely new to the text. Forensics on mobile devices, like cell phones, can provide an overlay to physical evidence and forensic timelines to give a clearer picture of the events preceding and following a crime event.

Key Features of the Eleventh Edition

The eleventh edition, which is now available in a variety of print and electronic formats, presents modern forensic science approaches and techniques with the aid of real-life examples, up to date information, and interactive media. Key features include:

Headline News stories at the beginning of each chapter introduce readers to the chapter topics by describing high-profile crimes and the related forensic science techniques used in the investigations.

headline news

Casey Anthony: The CSI Effect?

Few criminal proceedings have captured the attention of the American public or have invoked stronger emotions than the Casey Anthony murder trial.

How could a defendant who failed to report her two-year-old child missing for thirty-one days walk away scot-free from a murder conviction? This case had all the makings of a strong circumstantial case for the state.

The state's theory was that Casey used chloroform to render her daughter unconscious, placed duct tape over Caylee's mouth and nose, and kept the body in the trunk for several days before disposing of it. Caylee's decomposed remains were discovered more than five months after she was reported missing.

Have TV forensic dramas created an environment in the courtroom that necessitates the existence of physical evidence to directly link a defendant to a crime scene? The closest the state came to a direct link was a hair found in the trunk of Casey's car. However, the DNA test on the hair could only link the hair to Caylee's maternal relatives: Casey, her mother; her grandmother; and Casey's brother. No unique characteristics were found to link the duct tape on the body with that found in the Anthony home.

No DNA, no fingerprints, no conviction.

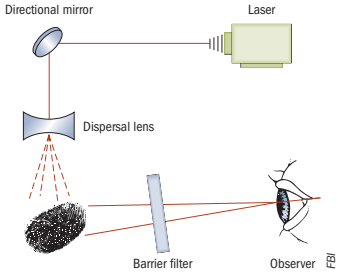
NEW! Inside the Science boxes throughout the text explore scientific phenomena and technology in relation to select chapter topics, and are accompanied by Review Questions for Inside the Science at the end of the chapter.

inside the science

Fluorescence

The first hint of things to come was the discovery that latent fingerprints could be visualized by exposure to laser light. This laser method took advantage of the fact that perspiration contains a variety of components that **fluoresce** when illuminated by laser light. Fluorescence occurs when a substance absorbs light and reemits the light in wavelengths longer than the illuminating source. Importantly, substances that emit light or fluoresce are more readily seen with either the naked eye or through photography than are non-light-emitting materials. The high sensitivity of fluorescence serves as the underlying principle of many of the new chemical techniques used to visualize latent fingerprints.

The earliest use of fluorescence to visualize fingerprints came with the direct illumination of a fingerprint with argon–ion lasers. This laser type was chosen because its blue-green light output induced some of the perspiration components of a fingerprint to fluoresce (see figure). The major drawback of this approach is that the perspiration components of a fingerprint are often present in quantities too minute to observe even with the aid of fluorescence. The fingerprint examiner, wearing safety goggles containing optical filters, visually examines the specimen being exposed to the laser light. The filters absorb the laser light and permit the wavelengths at which latent-print residues fluoresce to pass through to the eyes of the wearer. The filter also protects the operator against eye damage from scattered or reflected laser light. Likewise, latent-print residue producing sufficient fluorescence can be photographed by placing this same filter across the lens of the camera. Examination of specimens and photography of the fluorescing latent prints are carried out in a darkened room.



Schematic depicting latent-print detection with the aid of a laser. A fingerprint examiner, wearing safety goggles containing optical filters, examines the specimen being exposed to the laser light. The filter absorbs the laser light and permits the wavelengths at which latent-print residues fluoresce to pass through to the eyes of the wearer.

Case File boxes throughout the text present brief, real-life case examples that illustrate to the forensic science topics and techniques described in the chapters.

case files

The Night Stalker

Richard Ramirez committed his first murder in June 1984. His victim was a 79-year-old woman who was stabbed repeatedly and sexually assaulted and then had her throat slashed. It would be eight months before Ramirez murdered again. In the spring, Ramirez began a murderous rampage that resulted in 13 additional killings and 5 rapes.

His modus operandi was to enter a home through an open window, shoot the male residents, and savagely rape his female victims. He scribed a pentagram on the wall of one of his victims and the words *Jack the Knife*, and was reported by another to force her to "swear to Satan" during the assault. His identity still unknown, the news media dubbed him the "Night Stalker." As the body count continued to rise, public hysteria and a media frenzy prevailed.

The break in the case came when the license plate of what seemed to be a suspicious car related to a sighting of the Night Stalker was reported to the police. The police determined that the car had been stolen and eventually located it, abandoned in a parking lot. After processing the car for prints, police found one usable partial fingerprint. This fingerprint was entered into the Los Angeles Police Department's brand-new AFIS computerized fingerprint system.

The Night Stalker was identified as Richard Ramirez, who had been fingerprinted following a traffic violation some years before. Police searching the home of one of his friends found the gun used to commit the murders, and jewelry belonging to his victims was found in the possession of Ramirez's sister. Ramirez was convicted of murder and sentenced to death in 1989.

Corbis

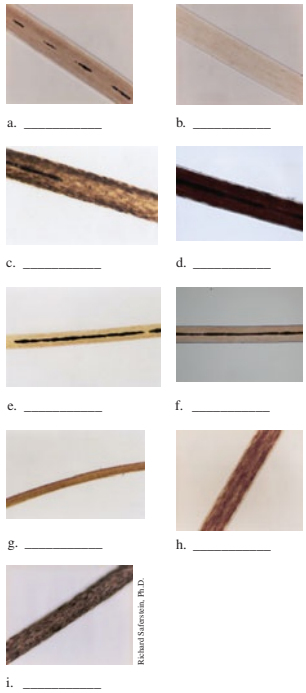
Richard Ramirez, the Night Stalker.

Application and Critical Thinking questions at the end of each chapter challenge students to demonstrate their understanding of the material through a variety of question types, including hypothetical scenarios and sets of images for visual identification and analysis. Answers to these questions are provided in the Instructor's Manual.

Webextras Webextras serve to expand the coverage of the book through video presentations, internet-related information, animations, and graphic displays keyed to enhancing reader's understanding of the subject's more difficult concepts. Webextras are accessible only in MyCJLab.

application and critical thinking

1. Indicate the phase of growth of each of the following hairs:
   a. The root is club-shaped
   b. The hair has a follicular tag
   c. The root bulb is flame-shaped
   d. The root is elongated
2. A criminalist studying a dyed sample hair notices that the dyed color ends about 1.5 centimeters from the tip of the hair. Approximately how many weeks before the examination was the hair dyed? Explain your answer.
3. Following are descriptions of several hairs; based on these descriptions, indicate the likely race of the person from whom the hair originated:
   a. Evenly distributed, fine pigmentation
   b. Continuous medullation
   c. Dense, uneven pigmentation
   d. Wavy with a round cross-section
4. Criminalist Pete Evett is collecting fiber evidence from a murder scene. He notices fibers on the victim's shirt and trousers, so he places both of these items of clothing in a plastic bag. He also sees fibers on a sheet near the victim, so he balls up the sheet and places it in a separate plastic bag. Noticing fibers adhering to the windowsill from which the attacker gained entrance, Pete carefully removes them with his fingers and places them in a regular envelope. What mistakes, if any, did Pete make while collecting this evidence?
5. For each of the following human hair samples, indicate the medulla pattern present.


Richard Saferstein, Ph.D.

a. _____ b. _____ c. _____ d. _____ e. _____ f. _____ g. _____ h. _____ i. _____

Public Fascination with Forensic Science

Many readers of this book have been drawn to the subject of forensic science by the assortment of television shows about scientific crime investigation. Story lines depicting the crime-solving abilities of forensic scientists have greatly excited the imagination of the general public. Furthermore, a constant of forensic science is how frequently its applications become front-page news. Whether the story is the sudden death of pop music superstar Michael Jackson, sniper shootings, or the tragic consequences of the terrorist attacks of 9/11, forensic science is at the forefront of the public response.

During the highly publicized O. J. Simpson criminal and civil trials, forensic scientists systematically placed Simpson at the crime scene through DNA analyses, hair and fiber comparisons, and footwear impressions. As millions of Americans watched the case unfold, they, in a sense, became students of forensic science. Intense media coverage of the crime-scene search and investigation, as well as the ramifications of findings of physical evidence at the crime scene, became the subject of study, commentary, and conjecture.

For instructors who have taught forensic science in the classroom, it comes as no surprise that forensic science can grab and hold the attention of those who otherwise would have no interest in any area of science. The O. J. Simpson case, for example, amply demonstrates the extent to which forensic science has intertwined with criminal investigation.

Perhaps we can attribute our obsession with forensic science to the yearnings of a society bent on apprehending criminals but desirous of a system of justice that ensures the correctness of its verdicts. The level of sophistication that forensic science has brought to criminal investigations is formidable. But once one puts aside all the drama of a forensic science case, what remains is *an academic subject emphasizing logic and technology*.

Purpose of This Book

It is to this end—revealing that essence of forensic science—that the eleventh edition of *Criminalistics* is dedicated. The basic aim of the book is still to make the subject of forensic science clear and comprehensible to a wide variety of readers who are or plan to be aligned with the forensic science profession, as well as to those who have a curiosity about the subject's underpinnings.

DNA profiling has altered the complexion of criminal investigation. DNA collected from saliva on a cup or from dandruff or sweat on a hat exemplifies the emergence of nontraditional forms of evidence collection at crime scenes. Currently, the criminal justice system is creating vast DNA data banks designed to snare criminals who are unaware of the consequences of leaving the minutest quantity of biological material behind at a crime scene.

Focus on Cutting-Edge Tools and Techniques

Through eleven editions, *Criminalistics* has strived to depict the role of the forensic scientist in the criminal justice system. The current edition builds on the content of its predecessors and updates the reader on the latest technologies available to crime laboratory personnel.

The computer, the Internet, and mobile electronic devices have influenced all aspects of modern life, and forensic science is no exception. Chapter 18, "Computer Forensics," and Chapter 19, "Mobile Devices Forensics," explore the retrieval of computerized information thought to be lost or erased during the course of a criminal investigation and delve into the investigation of hacking incidents.

A major portion of the text centers on discussions of the common items of physical evidence encountered at crime scenes. Various chapters include descriptions of forensic analysis, as well as updated techniques for the proper collection and preservation of evidence at crime scenes. The reader is offered the option of delving into the more difficult technical aspects of the subject by reading the "Inside the Science" features. This option can be bypassed without detracting from a basic comprehension of the subject of forensic science.

The implications of DNA profiling are important enough to warrant their inclusion in a separate chapter in *Criminalistics*. Chapter 15 describes the topic of DNA in a manner that is comprehensible and relevant to readers who lack a scientific background. The discussion defines DNA and explains its central role in controlling the body's chemistry. Finally, Chapter 15 explains the process of DNA typing and illustrates its application to criminal investigations through the presentation of actual case histories.

A Grounded Approach

The content of *Criminalistics* reflects the author's experience as both an active forensic scientist and an instructor of forensic science at the college level. The author assumes that readers have no prior knowledge of scientific principles or techniques. The areas of chemistry and biology relating to the analysis of physical evidence are presented with a minimum of scientific terminology and equations. The discussion involving chemistry and biology is limited to a minimum core of facts and principles that make the subject matter understandable and meaningful to the nonscientist. Although it is not the intent of this book to turn readers into scientists or forensic experts, the author would certainly be gratified if the book motivates some students to seek further scientific knowledge and perhaps direct their education toward careers in forensic science.

Although *Criminalistics* is an outgrowth of a one-semester course offered as part of a criminal justice program at many New Jersey colleges, the value of the book is not limited to college students. Optimum utilization of crime laboratory services requires that criminal investigators have knowledge of the techniques and capabilities of the laboratory. That awareness extends beyond any summary that may be gleaned from departmental brochures dealing with the collection and packaging of physical evidence. Investigators must mesh knowledge of the principles and techniques of forensic science with logic and common sense to gain comprehensive insight into the meaning and significance of physical evidence and its role in criminal investigations. Forensic science begins at the crime scene. If the investigator cannot recognize, collect, and package evidence properly, no amount of equipment or expertise will salvage the situation.

Likewise, there is a dire need to bridge the "communication gap" that currently exists among lawyers, judges, and forensic scientists. An intelligent evaluation of the scientist's data and any subsequent testimony will again depend on familiarity with the underlying principles of forensic science. Too many practitioners of the law profess ignorance of the subject or attempt to gain a superficial understanding of its meaning and significance only minutes before meeting the expert witness. It is hoped that the book will provide a painless route to comprehending the nature of the science.

In order to merge theory with practice, actual forensic case histories are included in the text. The intent is for these illustrations to move forensic science from the domain of the abstract into the real world of criminal investigation.

Instructor Supplements

The following supplements are available for instructors using *Criminalistics: An Introduction to Forensic Science:*

Instructor's Manual with Test Bank
MyTest Electronic Test Bank
Standard PowerPoint Presentations

Criminalistics is supported by online course solutions that include interactive learning modules, a variety of assessment tools, videos, simulations, and current event features. To access supplementary materials online, instructors need to request an instructor access code. Go to **www.pearsonhighered.com**, click the Instructor Resource Center link, and then click Request IRC access for an instructor access code. Within 48 hours after registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, go the site and log on for full instructions on downloading the materials you wish to use.

Acknowledgments

I am most appreciative of the contribution that retired Lieutenant Andrew (Drew) Donofrio of New Jersey's Bergen County Prosecutor's Office and now a leading private computer forensic examiner made to this new edition of *Criminalistics*. I was fortunate to find in Drew a contributor who not only possesses extraordinary skill, knowledge, and hands-on experience with computer forensics, but was able to combine those attributes with sophisticated communication skills. Likewise, I was fortunate to have Dr. Peter Stephenson contribute to this book on the subject of mobile forensics. He brings skills as a cybercriminologist, author, and educator in digital forensics.

Many people provided assistance and advice in the preparation of this book. Many faculty members, colleagues, and friends have read and commented on various portions of the text. Particular thanks go to the following people for their critical reading and discussions of the manuscript: Norman Demeter, John Lintott, Charles Midkiff, and Raymond Murray. In addition, I would like to acknowledge the contributions of Jeffrey C. Kercheval, Robert Thompson, Roger Ely, Jose R. Almirall, Darlene Brezinski, Michael Malone, Anita Wonder, Robert J. Phillips, David Pauly, Dr. Barbara Needell, Joshua Wiborne, Robin D. Williams, Peter Diaczuk, Jacqueline E. Joseph, and Robert Welsh. I'm appreciative for the contributions, reviews, and comments that Dr. Claus Speth, Dr. Mark Taff, Dr. Elizabeth Laposata, Thomas P. Mauriello, and Michelle D. Miranda provided during the preparation of Chapter 5, "Death Investigation."

Thanks also to the following reviewers: Earl Ballou, Jr., Palo Alto College; Adam C. Barton, Harrisburg Area Community College; Virginia G. Carson, Chapman University; David R Conklin, Trine University; April Babb Crisp, Regis University; Gilbert Ellis, Barry University; Darrell C. Hawkins, University of Cincinnati—Clermont College; Richard A. Jensen, Hofstra University; Craig William Laker, Trine University; Rupendra Simlot, Richard Stockton College of New Jersey; Anne Strouth, North Central State College; Luke Tolley, Southern Illinois University; and Oluseyi A. Vanderpuye, Albany State University.

The assistance and research efforts of Pamela Cook, Gonul Turhan, and Michelle Tetreault are an integral part of this text and were invaluable to the book's success. I am also appreciative of the time and talent given by Peggy Cole and this book's production editor, Lori Bradshaw.

I am grateful to the law enforcement agencies, governmental agencies, private individuals, and equipment manufacturers cited in the text for contributing their photographs and illustrations. Finally, I particularly wish to express my appreciation to Major E. R. Leibe (retired) and Major V. P. O'Donoghue (retired) for their encouragement and support.

Any author of a textbook must be prepared to contribute countless hours to the task, often at the expense of family obligations. My efforts would have fallen well short of completion without the patience and encouragement of my wife, Gail. Her typing and critical readings of the manuscript, as well as her strength of character under circumstances that were less than ideal, will always be remembered.

Richard Saferstein, Ph.D.

about the author

Richard Saferstein, Ph.D., retired in 1991 after serving 21 years as the chief forensic scientist of the New Jersey State Police Laboratory, one of the largest crime laboratories in the United States. He currently acts as a consultant for attorneys and the media in the area of forensic science. During the O. J. Simpson criminal trial, Dr. Saferstein provided extensive commentary on forensic aspects of the case for the *Rivera Live* show, the E! television network, ABC radio, and various radio talk shows. Dr. Saferstein holds degrees from the City College of New York and earned his doctorate degree in chemistry in 1970 from the City University of New York. From 1972 to 1991, he taught an introductory forensic science course in the criminal justice programs at the College of New Jersey and Ocean County College. These teaching experiences played an influential role in Dr. Saferstein's authorship in 1977 of the widely used introductory textbook *Criminalistics: An Introduction to Forensic Science*, currently in this eleventh edition. Saferstein's basic philosophy in writing *Criminalistics* is to make forensic science understandable and meaningful to the nonscience reader, while giving the reader an appreciation for the scientific principles that underlie the subject.

Dr. Saferstein has authored or co-authored more than 45 technical papers and chapters covering a variety of forensic topics. Dr. Saferstein has co-authored *Lab Manual for Criminalistics* (Pearson, 2015) to be used in conjunction with this text. He is also the author of *Forensic Science: An Introduction* (Pearson, 2008 and 2011) and *Forensic Science: From the Crime Scene to the Crime Lab* (2009 and 2015). He has also edited the widely used professional reference books *Forensic Science Handbook*, Volumes I, II, and III, 2nd edition (published in 2002, 2005, and 2010, respectively, by Pearson).

Dr. Saferstein is a member of the American Chemical Society, the American Academy of Forensic Sciences, the Canadian Society of Forensic Scientists, the International Association for Identification, the Northeastern Association of Forensic Scientists, and the Society of Forensic Toxicologists. He is the recipient of the American Academy of Forensic Sciences 2006 Paul L. Kirk Award for distinguished service and contributions to the field of criminalistics.

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Criminalistics

An Introduction to Forensic Science

headline news

Casey Anthony: The CSI Effect?

AP Images

Few criminal proceedings have captured the attention of the American public or have invoked stronger emotions than the Casey Anthony murder trial.

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No DNA, no fingerprints, no conviction.

chapter 1

introduction

KEY TERMS

expert witness
Locard's exchange principle
scientific method

Learning Objectives

After studying this chapter you should be able to:

- Define and distinguish forensic science and criminalistics
- Recognize the major contributors to the development of forensic science
- Account for the rapid growth of forensic laboratories in the past forty years
- Describe the services of a typical comprehensive crime laboratory in the criminal justice system
- Compare and contrast the *Frye* and *Daubert* decisions relating to the admissibility of scientific evidence in the courtroom
- Explain the role and responsibilities of the expert witness
- Understand what specialized forensic services, aside from the crime laboratory, are generally available to law enforcement personnel

Definition and Scope of Forensic Science

Forensic science in its broadest definition is the application of science to law. As our society has grown more complex, it has become more dependent on rules of law to regulate the activities of its members. Forensic science applies the knowledge and technology of science to the definition and enforcement of such laws.

Each year, as government finds it increasingly necessary to regulate the activities that most intimately influence our daily lives, science merges more closely with civil and criminal law. Consider, for example, the laws and agencies that regulate the quality of our food, the nature and potency of drugs, the extent of automobile emissions, the kind of fuel oil we burn, the purity of our drinking water, and the pesticides we use on our crops and plants. It would be difficult to conceive of a food or drug regulation or environmental protection act that could be effectively monitored and enforced without the assistance of scientific technology and the skill of the scientific community.

Laws are continually being broadened and revised to counter the alarming increase in crime rates. In response to public concern, law enforcement agencies have expanded their patrol and investigative functions, hoping to stem the rising tide of crime. At the same time, they are looking more to the scientific community for advice and technical support for their efforts. Can the technology that put astronauts on the moon, split the atom, and eradicated most dreaded diseases be enlisted in this critical battle?

Unfortunately, science cannot offer final and authoritative solutions to problems that stem from a maze of social and psychological factors. However, as the content of this book attests, science occupies an important and unique role in the criminal justice system—a role that relates to the scientist's ability to supply accurate and objective information about the events that have occurred at a crime scene. A good deal of work remains to be done if the full potential of science as applied to criminal investigations is to be realized.

Because of the vast array of civil and criminal laws that regulate society, forensic science, in its broadest sense, has become so comprehensive a subject that a meaningful introductory textbook treating its role and techniques would be difficult to create and probably overwhelming to read. For this reason, we have narrowed the scope of the subject according to the most common definition: **Forensic science is the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system.** *Forensic science* is an umbrella term encompassing a myriad of professions that use their skills to aid law enforcement officials in conducting their investigations.

The diversity of professions practicing forensic science is illustrated by the eleven sections of the American Academy of Forensic Science, the largest forensic science organization in the world:

1. Criminalistics
2. Digital and Multimedia Sciences
3. Engineering Science
4. General
5. Jurisprudence
6. Odontology
7. Pathology/Biology
8. Physical Anthropology
9. Psychiatry/Behavioral Science
10. Questioned Documents
11. Toxicology

Even this list of professions is not exclusive. It does not encompass skills such as fingerprint examination, firearm and tool mark examination, and photography.

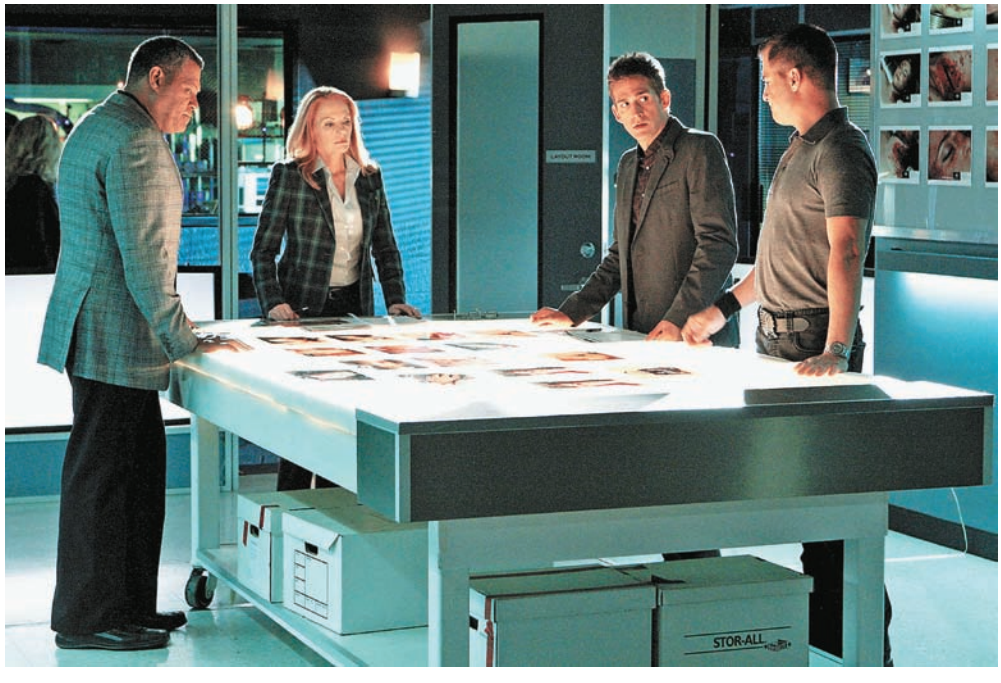
Obviously, to author a book covering all of the major activities of forensic science as they apply to the enforcement of criminal and civil laws by police agencies would be a major undertaking. Thus, this book will further restrict itself to discussions of the subjects of chemistry, biology, physics, geology, and computer technology, which are useful for determining the evidential value of crime-scene and related evidence. Forensic psychology, anthropology, and

odontology also encompass important and relevant areas of knowledge and practice in law enforcement, each being an integral part of the total forensic science service that is provided to any up-to-date criminal justice system. However, these subjects go beyond the intended scope of this book, and except for brief discussions, along with pointing the reader to relevant websites, the reader is referred elsewhere for discussions of their applications and techniques. Instead, this book focuses on the services of what has popularly become known as the crime laboratory, where the principles and techniques of the physical and natural sciences are practiced and applied to the analysis of crime-scene evidence.

For many, the term *criminalistics* seems more descriptive than *forensic science* for describing the services of a crime laboratory. Regardless of his or her title—criminalist or forensic scientist—the trend of events has made the scientist in the crime laboratory an active participant in the criminal justice system.

Prime-time television shows like *CSI: Crime Scene Investigation* have greatly increased the public's awareness of the use of science in criminal and civil investigations (Figure 1–1). However, by simplifying scientific procedures to fit the allotted airtime, these shows have created within both the public and the legal community unrealistic expectations of forensic science. In these shows, members of the CSI team collect evidence at the crime scene, process all evidence, question witnesses, interrogate suspects, carry out search warrants, and testify in court. In the real world, these tasks are almost always delegated to different people in different parts of the criminal justice system. Procedures that in reality could take days, weeks, months, or years appear on these shows to take mere minutes. This false image is significantly responsible for the public's high interest in and expectations for DNA evidence.

The dramatization of forensic science on television has led the public to believe that every crime scene will yield forensic evidence, and it produces unrealistic expectations that a prosecutor's case should always be bolstered and supported by forensic evidence. This phenomenon is known as the "CSI effect." Some jurists have come to believe that this phenomenon ultimately detracts from the search for truth and justice in the courtroom.



SUN/Newscom

FIGURE 1–1
A scene from *CSI,* a forensic science television show.

History and Development of Forensic Science

Forensic science owes its origins first to the individuals who developed the principles and techniques needed to identify or compare physical evidence, and second to those who recognized the need to merge these principles into a coherent discipline that could be practically applied to a criminal justice system.

Literary Roots

Today many believe that Sir Arthur Conan Doyle had a considerable influence on popularizing scientific crime-detection methods through his fictional character Sherlock Holmes (see Figure 1–2), who first applied the newly developing principles of serology (see Chapter 14), fingerprinting, firearms identification, and questioned-document examination long before their value was first recognized and accepted by real-life criminal investigators. Holmes's feats excited the imagination of an emerging generation of forensic scientists and criminal investigators. Even in the first Sherlock Holmes novel, *A Study in Scarlet,* published in 1887, we find examples of Doyle's uncanny ability to describe scientific methods of detection years before they were actually discovered and implemented. For instance, here Holmes probes and recognizes the potential usefulness of forensic serology to criminal investigation:

FIGURE 1–2

Sir Arthur Conan Doyle's legendary detective Sherlock Holmes applied many of the principles of modern forensic science long before they were adopted widely by police.

> "I've found it. I've found it," he shouted to my companion, running towards us with a test tube in his hand. "I have found a reagent which is precipitated by hemoglobin and by nothing else. . . . Why, man, it is the most practical medico-legal discovery for years. Don't you see that it gives us an infallible test for blood stains? . . . The old guaiacum test was very clumsy and uncertain. So is the microscopic examination for blood corpuscles. The latter is valueless if the stains are a few hours old. Now, this appears to act as well whether the blood is old or new. Had this test been invented, there are hundreds of men now walking the earth who would long ago have paid the penalty of their crimes. . . . Criminal cases are continually hinging upon that one point. A man is suspected of a crime months perhaps after it has been committed. His linen or clothes are examined and brownish stains discovered upon them. Are they blood stains, or rust stains, or fruit stains, or what are they? That is a question which has puzzled many an expert, and why? Because there was no reliable test. Now we have the Sherlock Holmes test, and there will no longer be any difficulty."

Important Contributors to Forensic Science

Many people can be cited for their specific contributions to the field of forensic science. The following is just a brief list of those who made the earliest contributions to formulating the disciplines that now constitute forensic science.

MATHIEU ORFILA (1787–1853) Orfila is considered the father of forensic toxicology. A native of Spain, he ultimately became a renowned teacher of medicine in France. In 1814, Orfila published the first scientific treatise on the detection of poisons and their effects on animals. This treatise established forensic toxicology as a legitimate scientific endeavor.

ALPHONSE BERTILLON (1853–1914) Bertillon devised the first scientific system of personal identification. In 1879, Bertillon began to develop the science of *anthropometry* (see Chapter 6), a systematic procedure of taking a series of body measurements as a means of distinguishing one individual from another (see Figure 1–3). For nearly two decades, this system was considered

Sirchie Fingerprint Laboratories

FIGURE 1–3
Bertillon's system of bodily measurements as used for the identification of an individual.

the most accurate method of personal identification. Although anthropometry was eventually replaced by fingerprinting in the early 1900s, Bertillon's early efforts have earned him the distinction of being known as the father of criminal identification.

FRANCIS GALTON (1822–1911) Galton undertook the first definitive study of fingerprints and developed a methodology of classifying them for filing. In 1892, he published a book titled *Finger Prints,* which contained the first statistical proof supporting the uniqueness of his method of personal identification. His work went on to describe the basic principles that form the present system of identification by fingerprints.

LEONE LATTES (1887–1954) In 1901, Dr. Karl Landsteiner discovered that blood can be grouped into different categories. These blood groups or types are now recognized as A, B, AB, and O. The possibility that blood grouping could be a useful characteristic for the identification of an individual intrigued Dr. Lattes, a professor at the Institute of Forensic Medicine at the University of Turin in Italy. In 1915, he devised a relatively simple procedure for determining the blood group of a dried bloodstain, a technique that he immediately applied to criminal investigations.

CALVIN GODDARD (1891–1955) To determine whether a particular gun has fired a bullet requires a comparison of the bullet with one that has been test-fired from the suspect's weapon. Goddard, a U.S. Army colonel, refined the techniques of such an examination by using the comparison microscope. From the mid-1920s on, Goddard's expertise established the comparison microscope as the indispensable tool of the modern firearms examiner.

ALBERT S. OSBORN (1858–1946) Osborn's development of the fundamental principles of document examination was responsible for the acceptance of documents as scientific evidence by the courts. In 1910, Osborn authored the first significant text in this field, *Questioned Documents*. This book is still considered a primary reference for document examiners.

WALTER C. MCCRONE (1916–2002) Dr. McCrone's career paralleled startling advances in sophisticated analytical technology. Nevertheless, during his lifetime McCrone became the world's preeminent microscopist. Through his books, journal publications, and research institute, McCrone was a tireless advocate for applying microscopy to analytical problems, particularly forensic science cases. McCrone's exceptional communication skills made him a much-sought-after instructor, and he was responsible for educating thousands of forensic scientists throughout the world in the application of microscopic techniques. Dr. McCrone used microscopy, often in conjunction with other analytical methodologies, to examine evidence in thousands of criminal and civil cases throughout a long and illustrious career.

HANS GROSS (1847–1915) Gross wrote the first treatise describing the application of scientific disciplines to the field of criminal investigation in 1893. A public prosecutor and judge in Graz, Austria, Gross spent many years studying and developing principles of criminal investigation. In his classic book *Handbuch für Untersuchungsrichter als System der Kriminalistik* (later published in English under the title *Criminal Investigation*), he detailed the assistance that investigators could expect from the fields of microscopy, chemistry, physics, mineralogy, zoology, botany, anthropometry, and fingerprinting. He later introduced the forensic journal *Archiv für Kriminal Anthropologie und Kriminalistik,* which still serves as a medium for reporting improved methods of scientific crime detection.

EDMOND LOCARD (1877–1966) Although Gross was a strong advocate of the use of the scientific method in criminal investigation, he did not make any specific technical contributions to this philosophy. Locard, a Frenchman, demonstrated how the principles enunciated by Gross could be incorporated within a workable crime laboratory. Locard's formal education was in both medicine and law. In 1910, he persuaded the Lyons police department to give him two attic rooms and two assistants to start a police laboratory.

During Locard's first years of work, the only available instruments were a microscope and a rudimentary spectrometer. However, his enthusiasm quickly overcame the technical and monetary deficiencies he encountered. From these modest beginnings, Locard's research and accomplishments became known throughout the world by forensic scientists and criminal investigators.

Eventually he became the founder and director of the Institute of Criminalistics at the University of Lyons; this quickly developed into a leading international center for study and research in forensic science.

Locard believed that when a person comes in contact with an object or person, a cross-transfer of materials occurs **(Locard's exchange principle).** Locard maintained that every criminal can be connected to a crime by dust particles carried from the crime scene. This concept was reinforced by a series of successful and well-publicized investigations. In one case, presented with counterfeit coins and the names of three suspects, Locard urged the police to bring the suspects' clothing to his laboratory. On careful examination, he located small metallic particles in all the garments. Chemical analysis revealed that the particles and coins were composed of exactly the same metallic elements. Confronted with this evidence, the suspects were arrested and soon confessed to the crime. After World War I, Locard's successes served as an impetus for the formation of police laboratories in Vienna, Berlin, Sweden, Finland, and Holland.

Locard's exchange principle
Whenever two objects come into contact with one another, there is exchange of materials between them.

Crime Laboratories

The most ambitious commitment to forensic science occurred in the United States with the systematic development of national and state crime laboratories. This development greatly hastened the progress of forensic science.

Crime Labs in the United States

In 1932, the Federal Bureau of Investigation (FBI), under the directorship of J. Edgar Hoover, organized a national laboratory that offered forensic services to all law enforcement agencies in the country. During its formative stages, agents consulted extensively with business executives, manufacturers, and scientists whose knowledge and experience were useful in guiding the new facility through its infancy. The FBI Laboratory is now the world's largest forensic laboratory, performing more than one million examinations every year. Its accomplishments have earned it worldwide recognition, and its structure and organization have served as a model for forensic laboratories formed at the state and local levels in the United States as well as in other countries. Furthermore, the opening of the FBI's Forensic Science Research and Training Center in 1981 gave the United States, for the first time, a facility dedicated to conducting research to develop new and reliable scientific methods that can be applied to forensic science. This facility is also used to train crime laboratory personnel in the latest forensic science techniques and methods.

The oldest forensic laboratory in the United States is that of the Los Angeles Police Department, created in 1923 by August Vollmer, a police chief from Berkeley, California. In the 1930s, Vollmer headed the first U.S. university institute for criminology and criminalistics at the University of California at Berkeley. However, this institute lacked any official status in the university until 1948, when a school of criminology was formed. The famous criminalist Paul Kirk (see Figure 1–4) was selected to head its criminalistics department. Many graduates of this school have gone on to help develop forensic laboratories in other parts of the state and country.

California has numerous federal, state, county, and city crime laboratories, many of which operate independently. However, in 1972 the California Department of Justice embarked on an ambitious plan to create a network of state-operated crime laboratories. As a result, California has created a model system of integrated forensic laboratories consisting of regional and satellite facilities. An informal exchange of information and expertise is facilitated among California's criminalist community through a regional professional society, the California Association of Criminalists. This organization was the forerunner of a number of regional organizations that have developed throughout the United States to foster cooperation among the nation's growing community of criminalists.

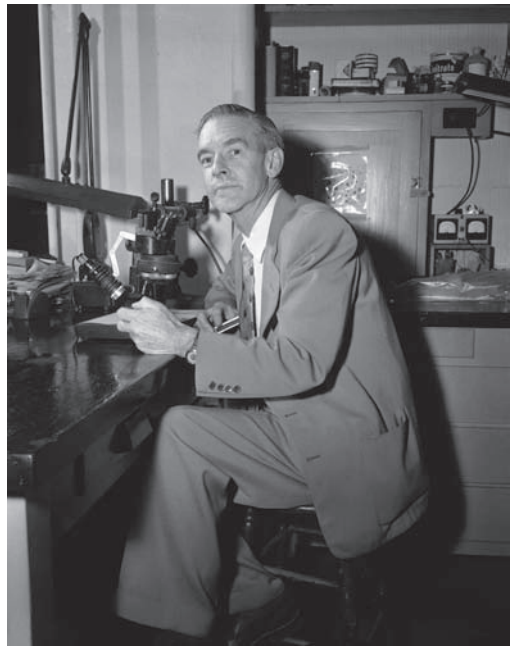


FIGURE 1–4
Paul Leland Kirk, 1902–1970.