

CRIMINALISTICS

AN INTRODUCTION TO FORENSIC SCIENCE

NINTH EDITION

RICHARD SAFERSTEIN, Ph.D.

Forensic Science Consultant, Mt. Laurel, New Jersey

Lecturer, Widener University School of Law

Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Saferstein, Richard, (date)

Criminalistics: an introduction to forensic science / Richard Saferstein. — 9th ed.

p. cm.

Includes index.

ISBN 0-13-221655-8

1. Criminal investigation. 2. Forensic ballistics. 3. Chemistry, Forensic. 4. Medical jurisprudence. I. Title.

HV8073.S2 2007

363.25—dc22

2005056485

Editor-in-chief: Vernon R. Anthony

Executive Editor: Frank Mortimer, Jr.

Assistant Editor: Mayda Bosco

Marketing Manager: Adam Kloza

Editorial Assistant: Jillian Allison

Production Editor: Linda Zuk

Production Liaison: Barbara Martine Cappuccio

Director of Manufacturing and Production: Bruce Johnson

Managing Editor: Mary Carnis

Manufacturing Manager: Ilene Sanford

Manufacturing Buyer: Cathleen Petersen

Senior Design Coordinator: Mary Siener

Interior Design: Pronk and Associates

Cover Designer: Jonathan Boylan

Cover Images: DNA strand, Chad Baker, Getty Images; Footprints, Alan Polansky: Broken glass: K. Hackenberg/zefa/Corbis; Fiber, Graeme Montgomery, Getty Images.

Director, Image Resource Center: Melinda Patelli

Manager, Rights and Permissions: Zina Arabia

Manager, Visual Research: Beth Brenzel

Manager, Cover Visual Research & Permissions: Karen Sanatar

Image Permission Coordinator: Richard Rodrigues

Photo Researcher: Melinda Alexander

Media Editor: John J. Jordan

Manager of Media Production: Amy Peltier

Media Production Project Manager: Lisa Rinaldi

Formatting: Carlisle Publishing Services

Printing and Binding: R.R. Donnelley & Sons, Willard, Ohio

Cover Printer: Lehigh Press

**Copyright 2007, 2004, 2001, 1998, 1995, 1990, 1987, 1981, 1977 by Pearson Education, Inc.,
Upper Saddle River, New Jersey, 07458.**

Pearson Prentice Hall. All rights reserved. Printed in the United States of America. This publication is protected by Copyright and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department.

Pearson Prentice Hall™ is a trademark of Pearson Education, Inc.

Pearson® is a registered trademark of Pearson plc

Prentice Hall® is a registered trademark of Pearson Education, Inc.

Pearson Education LTD.

Pearson Education Australia PTY, Limited

Pearson Education Singapore, Pte. Ltd

Pearson Education North Asia Ltd

Pearson Education, Canada, Ltd

Pearson Educación de Mexico, S.A. de C.V.

Pearson Education–Japan

Pearson Education Malaysia, Pte. Ltd

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-221655-8

ISBN 0-13-222710-X

To the Memory of Fran and Michael

***Criminalistics* Now Accompanied by DNA Evidence CD-ROMs**

A feature of this edition of *Criminalistics* is two CD-ROMs. One of the difficulties that instructors of forensic science have encountered in the past was how to bring the student reader to the crime scene. The recognition and proper collection of physical evidence at the crime scene is an integral part of forensic science. Yet because of the elaborate classroom preparation required, the task of enabling the student to experience a mock crime scene is not feasible for most instructors. The U.S. Department of Justice has helped to rectify this problem by creating a series of virtual crime scenes. In the words of the National Criminal Justice Reference Service:

“The two CD-ROMs present training modules that provide students with interactive training on the basic information about the identification, preservation, and collection of DNA evidence at a crime scene.

“The tutorial module presents best practices based on the work of the Crime Scene Investigation Working Group of the National Commission on the Future of DNA Evidence. The Commission was established by the Attorney General to achieve maximum usefulness of DNA evidence

in the criminal justice system. The module presents background information regarding DNA evidence and its use. It also presents interactive scenarios in which the first responding officer, investigating officer and/or evidence technician make choices regarding the handling of crime scenes and evidence collection related to homicide, sexual assault, burglary, and violent crime. The training modules also include tests that last 20–30 minutes, a glossary, and 15 references.”

Contents

Preface xiii

About the Author xvi

Chapter 1

Introduction 2

Definition and Scope of Forensic Science 4

History and Development of Forensic Science 5

Organization of a Crime Laboratory 10

Services of the Crime Laboratory 13

Functions of the Forensic Scientist 16

Other Forensic Science Services 21

Chapter Summary 25

Review Questions 26

Further References 28

Case Study: Detection of Curare in the Jasclevich Murder Trial 29

Chapter 2

The Crime Scene 36

Processing the Crime Scene 38

Legal Considerations at the Crime Scene 55

Chapter Summary 56

Review Questions 57

Further References 58

Case Study: The Enrique Camarena Case: A Forensic Nightmare 59

Chapter 3

Physical Evidence 68

Common Types of Physical Evidence 70

The Significance of Physical Evidence 72

Forensic Databases 79

Crime Scene Reconstruction 83

Chapter Summary 84

Review Questions 86

Further References 86

Chapter 4

Physical Properties: Glass and Soil 98

The Metric System 100

Physical Properties 102

Comparing Glass Fragments 109

Glass Fractures 116

Collection and Preservation of Glass Evidence 118

Forensic Characteristics of Soil 119

Collection and Preservation of Soil Evidence 122

Chapter Summary 123

Review Questions 124

Further References 125

Chapter 5

Organic Analysis 126

Elements and Compounds 128

Selecting an Analytical Technique 132

Chromatography 133

Spectrophotometry 144

Mass Spectrometry 150

Chapter Summary 154

Review Questions 155

Further References 157

Chapter 6

Inorganic Analysis 158

Evidence in the Assassination of President Kennedy 162

The Emission Spectrum of Elements 164

Atomic Absorption Spectrophotometer 167

The Origin of Emission and Absorption Spectra 169

Neutron Activation Analysis 171

X-Ray Diffraction 174

Chapter Summary 175

Review Questions 176

Further References 177

Chapter 7

The Microscope 178

The Compound Microscope 182

The Comparison Microscope 184

The Stereoscopic Microscope 186

The Polarizing Microscope 188

The Microspectrophotometer 189

The Scanning Electron Microscope (SEM) 192

Chapter Summary 195

Review Questions 196

Further References 197

Case Study: Microscopic Trace Evidence—The Overlooked Clue 198

Chapter 8

Hairs, Fibers, and Paint 206

Morphology of Hair 208

Identification and Comparison of Hair 212

Collection and Preservation of Hair Evidence 218

Types of Fibers 219

Identification and Comparison of Manufactured Fibers 224

Collection and Preservation of Fiber Evidence 231

Forensic Examination of Paint 232

Collection and Preservation of Paint Evidence 239

Chapter Summary 242

Review Questions 243

Further References 245

Chapter 9

Drugs 246

Drug Dependence 248

Narcotic Drugs 251

Hallucinogens 254

Depressants 259

Stimulants 260

Club Drugs 263

Anabolic Steroids 264

Drug-Control Laws 265

Drug Identification 268

Collection and Preservation of Drug Evidence 273

Chapter Summary 274

Review Questions 275

Further References 277

Chapter 10

Forensic Toxicology 278

Toxicology of Alcohol 281

The Role of the Toxicologist 297

Techniques Used in Toxicology 298

The Significance of Toxicological Findings 302

The Drug Recognition Expert 303

Chapter Summary 306

Review Questions 307

Further References 309

Chapter 11

Forensic Aspects of Arson and Explosion Investigations 310

The Chemistry of Fire 312

Searching the Fire Scene 318

Collection and Preservation of Arson Evidence 321

Analysis of Flammable Residues 323

Types of Explosives 327

Collection and Analysis of Explosives 332

Chapter Summary 340

Review Questions 341

Further References 342

Chapter 12

Forensic Serology 344

The Nature of Blood 347

Immunoassay Techniques 350

Forensic Characterization of Bloodstains 352

Stain Patterns of Blood 359

Principles of Heredity 364

Forensic Characterization of Semen 367

Collection of Rape Evidence 371

Chapter Summary 376

Review Questions 377

Further References 379

Chapter 13

DNA: The Indispensable Forensic Science Tool 380

What Is DNA? 382

DNA at Work 385

Replication of DNA 387

Recombinant DNA: Cutting and Splicing DNA 388

DNA Typing 390

Mitochondrial DNA 403

The Combined DNA Index System (CODIS) 410

Collection and Preservation of Biological Evidence for DNA Analysis 411

Chapter Summary 417

Review Questions 418

Further References 420

Case Study: The Forensic Community's Response to September 11 421

Chapter 14

Fingerprints 426

History of Fingerprinting 428

Fundamental Principles of Fingerprints 430

Classification of Fingerprints 435

Automated Fingerprint Identification Systems 436

Methods of Detecting Fingerprints 440

Preservation of Developed Prints 451

Digital Imaging for Fingerprint Enhancement 452

Chapter Summary 454

Review Questions 455

Further References 457

Chapter 15

Firearms, Tool Marks, and Other Impressions 458

Bullet Comparisons 460

Cartridge Cases 467

Automated Firearms Search Systems 468

Gunpowder Residues 471

Primer Residues on the Hands 475

Serial Number Restoration 478

Collection and Preservation of Firearms Evidence 479

Tool Marks 481

Other Impressions 484

Chapter Summary 492

Review Questions 493

Further References 494

Chapter 16

Document and Voice Examination 496

Handwriting Comparisons 498

Collection of Handwriting Exemplars 501

Typescript Comparisons 502

Photocopier, Printer, and Fax Examination 504

Alterations, Erasures, and Obliterations 505

Other Document Problems 510

Voice Examination 515

Chapter Summary 519

Review Questions 520

Further References 521

Chapter 17

Computer Forensics BY ANDREW W. DONOFRIO 522

From Input to Output: How Does the Computer Work? 525

Putting It All Together 529

How Data Is Stored 530

Processing the Electronic Crime Scene 532

Evidentiary Data 536

Chapter Summary 544

Review Questions 544

Further References 545

Case Study 1: Computer Forensic Analysis Answers the Question “Arson or Accident?” 546

Case Study 2: Counterfeiting and Fraud: A Forensic Computer Investigation 548

Chapter 18

Forensic Science and the Internet 550

What Is the Internet? 552

Where to Go on the Internet 555

Exploring Forensic Science on the World Wide Web 561

Websites You May Wish to Explore 563

Forensic Analysis of Internet Data 564

Forensic Investigation of Internet Communications 566

Hacking 569

Chapter Summary 570

Review Questions 571

Further References 571

Chapter 19

The Future 572

CASE READINGS 581

APPENDIXES

I Guides to the Collection of Physical Evidence—FBI 611

II Instructions for Collecting Gunshot Residue (GSR) 627

*III Chromatographic and Spectrophotometric Parameters for Figures Contained in the
Text 627*

IV Chemical Formulas for Latent Fingerprint Development 630

V Chemical Formulas for Development of Footwear Impressions in Blood 635

ANSWERS 639

INDEX 643

PHOTO CREDITS 653

Preface

The ninth edition of *Criminalistics* has a new look. Wider margins along with color photographs and figures have been incorporated into the book's design. A new chapter on computer forensics

has been added. What has not changed is the basic aim of the book: to make the subject of forensic science 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 are curious about the subject's underpinnings. Many readers of this book have been drawn to the subject by the assortment of television shows that are based on it. Story lines depicting the crime-solving abilities of forensic scientists have excited the imagination of the general public. 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 awesome. But one cannot lose sight of the fact that, once one puts aside all the drama of a forensic science case, what remains is an academic subject emphasizing logic and technology. It is to this end that the ninth edition of *Criminalistics* is dedicated.

Criminalistics strives to make the technology of the modern crime laboratory clear and comprehensible to the nonscientist. The nature of physical evidence is defined, and the limitations that technology and current knowledge impose on its individualization and characterization are examined. By combining case stories with applicable technology, *Criminalistics* endeavors to capture the pulse and fervor of forensic science investigations.

One of the constants of forensic science is how frequently its applications become front-page news. Whether the story is of sniper shootings or the tragic consequences of the terrorist attacks of September 11, 2001, forensic science is at the forefront of the public response. The horror of the terrorist attacks exemplified the critical role DNA has come to play in identifying victims of mass disaster. In this new century, the science of 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. The criminal justice system is creating vast DNA data banks designed to snare the criminal who is unaware of the consequence of leaving the minutest quantity of biological material behind at a crime scene.

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, all became the subject of study, commentary, and conjecture.

For those of us 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 amply demonstrates how intertwined criminal investigation has become with forensic science. Through nine editions, *Criminalistics* has striven 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.

Like all facets of modern life, forensic science has been touched by the computer and the Internet. This new edition introduces the reader to basic computer technologies and concepts relied on during the forensic investigation of crimes. Retrieval of computerized information thought to be lost or erased is explored, as is the investigation of hacking incidents. Exploration of web sites particularly relevant to forensic science and criminal investigation is emphasized.

A major portion of the text centers on discussions of the common items of physical evidence encountered at crime scenes. These chapters include descriptions of forensic analysis, as well as updated techniques for the proper collection and preservation of evidence at crime scenes. Particular attention is paid to the meaning and role of probability in interpreting the evidential significance of scientifically evaluated evidence.

The implications of DNA profiling are important enough to warrant their inclusion in a separate chapter in *Criminalistics*. The topic of DNA is described 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, the chapter explains the process of DNA typing and illustrates its application to criminal investigations through the presentation of actual case histories.

The content of *Criminalistics* is a reflection of the author's experience both as an active forensic scientist and as an instructor of forensic science at the college level. No prior knowledge of scientific principles or techniques is assumed of the reader. 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 will make the subject matter comprehensible and meaningful to the nonscientist. Although it is not the intent of this book to make scientists or forensic experts of readers, it will certainly be gratifying if the book motivates some students to seek further scientific knowledge and perhaps direct their education toward a career 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, its subject matter is not limited to the college student. Optimum utilization of crime laboratory services requires that criminal investigators

have a knowledge of the techniques and capabilities of the laboratory that extends beyond any summary that may be gleaned from departmental brochures dealing with the collection and packaging of physical evidence. Only by combining a knowledge of the principles and techniques of forensic science with logic and common sense will the investigator 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” among lawyers, judges, and the forensic scientist. An intelligent evaluation of the scientist’s data and any subsequent testimony again depends 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, a number of 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.

Acknowledgments

I am most appreciative of the contribution that Detective Sergeant Andrew (Drew) Donofrio of New Jersey’s Bergen County Prosecutor’s Office 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.

Sarah A. Skorupsky-Borg, MSFS, invested an extraordinary amount of time and effort in preparing an accompanying supplement to this edition: *Basic Laboratory Exercises for Forensic Science*. Her skills and tenacity in carrying out this task are acknowledged and greatly appreciated.

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, Raymond Murray, and Richard Tidey. In addition, I would like to acknowledge the contributions of Jeffrey C. Kercheval, Robert Thompson, Roger Ely, Jose R. Almirall, Darlene Brezinski, Michael Malone, and Ray Feldherr.

The following reviewers provided insightful reviews and suggestions on this new edition: Professor John Kavanagh, Scottsdale Community College, Scottsdale, AZ; Professor Suzanne Montiel, Nash Community College, Rocky Mount, NC; Professor Walter F. Rowe; George Washington University; Washington, D.C.; Professor David Tate, Purdue University, West Lafayette, IN; and Professor Sue Salem, Washburn University, Topeka, KS.

The assistance of Pamela Cook and Gonul Turhan, whose research efforts are an integral part of this text, was invaluable. I am also appreciative of the time and talent given by Peggy Cole; development editor Mayda Bosco; and production editor Linda Zuk.

I am grateful to the law enforcement agencies, government 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 twenty-one 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 ninth 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 currently teaches a course on the role of the expert witness in the courtroom at the law school of Widener University in Wilmington, Delaware. He has authored or co-authored more than forty-two technical papers covering a variety of forensic topics. Dr. Saferstein has co-authored *Lab Manual for Criminalistics* (Prentice Hall, 2004). He has also edited the widely used professional reference books *Forensic Science Handbook*, Volume 1, 2nd edition (Prentice Hall, 2002), *Forensic Science Handbook*, Volume 2, 2nd edition (Prentice Hall, 2005), and *Forensic Science Handbook*, Volume 3 (Prentice Hall, 1993). Dr. Saferstein is a member of the American Chemical Society, the American Academy of Forensic Sciences, the Forensic Science Society of England, the Canadian Society of Forensic Scientists, the International Association for Identification, the Mid-Atlantic Association of Forensic Scientists, the Northeastern Association of Forensic Scientists, the Northwestern Association of Forensic Scientists, and the Society of Forensic Toxicologists.

In 2006, Dr. Saferstein received the American Academy of Forensic Sciences Paul L. Kirk award for distinguished service and contributions to the field of criminalistics.

CRIMINALISTICS