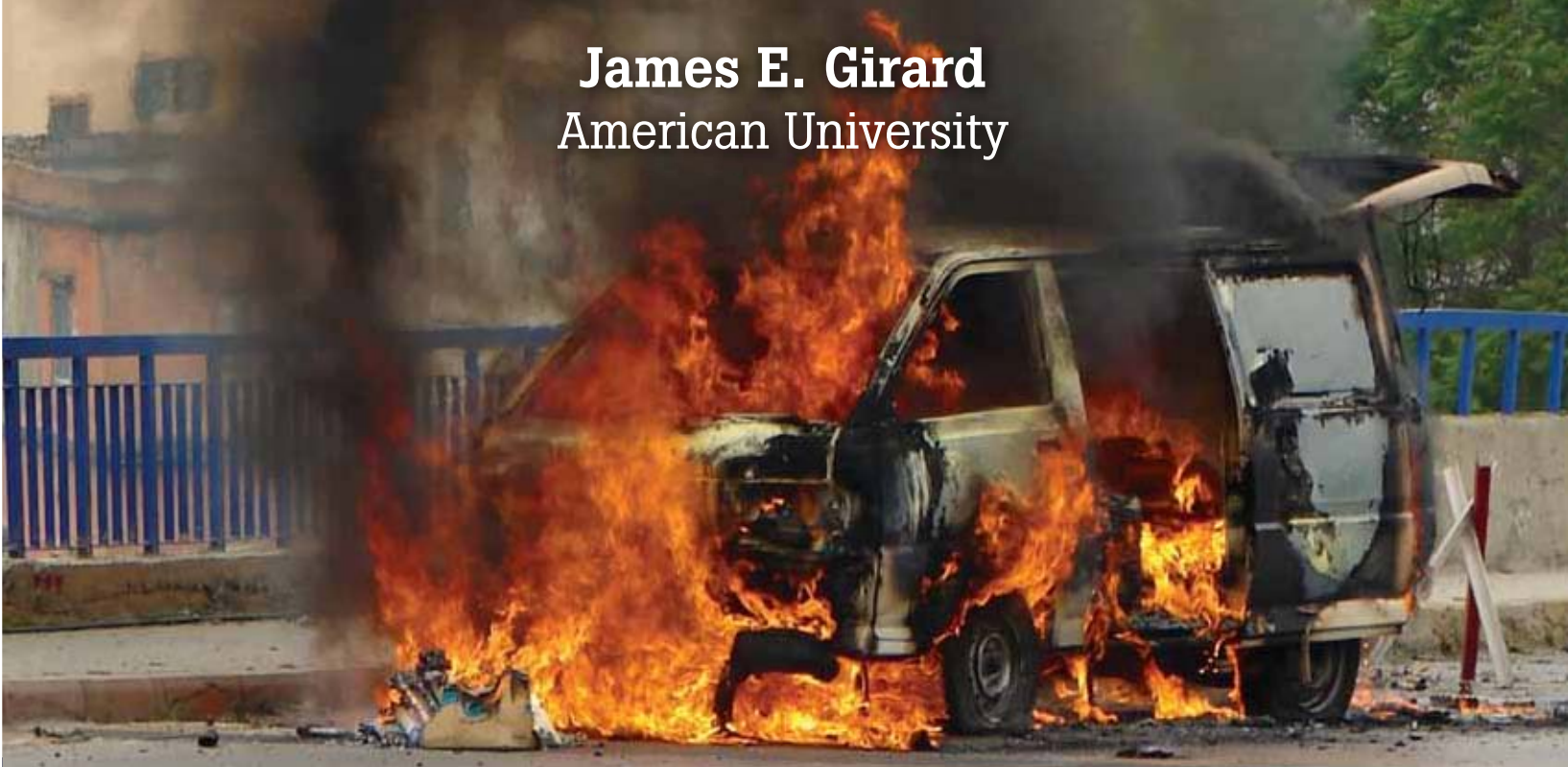


SECOND EDITION

Criminalistics

Forensic Science, Crime, and Terrorism

James E. Girard
American University



© Jones & Bartlett Learning, LLC. NOT FOR SALE OR DISTRIBUTION.



World Headquarters

Jones and Bartlett Publishers
40 Tall Pine Drive
Sudbury, MA 01776
978-443-5000
info@jbpub.com
www.jbpub.com

Jones and Bartlett Publishers
Canada
6339 Ormindale Way
Mississauga, Ontario L5V 1J2
Canada

Jones and Bartlett Publishers
International
Barb House, Barb Mews
London W6 7PA
United Kingdom

Jones and Bartlett's books and products are available through most bookstores and online booksellers. To contact Jones and Bartlett Publishers directly, call 800-832-0034, fax 978-443-8000, or visit our website, www.jbpub.com.

Substantial discounts on bulk quantities of Jones and Bartlett's publications are available to corporations, professional associations, and other qualified organizations. For details and specific discount information, contact the special sales department at Jones and Bartlett via the above contact information or send an email to specialsales@jbpub.com.

Copyright © 2011 by Jones and Bartlett Publishers, LLC

All rights reserved. No part of the material protected by this copyright may be reproduced or utilized in any form, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without written permission from the copyright owner.

This publication is designed to provide accurate and authoritative information in regard to the Subject Matter covered. It is sold with the understanding that the publisher is not engaged in rendering legal, accounting, or other professional service. If legal advice or other expert assistance is required, the service of a competent professional person should be sought.

Production Credits

Chief Executive Officer: Ty Field
Chief Operating Officer: Don W. Jones, Jr.
President: James Homer
Chairman of the Board: Clayton Jones
V.P., Design and Production: Anne Spencer
V.P., Manufacturing and Inventory Control: Therese Connell
Publisher, Higher Education: Cathleen Sether
Acquisitions Editor: Sean Connelly
Associate Editor: Megan R. Turner
Associate Production Editor: Jessica Steele Newfell
Associate Production Editor: Sarah Bayle
Associate Marketing Manager: Jessica Cormier
Composition: Publishers' Design and Production Services, Inc.
Cover Design: Scott Moden
Assistant Photo Researcher: Carolyn Arcabascio
Cover Image: © to come
Printing and Binding: Courier Kendallville
Cover Printing: Courier Kendallville

Library of Congress Cataloging-in-Publication Data

Girard, James.

Criminalistics : forensic science, crime, and terrorism / James E. Girard.—2nd edition
p. cm.

Includes index.

ISBN 978-0-7637-7731-9 (casebound : alk. paper)

1. Forensic sciences. 2. Criminal Investigation. I. Title

HV8073.G564 2011

363.25'62—dc22

6048

Printed in the United States of America

14 13 12 11 10 10 9 8 7 6 5 4 3 2 1

Dedicated to all my children and grandchildren.

Brief Contents

SECTION 1

Introduction to Criminalistics	3
CHAPTER 1 Investigating the Crime Scene.....	5
CHAPTER 2 Investigating and Processing Physical Evidence	31

SECTION 2

Trace Evidence	57
CHAPTER 3 Physical Properties: Forensic Characterization of Soil.....	59
CHAPTER 4 The Microscope and Forensic Identification of Hair, Fibers, and Paint.....	79
CHAPTER 5 Forensic Analysis of Glass	111

SECTION 3

Pattern Evidence	131
CHAPTER 6 Fingerprints	133
CHAPTER 7 Questioned Documents.....	161
CHAPTER 8 Firearms	187

SECTION 4

Chemical Evidence	211
-------------------------	-----

CHAPTER 9	Inorganic Analysis: Forensic Determination of Metals and Gunshot Residue	213
CHAPTER 10	Arson	245
CHAPTER 11	Drugs of Abuse	269
SECTION 5		
	Biological Evidence.....	303
CHAPTER 12	Forensic Toxicology.....	305
CHAPTER 13	Biological Fluids: Blood, Semen, Saliva, and an Introduction to DNA	329
CHAPTER 14	Forensic DNA Typing.....	357
SECTION 6		
	Terrorism.....	389
CHAPTER 15	Computer Forensics, Cybercrime, and Cyberterrorism	391
CHAPTER 16	Explosives	415
CHAPTER 17	Detecting Weapons of Mass Destruction	443
APPENDIX A		
	Forensic Science Resources	467
APPENDIX B		
	Measurement and the International System of Units (SI)	471

Contents

Resource Review	00
Preface	00
Organization	xiii
Course Use	xiv
Acknowledgments	00

SECTION 1

Introduction to Criminalistics	3
--------------------------------------	---

CHAPTER 1

Investigating the Crime Scene	5
Introduction	6
Securing the Crime Scene	6
Identifying, Establishing, Protecting, and Securing the Boundaries	6
Documenting the Scene and the Evidence ..	8
Note Taking	8
Photography	9
Sketching	10
Videography	12
Systematic Search for Evidence	13
Recognition of Physical Evidence	14
Collection, Preservation, Inventory, and Transportation of Physical Evidence	15
Types of Evidence	15
Packaging Evidence	17
Submitting Evidence to the Crime Laboratory	18
Chain of Custody	19

Criminal Evidence and the Fourth Amendment	19
Exceptions to the Fourth Amendment	20
The Supreme Court and the Fourth Amendment ..	21
Conclusion	23

CHAPTER 2

Investigating and Processing Physical Evidence	31
Introduction	32
Types of Evidence	32
The Modern Crime Lab	33
National Laboratories	34
State and Municipal Laboratories	35
Divisions of the Crime Lab	35
Functions of a Forensic Scientist	36
Additional Information	36
State of the Evidence	37
Why Examine Physical Evidence?	38
Characteristics of Physical Evidence	38
Identification	38
Associative Evidence	39
Crime Scene Reconstruction	43
Pattern Evidence	44
Explosion Patterns	44
Firearm Ballistics	44
Entry and Exit Hole Geometry	44
Bullet Trajectory	44
Bullet Ricochet	45
Shell Casings	45
Bloodstain Patterns	45

Point of Convergence	47
Physical Evidence in Court	49
Expert Testimony	50

SECTION 2

Trace Evidence	57
-----------------------------	-----------

CHAPTER 3

Physical Properties: Forensic Characterization of Soil..... 59

Introduction	60
Physical and Chemical Properties	60
The Metric System	61
The International System of Units.....	62
SI Base Units	62
Conversion from the SI to the English System (and Vice Versa)	63
Mass and Weight	64
Temperature.....	64
Density.....	66
Soils	67
Forensic Characteristics of Soils	68
Gradient Tube Separation of Soil: Separation by Density	70
Collection and Preservation of Soil Evidence	71

CHAPTER 4

The Microscope and Forensic Identification of Hair, Fibers, and Paint..... 79

Introduction	80
Magnifying Small Details	80
Refraction	80
Types of Microscopes	81
Compound Microscopes	83
Comparison Microscopes	85
Stereoscopic Microscopes	85
Polarizing Microscopes	86
Microspectrophotometers	88
Scanning Electron Microscopes.....	89
Forensic Applications of Microscopy:	
Hair	90
Hair Morphology.....	90
Hair Growth.....	92
Comparison of Hair by Microscopy	93
Collecting Hair Evidence.....	93
Information Obtained by Microscopic Comparison of Hair.....	93

Forensic Applications of Microscopy:

Fibers	94
Natural Fibers	94
Synthetic Fibers.....	97
Paint	101
Automobile Paint.....	101
Collection of Paint Evidence	102
Forensic Analysis of Paint	102

CHAPTER 5

Forensic Analysis of Glass 111

Introduction	112
Types of Glass	112
Tempered Glass	113
Windshield Glass.....	113
Forensic Examination of Glass Evidence:	
An Overview	114
Non-Optical Physical Properties of Glass	115
Surface Striations and Markings	115
Surface Contaminants	115
Thickness.....	115
Hardness	115
Glass Fractures	116
Characteristics of Glass Fractures.....	116
Forensic Examination of Glass Fractures	117
Glass Density Tests	118
Optical Physical Properties of Glass	119
Color	119
Refractive Index.....	119
Refractive Index of Tempered versus Nontempered Glass.....	122
Variations in Density and Refractive Index.....	123
Elemental Analysis of Glass.....	124

SECTION 3

Pattern Evidence	131
-------------------------------	------------

CHAPTER 6

Fingerprints 133

Introduction	134
History of Fingerprinting	134
Characteristics of Fingerprints	137
Uniqueness of Fingerprints.....	137
Permanence of Fingerprints	138
Fingerprint Patterns.....	139
Fingerprint Identification Points.....	140
Methods for Developing Fingerprints	140
Recovering Fingerprints from Hard and Nonabsorbent Surfaces	142

Recovering Fingerprints from Soft and Porous Surfaces	143
Preservation of Fingerprints	145
Photography of Fingerprints: An Overview	145
Digital Imaging of Fingerprints	148
Classification of Fingerprints	149
Primary Classification	149
Automated Fingerprint Identification System	150
Fingerprints for Biometric Identification	151
Finger Scanning	151
Biometrics-Related Issues	153

CHAPTER 7

Questioned Documents	161
Introduction	162
Handwriting	163
Development of Handwriting	164
Comparison of Handwriting	164
Collection of Handwriting Exemplars	166
Signatures	166
Erasures, Obliterations, and Alterations	168
Optical Analysis of Ink	169
Optical Analysis of Concealed Information	169
Chemical Analysis of Ink	170
Indented Writing	170
Typed and Word-Processed Documents	171
Photocopied Documents	173
Paper	174
Nondestructive Tests for Paper	174
Destructive Tests for Paper	174
Security Printing	175
Currency	175
Canadian Currency	176
Identity Documents	177
Use of Biometrics for Identity Authentication	178
US-VISIT	178
Testimony of Document Examiners	179

CHAPTER 8

Firearms	187
Introduction	188
Firearm Accuracy	188
Increasing the Force of the Bullet	191
Improving the Rate of Firing and Firing Reliability	191
Handguns	192
Revolvers	192
Semiautomatic Pistols	192

Silencers	194
Submachine Guns	194
Rifles	194
Shotguns	195
Ammunition	195
Cartridges	196
Shotgun Ammunition	198
Ballistics	198
Collection and Preservation of Firearm Evidence	199
Collection and Preservation of Firearms	199
Serial Number Restoration	200
Collection and Preservation of Ammunition	201
Laboratory Examination of Firearm Evidence	201
Laboratory Examination of Fired Bullets	202
Automated Ballistics Comparisons	203
Laboratory Examination of Expended Cartridges	204

SECTION 4

Chemical Evidence	211
------------------------------------	------------

CHAPTER 9

Inorganic Analysis: Forensic Determination of Metals and Gunshot Residue	213
Introduction	214
Elements and Compounds	214
Elements and Molecules	216
Physical Properties of Inorganic Substances	217
Elements and Subatomic Particles	218
Atomic Number	219
Periodic Table	219
Periods and Groups	219
Metals and Nonmetals	221
Techniques for the Analysis of Inorganic Materials	221
Electromagnetic Radiation and Spectra	222
Electron Configuration and the Periodic Table	226
Forensic Determination of Metals	229
Atomic Spectroscopy	229
Inductively Coupled Plasma Optical Emission Spectroscopy	229
Determining the Elemental Composition of Glass by ICP-OES	231
X-Ray Fluorescence Spectrometry	232

Gunpowder Residue	233
Composition of Gunshot Residue	233
Detection of Gunshot Residue	233
Gunpowder Residue: Greiss Test	237

CHAPTER 10

Arson	245
Introduction	246
Oxidation: The Heart of Fire	246
Chemical Reactions: What Makes Them Happen?	247
Spontaneous Reactions	247
Getting a Reaction Started	247
Factors That Influence the Intensity of a Fire	248
The Effect of Temperature	248
The Effect of Concentration	249
The Sequence of Events During a Fire	249
Incipient Stage	249
Free-Burning Stage	250
Smoldering Stage	250
Hydrocarbon Accelerants	250
Hydrocarbons	250
The Composition of Petroleum	252
Refining Petroleum	253
Determining the Origin and Cause of a Fire	254
Burn Patterns	255
Burn Pattern Geometry	257
Melting of Materials	258
Discolored Metals	258
Indicators of Arson	258
Charring of Floor Surfaces	258
Containers	259
Odors	259
Collection and Preservation of Arson Evidence	260
Analysis of Flammable Residue	260
Heated Headspace Sampling	260
Passive Headspace Diffusion (Charcoal Sampling)	260
Solid-Phase Microextraction	261
Gas Chromatography	261

CHAPTER 11

Drugs of Abuse	269
Introduction	270
History of Drug Regulation	270
Drug Control Laws	271

The Comprehensive Drug Abuse Prevention and Control Act of 1970	272
Drug Dependence	274
Commonly Abused Drugs	274
Narcotics	274
Why Opiates Work	275
Morphine and Codeine	277
Heroin	277
Methadone	278
OxyContin	279
Hallucinogens	279
Marijuana	279
Mescaline	282
Lysergic Acid Diethylamide	282
Phencyclidine	283
Methylenedioxymethamphetamine (Ecstasy)	283
Depressants	284
Ethyl Alcohol	284
Barbiturates	284
Stimulants	285
Amphetamines	285
Cocaine	287
Inhalants	287
Club Drugs	288
Anabolic Steroids	288
Identifying Compounds in Evidence Samples Suspected of Containing Controlled Substances	289
Principles of Drug Analysis	289
Presumptive Tests	290
Confirmatory Tests	293
Tracking Drug Distribution: CISPA	295
Personal Testing for Drugs of Abuse	296

SECTION 5

Biological Evidence	303
--------------------------------------	------------

CHAPTER 12

Forensic Toxicology	305
Introduction	306
Postmortem Toxicology	306
Collection of Postmortem Specimens	306
Analysis of Toxicology Specimens	308
Interpretation of Toxicological Information	309
Human Performance Testing	310
Field Sobriety Testing	310
BAC Levels	311
Alcohol and the Law	311
Alcohol Metabolism	313
Absorption of Alcohol into the Body	313

Elimination of Alcohol by Oxidation– Reduction Reactions	314
Measurement of Blood Alcohol	
Concentration	315
Estimating the BAC from Absorption– Elimination Data	315
Estimating the Amount of Alcohol in the Circulatory System	316
Breath Tests for Alcohol	317
Breathalyzer	317
Intoxilyzer	318
Alcosensor	319
Blood Tests for Alcohol	320
Collection and Preservation of Blood	321
Gas Chromatography Analysis of BAC	321
Noninvasive Alcohol Testing	322

CHAPTER 13

Biological Fluids: Blood, Semen, Saliva, and an Introduction to DNA 329

Introduction	330
Blood	331
Tests for the Presence of Blood	332
Presumptive Tests for Blood	332
Serological Tests for Blood	332
Serological Blood Typing	335
Forensic Characterization of Saliva	337
Forensic Characterization of Semen	337
Rape Evidence Collection	338
Principles of Paternity	340
Introduction to DNA	341
Functions of Nucleic Acids	341
Structure of Nucleic Acids	342
The Double Helix	343
DNA, Genes, and Chromosomes	343
Cell Replication	344
Protein Synthesis	345
The Genetic Code	347
Nuclear DNA and the Law	349
Mitochondrial DNA	350

CHAPTER 14

Forensic DNA Typing 357

Introduction	358
Restriction Fragment Length Polymorphisms	359
Polymerase Chain Reaction: A DNA Copy Machine	360
Short Tandem Repeats	363

DNA Sequence Variations Among Individuals	364
Inheritance of Alleles	365
Analyzing the STR by Electrophoresis	365
Gel Electrophoresis	365
Capillary Electrophoresis	368
Multiplex DNA Analysis	371
Multiplexing by Size	371
Multiplexing by Dye Color	371
Multiplexing with Multiple Capillaries	372
Forensic STRs	372
CODIS	374
Interpretation of DNA Profiles	376
Simple Population Genetics	376
Interpreting Multiplex DNA Profiles	378
Paternity Testing	378
Mitochondrial DNA Analysis	380
The Y Chromosome: STRs and SNPs	383
Low-Copy-Number DNA Typing	383

SECTION 6

Terrorism 389

CHAPTER 15

Computer Forensics, Cybercrime, and Cyberterrorism 391

Introduction	392
Personal Computer	394
Central Processing Unit (CPU)	394
Read-Only Memory (ROM)	394
Random-Access Memory (RAM)	395
How Data Is Stored: The Hard Disk Drive (HDD)	396
The Electronic Crime Scene	397
Electronic Equipment and the Fourth Amendment	397
Cybercrime	397
Cyberspace and Cyberterrorism	398
Electric Power Grid	398
Other Cybercrimes	399
How Cybercrime Changes the Picture	400
Processing the Crime Scene	401
Processing the Physical Crime Scene	401
Processing the Electronic Crime Scene	403
Acquiring an Electronic Image of the Crime Scene: The Hard Drive	404
Forensic Examination of Computer Devices	404
Copying the Hard Disk Drive	404
Analyzing Digital Evidence	406

Forensic Electronic Toolkits	407
E-Evidence Collection Process	407
File Slack	407
Deleted Files	409

CHAPTER 16

Explosives	415
Introduction	416
Explosions	416
Types of Explosives	418
Low Explosives	418
High Explosives	419
Commercial Explosives	419
Dynamite	419
Ammonium Nitrate/Fuel Oil	420
Military Explosives	420
TNT	420
RDX	421
HMX	421
Improvised Explosives	421
Low-Explosive IEDs	422
High-Explosive IEDs	422
Initiators	422
Safety Fuses	422
Electric Matches	423
Detonators	423
Collection of Explosive-Related Evidence	423
Field Tests for Explosive Residue	425
Laboratory Analysis of Explosives and Explosive Residues	428
Thin-Layer Chromatography	429
Gas Chromatography	429
Infrared Tests	431
Analysis of Inorganic Explosive Residues	432
Ion Chromatography	433
Taggants	434

CHAPTER 17

Detecting Weapons of Mass Destruction	443
Introduction	444
Chemical Warfare Agents	445
Choking Agents	445
Blister Agents	445
Blood Agents	446
Irritating Agents	446
Incapacitating Agents	446
Nerve Agents	446
Toxic Industrial Chemicals and Materials	448

Detection of Chemical Warfare Agents and Toxic Industrial Materials	448
Point Detection Technologies	448
Analytical Instruments	450
Standoff Detectors	451
Nuclear Weapons	452
Nuclear Radiation	452
Penetrating Power and Speed of Radiation	452
Nuclear Reactions	453
Radioisotope Half-life	453
The Harmful Effects of Radiation on Humans	454
Why Is Radiation Harmful?	454
Factors Influencing Radiation Damage	454
Units of Radiation	455
Detection of Radiation	455
Biological Weapons	455
Government Efforts to Thwart Bioterrorism	457
Detection of Biological Agents	458

APPENDIX A

Forensic Science Resources	467
Professional Organizations	467
Federal Forensic Laboratories	468
Non-Government Forensic Testing Laboratories	468
DNA	468
Fingerprints	469

APPENDIX B

Measurement and the International System of Units (SI)	471
The International System of Units (SI)	471
Base Units	472
Prefixes	472
Derived SI Units	472
Conversions Within the SI	473
Conversions from the SI to the English System and Vice Versa	473
Useful Approximations Between SI and English Units	474
Other Commonly Used Units of Measurement	474
Temperature	474
Conversions Between °C and °F	475
Energy	475
The Difference Between Mass and Weight	475
Problems	475
Glossary	477

Resource Preview

OBJECTIVES

In this chapter you should gain an understanding of:

- The characteristics that permit fingerprints to be used for personal identification
- Methods used to develop latent fingerprints
- Methods used to visualize fingerprints
- The classification of fingerprints
- The use of fingerprints for biometric identification



Fingerprints

CHAPTER

6

OBJECTIVES

In this chapter you should gain an understanding of:

- The characteristics that permit fingerprints to be used for personal identification
- Methods used to develop latent fingerprints
- Methods used to visualize fingerprints
- The classification of fingerprints
- The use of fingerprints for biometric identification

FEATURES

[On the Crime Scene](#)

[Back at the Crime Lab](#)

[See You in Court](#)

WRAP UP

[Chapter Spotlight](#)

[Key Terms](#)

[Putting It All Together](#)



YOU ARE THE FORENSIC SCIENTIST

As mentioned in Chapter 1, the smallest objects found as evidence are referred to as *trace evidence*. These objects (i.e., fibers, glass fragments, gunshot residue) are so easily transferred from one individual to another that they may provide evidence of association between a suspect and the victim. Because they are so readily transferred, investigators must take great care to avoid losing or cross-contaminating this evidence.

Usually trace evidence is transferred from one object to another in a process referred to as *direct transfer*. On other occasions, trace evidence is transferred from one object to another by way of an intermediate object, in a process known as *secondary transfer*. It is also possible that two or more intermediate objects may be involved in secondary transfer.

It is important that investigators consider the possibility of secondary transfer whenever they examine trace evidence. Consider the following trace evidence, which was found at the scene of a murder. In the victim's room, where the murder occurred, there is a fabric-covered chair. The suspect's jacket and sweater are seized from his apartment and examined for fiber evidence. The chair has fibers on it that match fibers from the jacket and the sweater. The jacket has fibers from the chair. The sweater does not have fibers from the chair on it.

1. Explain how the fibers might have been transferred.
2. Does this evidence prove that the suspect was in the victim's room more than once?

Introduction

Physical evidence is merely one piece of the puzzle when investigators are trying to solve a case. In some types of crimes (e.g., homicide, sexual assault), it may be the most important factor in proving the link between the suspect and the victim. Physical evidence may also be essential to prove that the same suspect is linked to a series of incidents. In other cases, the implications of the physical evidence must be confirmed by the testimony of witnesses and/or the confession of the suspect to warrant a conviction. This chapter describes how physical evidence is identified, classified, and then presented to a court of law.

Types of Evidence

Four types of evidence are distinguished: testimony, physical, documentary, and demonstrative (TABLE 2-1). The most common types of physical evidence are listed in TABLE 2-2. Because a crime scene tends to include so many physical items, it is impractical to treat each and every object that is encountered as evidence. Nevertheless, it is extremely important to identify those items that might provide significant probative information related to the crime. To do so, experienced investigators

TABLE 2-1

Types of Evidence		
Type	Definition	Example
Physical evidence	Tangible objects that are real, direct, and not circumstantial	A weapon used to commit a crime; trace evidence found at the crime scene (e.g., blood, hair, fibers)
Documentary evidence	Any kind of writing, sound, or video recording; its validity is usually authenticated by expert testimony	A transcript of a recorded telephone conversation
Demonstrative evidence	Real evidence used to illustrate, demonstrate, or recreate a prior event	A cardboard model of the crime scene
Testimony	Evidence in the form of witnesses speaking under oath in court	Eyewitnesses; hearsay witnesses; character witnesses

You are the Forensic Scientist: Realistic case studies and accompanying discussion questions challenge readers to think like a practicing forensic scientist.

scans recorded earlier at the embassy abroad. If the two finger scans match, the visitor is allowed to enter the country. In addition, US-VISIT uses a biometric digital photograph of the individual's face that is matched by a federal agent at the border crossing.

The index finger scanning system included in US-VISIT has been criticized because it is not linked to the Federal Bureau of Investigation (FBI) fingerprint files or the government terrorist watch list file. Both of these databases rely on state-of-the-art, 10-fingerprint systems, rather than just fingerprints taken from the two index fingers. In addition, the discrepancy in the number of fingerprints found in the IDENT and FBI databases are striking. The IDENT database contains fingerprints for 15,000 suspected terrorists and their alleged associates and about 1 million known criminals or deportees overall; the FBI fingerprint database contains data for 47 million people. According to the U.S. Justice Department, Homeland Security officials expected to check about 800 people out of the roughly 118,000 visitors a day who should be screened against the FBI database in 2006. The failure to check visitors' information against the much more extensive FBI database suggests that the US-VISIT program might inadvertently allow terrorists to slip into the United States.

Testimony of Document Examiners

Testimony from document examiners has been accepted by the courts for almost 100 years. In 1989, however, three law school professors—D. Michael Risinger, Mark P. Denbeaux, and Michael J. Saks—wrote an article challenging the use of expert handwriting testimony. These authors argued that documentation examination had an unacceptably high error rate and that no evidence had ever been

presented proving that trained document examiners would make fewer errors when examining documents than would nonexperts. This article had an immediate effect, prompting courts to subject expert document testimony to more scrutiny and defense attorneys to more aggressively challenge expert document testimony. In a 1995 case, *United States v. Starzecpzel*, the court ruled that the document examiner provides technical—rather than scientific—testimony. This decision marked a major turning point in how expert document testimony was viewed under the Federal Rules of Evidence.

A subsequent study of the proficiency of document examiners was published in 1997 (Kam, Fielding, & Conn, 1997). It revealed that when trained document examiners were compared with nonexperts in terms of their proficiency in handwriting identification, the experts erred only 6.5% of the time, whereas the error rate for nonexperts was 38.3%. The nonexperts mistakenly matched handwriting samples at a rate more than 5 times higher than the experts did. In 2001, another study by the same authors found that when examining false signatures, trained document examiners had an error rate of less than 1%, whereas nonexperts had an error rate greater than 6% (Kam, Fielding, & Conn, 2001). Thus, both studies demonstrated that trained document examiners possess skills that exceed those of nonexperts.

In 1999, the U.S. Court of Appeals for the 11th Circuit upheld a ruling in *United States v. Paul* that had admitted expert handwriting testimony. In addition, it upheld the lower court's decision to exclude the testimony of Mark Denbeaux, who had attempted to be qualified as a document expert. The court ruled that Denbeaux's education and training as a lawyer did not qualify him to testify about the reliability of handwriting examination because he had no specific training or education in handwriting examination.



BACK AT THE CRIME LAB

Questioned document examination often involves studying obliterated writing. Examiners must take care with this type of evidence to ensure that the sample is not further altered or destroyed.

For example, organic solvents used to clean surfaces may destroy trace evidence that was invisible to the naked eye but might be readily viewed under ultra-

violet or infrared light. Infrared photographs of questioned documents are commonly taken, even when writing is visible, to see whether the document has been altered. Looking at questioned documents under various types of light can help examiners identify writing imprints, altered writing, and writing that may have been covered by paint.

Back at the Crime Lab: Summary of scientific principles and procedures.

WRAP UP



YOU ARE THE FORENSIC SCIENTIST SUMMARY

1. Section 215 of the USA Patriot Act allows the FBI to order any person or entity to turn over "any tangible things," so long as the FBI "specifies" that the order is "for an authorized investigation . . . to protect against international terrorism or clandestine intelligence activities." Section 215 vastly expands the FBI's power to spy on ordinary people living in the United States, including U.S. citizens and permanent residents.
 - a. The FBI need not show probable cause, nor even reasonable grounds to believe, that the person whose records it seeks is engaged in criminal activity.
 - b. The FBI need not have any suspicion that the subject of the investigation is a foreign power or an agent of a foreign power.
 - c. The FBI can investigate U.S. citizens based in part on their exercise of First Amendment rights, and it can investigate non-U.S. citizens based solely on their exercise of First Amendment rights. For example, the FBI could spy on a person because it doesn't like the books she reads, or because it doesn't like the websites she visits. It could spy on her because she wrote a letter to the editor that criticized government policy.
 - d. Anyone served with Section 215 orders is prohibited from disclosing that fact to anyone else. The people who are the subjects of the surveillance are never notified that their privacy has been compromised.
2. Yes, the police officer would be able to search the backpack under the emergency exceptions, plain view doctrine, and open fields exceptions.

Chapter Spotlight

- There are three types of WMDs: chemical, biological, and nuclear weapons.
- Chemical weapons, which have the greatest potential for terrorist use, are classified into six categories: choking agents, blister agents, blood agents, irritating agents, incapacitating agents, and nerve agents.
- TIMs, which are commonly used by the chemical industry, can be used as WMDs.
- A point detector is a sensor that samples the air around it.
- The PID, SAW, and colorimetric tubes are all used as point detectors for sensing chemicals present in the air.
- Standoff detectors are used to warn of clouds of CWA or TIM approaching from a distance.
- A "dirty bomb," which is also known as an RDD, uses conventional explosives to spread nuclear contamination.
- Radioactive materials can emit three types of radiation: alpha, beta, and gamma rays.
- The amount of damage caused by radioactive materials depends on the type and penetration power of the radiation, the location of the radiation, the type of tissue exposed, and the amount or frequency of exposure.
- Radioactive contamination is detected by a Geiger counter.
- BWs disseminated through the air pose a threat to the general public.
- Current biological detection systems that use immunoassays or DNA-based technologies are not as reliable as are chemical detection systems.

Key Terms

- Alpha particle** A radioactive particle that is a helium nucleus.
- Beta particle** A radioactive particle that has properties similar to those of an electron.
- Biological weapon (BW)** Disease-producing microorganisms, toxic biological products, or organic biocides used to cause death or injury.
- Blister agent** A chemical that injures the eyes and lungs and burns or blisters the skin.
- Chemical warfare agent (CWA)** A chemical used to cause disease or death.
- Choking agent** A chemical agent that attacks the lung tissue, causing the lung to fill with fluid.
- Cholinesterase** An enzyme found at nerve terminals.
- Curie** A unit of radioactivity.
- Enzyme-linked immunosorbent assay (ELISA)** A sensitive immunoassay that uses an enzyme linked to an antibody or antigen as a marker for the detection of a specific protein, especially an antigen or antibody. It is often used as a diagnostic test to determine exposure to a particular infectious agent.
- Gamma ray** A high-energy photon emitted by radioactive substances.
- Geiger counter** An instrument that detects and measures the intensity of radiation.
- Gray** The new international unit that is intended to replace the rad (1 Gy = 100 rad).
- Half-life** The time required for half of the atoms originally in a radioactive sample to decay.
- Immunoassay** A test that makes use of the binding between an antigen and its antibody to identify and quantify the specific antigen or antibody in a sample.

- Incapacitating agent** A chemical that disables but does not kill immediately.
- Ionizing radiation** Radiation capable of dislodging an electron from an atom, thereby damaging living tissue.
- Nerve agent** A chemical that incapacitates its target by attacking the nerves.
- Neurotransmitter** A chemical that carries nerve impulses across the synapse between nerve cells.
- Point detector** A sensor that samples the environment wherever it is located.
- Rad** Radiation absorbed dose; the basic unit of measure for expressing absorbed radiation energy per unit mass of material.
- Rem** Roentgen equivalent for man; a dose of ionizing radiation.
- Sarin** A nerve gas.
- Sievert** The new international unit intended to replace the rem (1 Sv = 100 rem).
- Standoff detector** A sensor that reacts to distant events or hazards and can be used to warn of approaching chemicals.
- Synapse** A narrow gap between nerve cells across which an electrical impulse is carried.
- Tabun** A nerve gas.
- Transmutation** Conversion of one kind of atomic nucleus to another.
- Weapon of mass destruction (WMD)** A weapon that kills or injures civilians as well as military personnel. WMDs include nuclear, chemical, and biological weapons.

Wrap Up: Each chapter concludes with answers to the case study, a chapter summary, key terms, review questions, review problems, and suggestions for further reading specific to the chapter's subject matter.

Preface

The criminal justice system has learned to rely heavily on the analysis of physical evidence as scientific procedures and methods have become increasingly more reliable and telling than eyewitness testimony. The influence of television programs showing the use of highly sophisticated analytical equipment to solve crimes has caused juries to come to expect scientific evidence to be presented in all criminal cases. Greater stress is now placed on investigators to handle physical evidence in an appropriate scientific manner for later presentation in court. The introduction of DNA typing and database matching have revolutionized how physical evidence from the crime scene is processed. Forensic investigators must process both a sound understanding of the scientific principles that underlie the measurements they make and a keen knowledge of how to locate physical evidence without disrupting any trace elements at the scene.

In many ways, the attacks of September 11, 2001, expanded the role of criminalistics from traditional examination of crime scenes and physical evidence to assisting the Department of Homeland Security in deterring terrorism. Threats of terrorism from both within and outside of United States borders widen the scope of those working in the criminal justice system. I have included sections of this book that speak directly to these issues because of the changed nature and role of criminalistics.

New laws passed since 9/11 have placed a precarious balance between the rights and freedoms of individuals and the protection of society as a whole. This tension is evident when we are asked by politicians how much personal freedom we are willing to sacrifice in the name of national security. We now stand in long lines to pass through extensive security monitoring to board airplanes. We are limited in what we can carry with us on these flights. We face the potential of having our telephone conversations recorded. We can even be questioned about the material we check out of public and academic libraries. While these issues are of great importance to the individual, they are of even greater importance to understand for those working in the criminal justice field.

There are no easy answers to these issues, but it is the goal of this textbook to present information to students to help them understand how forensic measurements are made and to find a balance that protects the individual and benefits society as a whole.

Organization

The organization and approach of this text differ in several ways from other criminalistics books intended solely for criminal justice students. It places

forensic science with the framework of the basic principles of chemistry, biology, and physics and assumes the reader has little or no scientific background.

The first two chapters introduce the student to the crime scene and physical evidence. In Chapter 1, we learn to secure and document the crime scene. Next, to collect, preserve, package, inventory, and then submit evidence to the crime lab. In Chapter 2, common types of physical evidence are described, and basic scientific principles familiarize students with crime scene reconstruction. This early description of the many types of physical evidence found at crime scenes not only establishes the importance of a careful methodical approach to the crime scene but also gives students a firm foundation for how this evidence will be used to reconstruct the events that transpired during the commission of the crime.

Chapters 3, 4, and 5 offer a solid introduction to the core physical properties that are normally used to examine trace evidence. Chapter 3 shows how the physical properties can be used to characterize evidence. Chapter 4 describes the many types of microscopes used to examine fiber, hair, and paint evidence. The addition of paint evidence is new to the second edition and a response to requests from users of the first edition. Chapter 5 describes optical physical properties, such as color and refractive index, and how they can be used to characterize glass evidence. Wherever possible in these chapters, physical properties are discussed in the context of characterizing physical evidence, building a bridge to understanding how patterns and chemical and biological properties will be used to characterize evidence in the chapters that follow.

Next, students are introduced to pattern evidence. Chapter 6 covers fingerprints—their classification and the methods used to visualize latent fingerprints. A new box in Chapter 6 describes the new hand-held fingerprint scanners that search fingerprint databases while wirelessly connected to the Internet. The focus of Chapter 7 turns to questioned documents, with discussion of handwriting, typed and word processed documents, ink, indented writing, and security printing. Chapter 8 is devoted to firearms and describes handguns, rifles, shotguns, and submachine guns. Techniques used to compare fired bullets and shell casings are described, as well

as the methods used to restore obliterated serial numbers.

We then focus on chemical evidence. Chapter 9, which introduces readers to the periodic table and inorganic chemistry, provides a useful introduction to the examination of bullets and gunshot residue. In addition, it provides a foundation for more advanced chemical principles that will be presented in later chapters. Chapter 10 describes the chemistry of fire and introduces the student to organic chemistry through a discussion of hydrocarbon accelerants that are used by arsonists. In Chapter 11, drugs of abuse are arranged by category and the techniques used to detect them in bulk or in person samples are described.

Chapters 12, 13, and 14 deal with biological evidence. Chapter 12 describes how toxicological measurements are made. Even if the measurements are made after a person has died, they can often be used to reconstruct events that transpired days before. Biological fluids, such as blood, semen, and saliva are the focus of Chapter 13. Techniques used to locate and characterize biological evidence are presented, along with an introduction to DNA. Chapter 14 presents the separation and characterization of short tandem repeats (STRs) by capillary electrophoresis and how this information is used to establish paternity and match offender profiles.

The final section of the text focuses on terrorism. Chapter 15, a new chapter added for the second edition, describes computer forensics, cybercrime, and cyberterrorism. Chapter 16 describes the construction of explosive devices such as improvised explosive devices and the methods used to test for explosive residue. Chapter 17 presents the three major types of weapons of mass destruction—chemical, nuclear, and biological—and the techniques being developed to detect these threats, both point and standoff detectors.

Course Use

Criminalistics: Forensic Science, Crime, and Terrorism, Second Edition, offers the flexibility to tailor a course to suit both instructors' preferences and the needs of particular audiences. The full text may be used for a comprehensive two-semester course, or the book may be broken down in several ways for a one-

semester course. The text is arranged in a traditional format, beginning with the crime scene and physical evidence, followed by sections on trace evidence, pattern evidence, and terrorism. Those who have been teaching a one-semester criminalistics course with a different text can use the first 12 chapters of this text in sequence. Other options for a

one-semester course are to use the first five chapters, followed by choices for the remaining chapter depending on the teacher's preferences. Those instructors who stress chemical and biological evidence may choose to skip Chapters 6, 7, and 8. Those wanting to stress terrorism may chose to skip the first three chapters.

Acknowledgments

In preparing the second edition of this book I have added topics that weren't covered in the first edition. A section on the composition and analysis of paint has been added to Chapter 4. Most importantly, a whole new chapter (15) on computer forensics and cybercrime has been added as a response to instructor requests. Since the publication of the first edition in 2007, there have been many advances in the field of forensic science, and the book has been updated throughout to incorporate these changes.

I would like to express my gratitude and appreciation to everyone who contributed to this book. I extend special gratitude to Erik Garcia, who worked with me for over four years to create the wonderful graphic drawings in this text; Jonathan Edwardsen, who analyzed samples and produced the chromatograms and spectra contained in the book; Seth Reuter, who worked with me to develop the computer forensics chapter; Connie Diamant, my wife, who crafted the case studies and put up with me during this project.

To the reviewers of *Criminalistics: Forensic Science, Crime and Terrorism, Second Edition*, for their helpful comments and suggestions.

Russell Carter
Northern Virginia Community College
Manassas, Virginia

Steven Christiansen
Green River Community College
Auburn, Washington

Mark Conrad
Troy University
Dothan, Alabama

Daniel David
Green River Community College
Auburn, Washington

Chris DeLay
University of Louisiana
Lafayette, Louisiana

David Ferster
Edinboro University of Pennsylvania
Edinboro, Pennsylvania

Kimberly GLovery
Saint Leo University
Saint Leo, Florida

Don Haley
Tidewater Community College
Norfolk, Virginia

Donald Hanna
Cedarville University
Cedarville, Ohio

Robyn Hanningan
Arkansas State University
Jonesboro, Arkansas

John Kavanaugh
Scottsdale Community College
Scottsdale, Arizona

Michael Meyer
University of North Dakota
Grand Forks, North Dakota

Evaristus Obinyan
Virginia State University
Petersburg, Virginia

Gregory Russell
Arkansas State University
Jonesboro, Arizona

Jill Shelley
Northern Kentucky University
Highland Heights, Kentucky

David Tate
Purdue University
West Lafayette, Indiana

Dean Van Bibber
Fairmont State University
Fairmont, West Virginia

Harrison Watts
Cameron University
Lawton, Oklahoma

Robert Webb
Illinois Central College
East Peoria, Illinois

John Wyant
Illinois Central College
East Peoria, Illinois

Certain chapters were reviewed by experts. My thanks to the content experts who reviewed specific chapters:

Len Pinaud—Chapter 8: Firearms
State Coordinator for Range3000

Joseph M. Ludas and James W. Gocke—Chapter 6:
Fingerprints
Sirchi® Finger Print Laboratories, Inc.
100 Hunter Place
Youngsville, North Carolina 27596

John E. Parmeter, PhD—Chapter 16: Explosives
and Chapter 17: Detecting Weapons of Mass
Destruction
Sanida National Laboratories
PO Box 5800
Albuquerque, New Mexico 87185-0782

Detective Darrel Taber—Chapter 15: Computer
Forensics and Cybercrime
Arlington County Police Department
Computer Forensics unit
Arlington, Virginia

Special thanks to the following people for their contributions to the text:

Maureen Dolan
Arkansas State University
Jonesboro, Arkansas

Carolyn Dowling
Arkansas State University
Jonesboro, Arkansas

Robyn Hannigan
Arkansas State University
Jonesboro, Arkansas

Amy Harrell
Nash Community College
Rocky Mount, North Carolina

Ellen Lemley
Arkansas State University
Jonesboro, Arkansas

Tanja McKay
Arkansas State University
Jonesboro, Arkansas

Kelly Redeker
Arkansas State University
Jonesboro, Arkansas

Gregory Russell
Arkansas State University
Jonesboro, Arkansas