3rd Edition

FORENSIC SCIENCE

FUNDAMENTALS & INVESTIGATIONS

Anthony J. Bertino

Patricia Nolan Bertino

CENGAGE

Australia • Brazil • Mexico • Singapore • United Kingdom • United States

Acknowledgments

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Dedication

To my parents, Joe and Alice Bertino, who taught me the meaning of "doing what you like brings freedom but liking what you do brings happiness."

— Anthony (Bud) Bertino

To my father, Arthur J. Nolan, for his keen interest, guidance, and encouragement during my teaching career and his invaluable technical support of this book.

— Patricia Nolan Bertino

Preface

Transform Your Course and Engage Your Students with

FORENSIC SCIENCE

Fundamentals and Investigations, 3e

Forensic Science: Fundamentals and Investigations 3e is student- *and* teacher-friendly. Students benefit from a practical approach to forensics with photographs sourced from the field, descriptive illustrations and tables, current case studies, and hands-on activities and projects, while teachers enjoy the extra support of measurable outcomes, validated teaching advice, and additional activities for differentiating learning.

AT A GLANCE

Forensic Science: Fundamentals and Investigations 3e reveals the science used in forensic science techniques. It provides a chapter-by-chapter description of specific types of evidence and the techniques to collect, analyze, and evaluate the evidence. As students progress through the course, they refine the techniques and apply them to other areas of study. As teachers guide their students through the course, essential teaching support enables them to deliver technical content and conduct hands-on activities in a focused and engaging way.

Forensic Science: Fundamentals and Investigations 3e is comprised of the following learning and teaching tools:

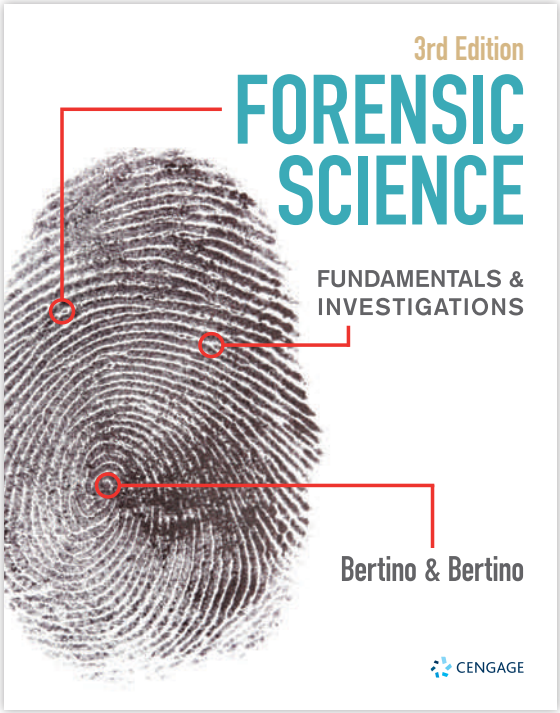
Student Edition (PRINT)

The 18 chapters are designed to both inform and motivate students while developing problem-solving skills. Each chapter features engaging opening scenarios, photographs and illustrations, and case studies that bring relevancy to the content. Forensic topics covered in the chapters include:

- Crime scene investigation
- The collection, handling, and analysis of trace evidence such as hair, fibers, soil, pollen, and fingerprints

- Blood and blood-spatter examination
- Forensic analysis of DNA, insects, drugs, glass, handwriting, and tool marks and impressions
- Firearms and ballistics
- Forensic anthropology
- The determination of the manner, mechanism, and cause of death
- The estimation of postmortem interval

Each chapter is accompanied by hands-on activities that allow students to explore these topics, and the text concludes with 10 Capstone Projects that integrate several forensic techniques into a single activity.



NEW TO THIS EDITION

- Aligned to current national standards, including Next Generation Science Standards (NGSS)
- Validated Learning Objectives streamline and align technical content with the end-of-lesson chapter questions, in addition to all supplementary assessments, to provide a clear pathway for learning
- New Chapter Scenarios and Case Studies reflect current events and methodologies in forensic investigation and include supporting questions to develop analytical skills
- Emphasizes the collaboration of various forensic investigators and experts in solving crimes
- Enhanced sections in history, evidence collection, and documentation and analysis provide context and facilitate understanding of forensic processes
- Current statistics reflect trends that affect forensic investigation and analysis
- New photographs and graphics engage and enhance the learning experience
- Current references to additional resources, including books and journals, tutorials, videos, and animations, promote further exploration and learning
- New sections in each chapter focus on advances in forensic science, including new technologies and techniques related to forensic investigation and analysis
- Includes over 100 hands-on activities, including 14 new activities for this edition
- Combined Glossary and Glosario provides additional support for English-Language Learners (ELLs)

CHAPTER REVISIONS

Specifically, revisions include some of the following new and enhanced topics:

- Formation and alteration of memory and its influence on eyewitness accounts
- Interrogation techniques for interviewing suspects
- Fingerprint analysis using algorithms
- Handheld devices to collect drug samples and fingerprints
- DNA single-nucleotide polymorphism (SNP) analysis
- DNA phenotyping and digital facial reconstruction
- Forensic genealogy
- Forensic microbiology and postmortem interval (PMI)
- Next Generation Identification (NGI)
- N-tracing used in handwriting analysis
- Art forgeries
- Online credit card fraud and counterfeiting of merchandise
- Expanded coverage in soil analysis, including worldwide sand shortage and theft
- Improved spectrometers and instrumentation to analyze evidence
- Claim-Evidence-Reasoning format in activity analysis

Wraparound Teacher's Edition (PRINT)

This version includes the SE pages with the addition of teaching tips, correlations to Activities and Capstone Projects, additional activities for differentiating learning, and cross-curricular information.

NEW TO THIS EDITION

- New tips on how to present information, set-up and deliver activities, and engage students
- New advice on how to support and encourage students at different levels of learning to inclusively support the heterogeneous nature of a forensics classroom

Companion Site (DIGITAL)

Providing support for both students and teachers, this site includes supporting worksheets and teacher notes for the Activities and Capstone Projects, lesson plans, PowerPoint® presentations, test banks, and additional Activities.

NEW TO THIS EDITION

- Site design facilitates the teaching process with practical resources
- All-new Lesson Plans correlating to teacher and student resources
- Thoroughly revised question banks to reflect new content, provide feedback, accurately assess students, and provide additional learning opportunities
- New lab activities enrich learning and reinforce chapter concepts

Forensic Science: Fundamentals and Investigations 3e, MindTap (DIGITAL)

This all-encompassing digital course includes the e-book, auto-graded quizzing, PowerPoint® presentations, activities and projects, and interactive virtual simulations.

NEW TO THIS EDITION

- Learning path design facilitates the learning process, with each chapter building knowledge and skills through different levels of assessments and authentic activities.
- Chapter activities are offered in an interactive format and include all Activities from both the student edition and companion site.
- Assessments align to learning objectives and provide feedback, including rationale, to support learning.

Refer to page xii to explore the teacher offerings further.

TRANSFORM YOUR COURSE WITH MEASURABLE OUTCOMES

A focus on learning design ensures that technical content and pedagogy clearly support, and assessments accurately measure, the learning objectives to bolster student success.

- Validated learning objectives align technical content with the end-of-chapter questions, in addition to the supplementary assessments, to provide a clear pathway for learning.
- Concepts build from simple to more complex to increase student comprehension and support learning.
- Differentiated Learning is recognized with various activities and advice on how to reach and engage students of varying levels of abilities.

Differentiated Learning

Additional Support for Learners

Engage students by asking them to describe a two-car accident in which glass evidence is present. What kind of glass would be present as evidence? How would they determine which car the glass came from? How would they, step by step, collect and document it? (See Chapter 2.)

Differentiated Learning

Accelerated Learners

Interested students should research the advanced technological methods used to analyze glass evidence.

Differentiated Learning

English-Language Learners

Students may not know what a halo is and therefore will not be able to envision the halo effect of the Becke lines. Use pictures or illustrations to describe halos to the class before students read this section.

The WTE includes many ideas and activities for supporting learning in the classroom.

LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

1.1 Describe the purpose of forensic science.
1.2 Explain the role and responsibilities of a forensic scientist.
1.3 Distinguish between observation and perception.
1.4 Distinguish between fact and opinion as they relate to eyewitness testimony.
1.5 Describe ways to improve observation skills.
1.6 Describe effective techniques that result in an accurate eyewitness interview.
1.7 Develop your observational skills and ability to assess the validity of eyewitness accounts of a crime.
1.8 Design an experiment that demonstrates how different factors influence our observational abilities.

Chapter 1
REVIEW

TRUE OR FALSE

1. The word *forensic* refers to the application of scientific knowledge to legal questions. *Obj. 1.1*
2. Good observation skills come naturally to investigators; they do not need to be trained. *Obj. 1.2*
3. If we remember seeing something happen, we can trust that it happened just as we think it did. *Obj. 1.3, 1.4*
4. The Innocence Project is an organization that seeks to get convicted killers out of prison. *Obj. 1.4*

MULTIPLE CHOICE

5. A forensic scientist is called to a court of law to provide *Obj. 1.2*
   a) facts.
   b) opinion.
   c) judgment.
   d) reflection.
6. The Innocence Project found that most faulty convictions were based on *Obj. 1.4*
   a) out-of-date investigating equipment.
   b) poor DNA sampling.
   c) inaccurate eyewitness accounts.
   d) officers not thoroughly observing a crime scene.

SHORT ANSWER

7. Explain why eyewitnesses are (a) separated before providing their account of what happened and (b) asked to repeat their story several times. *Obj. 1.6*
8. Summarize effective techniques to improve observational skills. *Obj. 1.5*
9. Discuss methods practiced by law enforcement that are used to obtain accurate eyewitness accounts. *Obj. 1.6*
10. Two people witness the same car accident. Each person provides an eyewitness account and is confident it is 100 percent accurate. However, the eyewitness accounts differ. Based on the information about observations and perceptions, explain how they can have two different accounts of the same event. *Obj. 1.3, 1.4*
11. Much can be learned about a person through observation. Form groups of four and choose one of the following categories to discuss. List observable clues that indicate each of the following about a person. Select one person to be the recorder. Other team members should share observations that would support their descriptions. *Obj. 1.3, 1.5*
    a) Occupation
    b) Family status
    c) Age

Learning Objectives are identified at the point of introduction, throughout the chapter and end-of-chapter questions. Chapter Review questions scaffold from simple to more complex to build and accurately evaluate student comprehension.

TRANSFORM YOUR COURSE WITH CROSS-CURRICULAR INTEGRATION

Teachers can conduct a full-year study of forensics or select topics that can be incorporated into a half-year course. As another option, teachers can use the topics to motivate students in all science classes by using forensics to teach basic science concepts. For this purpose, technical content is correlated to the NGSS. Additionally, opportunities for integrating connections to other disciplines are interwoven throughout the chapters. Each chapter integrates history, science, mathematics, literacy, technology, and political science along with writing and presentation skills using real-life applications to provide complete flexibility for any science program.

Academic icons help students make connections between forensic science and other areas of study.

Academic Connections

BIOLOGY:
collecting biological evidence such as pollen, blood, semen, and DNA

EARTH SCIENCES:
identifying soil evidence

MATHEMATICS:
laying out crime scene perimeters, determination of angle using a compass, and using statistical values of evidence

CHEMISTRY:
laboratory analysis of evidence

TECHNOLOGY:
New devices that map out crime scenes

LITERACY:
further exploration of crime scene investigation and analysis, synthesize information from various sources

Academic references provide insight into how teachers can help students make those cross-curriculum connections.

ENGAGE YOUR STUDENTS WITH CURRENT AND RELEVANT CONTENT

Thoughtfully designed content in each chapter promotes learning in the classroom and encourages further exploration.

- Chapters open with a **case scenario** pulled directly from headlines and features both pivotal historical and current ***Case Studies*** at the end, offering high-interest topics for critical thinking, writing, and class discussion.
- ***Did You Know?*** notes provide additional interesting facts and information to pique students' interest.
- ***Digging Deeper*** identifies additional topics relevant to the chapter for students to explore.
- ***Careers in Forensics*** highlight prolific forensic scientists, describing a forensic occupation related to the chapter.

DNA Profiling

Who Are You? Cold Cases Solved Using Forensic Genealogy

In April 1981, the body of a young girl with red, braided hair wearing a buckskin jacket (known as the "Buckskin Girl") was found murdered by the side of an Ohio road. Detailed fingerprint analysis; dental record comparisons; hair, pollen, and isotope analysis; and facial reconstructions completed by the National Center for Missing and Exploited Children (NCMEC) network failed to identify the young woman until 2018. At that time, a volunteer group known as John and Jane Doe Project used the stored 37-year-old blood sample with its degraded DNA to compare the unidentified person's DNA with the DNA found in public genealogical databases (GEDmatch provides tools for DNA and genealogical analyses). Based on that search, relatives were identified from the public genealogical database, family trees were viewed, interviews were conducted by detectives, and ultimately, the "Buckskin Girl" was identified as 21-year-old Marcia L. King from Arkansas.

This was one of the many cold cases solved by using public genealogical databases and SNPs (single nucleotide polymorphisms) to analyze DNA. You may have heard of genealogy searches through Ancestry.com and 23andMe. As of 2019, over 26 million people have submitted their DNA to undergo this genetic screening. To collect an individual's DNA, the mouth is swabbed, and then the sample is mailed to the company for analysis. They analyze the DNA to trace ancestry and help locate relatives. This same amazing technology is being used to solve many cold case crimes because SNP analyses use shorter DNA fragments. Degraded or damaged DNA evidence, once thought to be useless, can now be reevaluated and used to identify perpetrators of crime who have eluded capture. It can also be used to identify the remains of unknown deceased individuals such as the "Buckskin Girl."

National Center for Missing and Exploited Children

Artist sketch of the unidentified murder victim known as the "Buckskin Girl."

Courtesy of Marcia King's Mother

Marcia Lenore King's remains were identified 37 years after her murder using public genealogy databases.

Case STUDIES

Lamar Johnson (2005)

In 2005, Lamar Johnson pleaded not guilty to killing Carlos Sawyer, who was shot and killed outside an elementary school in East Baltimore. Based on eyewitness testimony that Lamar Johnson resembled the killer, Lamar Johnson was sentenced to life in prison.

Lawyers from the Innocence Project discovered three other witnesses who independently confirmed that Johnson was not the gunman. One man said he saw the shooter and it was not Johnson. Another told investigators that he heard a different person confess to the killing. The third witness, a woman, said that the gunman ran past her after the shooting and it was not Lamar Johnson. Asked why they did not come forward earlier, they said they were afraid to testify.

The attorneys presented their evidence to Baltimore prosecutors. Together, both offices asked the court to free Lamar Johnson. After more than 13 years, Johnson was a free man. Police have reopened the investigation to find Sawyer's killer.

Courtesy of Mid-Atlantic Innocence Project

Lamar Johnson exonerated by the Innocence Project after 13 years in prison.

Careers IN FORENSICS

Dr. Michael Baden

FORENSIC PATHOLOGIST

Dr. Michael M. Baden is an internationally known and respected board-certified forensic pathologist. In his long, fascinating career, he has performed more than 20,000 autopsies. After earning a Bachelor of Science degree from the City College of New York, he attended New York University School of Medicine and was

- ***Activities*** provide hands-on experiences with the opportunity to perform forensic science techniques and develop problem-solving skills. Each activity has clear instructions, including a list of materials, important safety information, step-by-step directions to guide students through the activity, questions for analysis, reflection and class discussion, and opportunities for further exploration beyond the activity to provide enrichment for student learning. For teachers, they offer easy, quick preparation, and minimal expense for materials.
- ***Capstone Projects*** build upon the activities in the chapters and combine concepts from different chapters as well as focus on specific forensic science techniques or skills.

CAPSTONE PROJECT 7

Forensic Science Career Exploration

LEARNING OBJECTIVES:

By the end of this project, you will be able to:

1. Identify different types of careers in forensic science.
2. Discuss the education requirements, job skills, job training, salary ranges, and so on of different careers in forensic science.
3. Present your research to the class.

Time Required

Varies depending on if research is done during class time or outside of class.

Materials

- CP-7 WKST *Careers in Forensic Science Sign-up Form*
- CP-7 WKST *Career Research Questions*
- Computer with Internet access (*Optional*)

Safety Precautions

None

Introduction

Thinking of pursuing a career in forensic science? In this project, you explore various career opportunities in forensic science. Research what type of training is needed, what the day-to-day work experiences are, and what type of income and job opportunities are associated with this career. You will present and share your findings with your classmates.

ACTIVITY 6–5

Minutiae Patterns *Obj. 6.3, 6.10*

Objectives:

By the end of this activity, you will be able to:

1. Describe different types of fingerprint minutiae patterns.
2. Identify different minutiae patterns found in fingerprints.

Time Required to Complete Activity:

15 minutes

Materials:

Act 6-5 WKST *Minutiae Patterns*
Red pen
Ruler or straight edge
Magnifying glasses

SAFETY PRECAUTIONS:

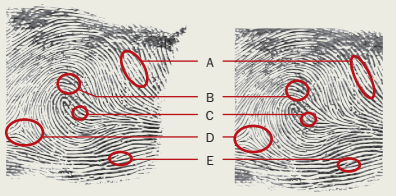
None

Introduction:

Latent fingerprints found at crime scenes are usually incomplete (partial) prints. Investigators need to examine the characteristics of a fingerprint very carefully. The simple identification of a whorl, loop, or arch is not sufficient. Other markers (minutiae) are used in distinguishing one fingerprint from another.

Procedure:

1. Study the following picture. It shows fingerprints obtained from a suspect (left) and a fingerprint lifted from the crime scene (right). Notice how the investigator has labeled the points of comparison with the same letter on the rolled ink print and the latent print from the crime scene. Use the table of minutiae



Suspect print Latent print from crime scene

TRANSFORM YOUR COURSE WITH TEACHING SOLUTIONS

WRAPAROUND TEACHER'S EDITION

The **Wraparound Teacher's Edition** (WTE) contains teaching strategies to support and engage students. The WTE provides clarification of science content and forensic science procedures, ideas to help stimulate students, evaluation opportunities, additional questions, and suggestions for further exploration and research. Additional support for offering differentiating learning in the classroom is also included.

Chapter Overview: introduces chapter and topics of discussion

The Big Ideas: highlight the main points of the chapter

Scenario: provides questions for opening class discussion based on the case presented at the beginning of the chapter

Academic Connections: provide relevant information connecting to other discipline areas, including math, science, chemistry, biology, earth sciences, technology, and literary references

Differentiated Learning: presents teaching strategies for delivering content to students who need additional support, as well as those seeking additional enrichment

Activities: point out appropriate points in the lesson to introduce a lab activity

Capstone Projects: point out appropriate points in the lesson to introduce a project

Teach: tips for teachers to highlight the main points of the lesson, guide students, and prepare for activities

Engage: advice for engaging students in an interactive way with the content

Explore: opportunities for further research on relevant topics

Chapter Overview

Soil is more than just dirt or rock. It is the medium that supports plant growth. Soil is primarily made up of weathered rock, but it also contains air, water, and organic matter. Soil has three different textures that differ in size from coarsest to finest: sand, clay, and silt. Soil samples also differ in shape, color, mineral composition, and organic composition. Each sample of soil has unique chemical and physical characteristics. Forensic scientists use soil's distinguishing traits to help solve crimes. Soil and sand can be examined for its general texture and appearance and then further analyzed for its mineral and chemical composition.

The Big Ideas

Soil scientists agree that no two places on Earth have precisely the same soil. Soil recovered from a crime scene, a victim, or a suspect can be analyzed for consistencies that can link the suspect to the crime scene or victim. Soil is part of the top layer of the earth's crust and contains minerals, decaying organisms, water, and air in uniquely varying amounts in each location. Soil is classified by its texture or grain size. Soils form in horizons, or layers, and each horizon has characteristic properties that differ. The horizons unique to an area make up its soil profile. Being able to recognize alterations to soil in an area can help forensic scientists locate a burial site. Proper collection and documentation of soil evidence are required. While soil evidence has been used in many cases, its reliability has been questioned in the courts.

ACTIVITY

Consider introducing Activity 13-9 *ACT Sand Theft*, including the accompanying podcast, at this point in the lesson. It is located on the Companion Site.

536 Chapter 13

Chapter 13

Soil Evidence

Sand Theft and Worldwide Sand Shortage

In 2008, the pure white sand of an entire Jamaican beach disappeared overnight. An eyewitness reported the theft, relaying that most of the sand was removed using heavy equipment. The prime suspects included the owners of the exclusive Jamaican beachfront resorts, who were known to steal or purchase white sand to replenish sand continually lost due to tides and hurricanes. Because Jamaica is a commonwealth of Great Britain, the Queen of England was involved in the investigation. The search for the stolen sand involved helicopters, police warrants, death threats, police corruption, and an early and abrupt judge retirement. The case was never resolved.

Overcrowded countries such as Singapore and Dubai are reclaiming land by importing massive amounts of sand to extend their borders. Entire islands, some purchased and some stolen, have provided sand to countries seeking to increase landmass. In India and Morocco, a corrupt sand "mafia" was organized to steal entire beaches!

In the United States, the Army Corps of Engineers continues to replace sand washed away by storms at beach resorts in Miami and other high tourism areas. Despite efforts to restore the coastline, tidal erosion continues to deplete coastal waterfronts.

Sand is essential to the infrastructure of a country; it is used in the construction of concrete buildings, roads, bridges, dams, highways, technology, and in the manufacture of glass. Human use of sand in 2019 is estimated to be 50 billion metric tons a year. Dr. Pascal Peduzzi of the United Nations has declared a worldwide sand shortage and has stated that the sand shortage is a major sustainability challenge of the 21st century.

Sand and other types of soils are analyzed to combat the worldwide sand shortage problems and the associated sand thefts. The analysis of sand and soils provides physical evidence that links a person or an object to a specific crime scene.

This sea wall is being build in St. Patrick, Grenada, after tons of sand was stolen from the beach, opening the area to erosion.

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Scenario

After reading the scenario in class, have students consider the following questions. You should revisit these questions as you move through the lessons in this chapter:

1. How many have heard of the worldwide sand shortage?
2. Why is sand in such high demand? How is sand being used?
3. What is their opinion about replacing beach sand lost due to erosion?
4. Discuss some of the effects of reclaiming land on the ecosystem.
5. What is the relationship between crime and the worldwide sand shortage?
6. Brainstorm ideas on how sand or soils can be analyzed to determine if two different samples of sand/soil came from the same location

Enrich: ideas for bringing experts from the field to the classroom and extending learning beyond the activities and projects presented in the chapter

Reteach: presents ways to revisit previously learned content

Assess: prompts teachers to review the learning objectives and key terms with students

Close: revisits the main points of the chapter

COMPANION SITE

The **Companion Site** includes the following resources in addition to other valuable references to enhance the teaching and learning experience:

Lesson Plans provide an outline of the key topics in each chapter and correlate topics to the learning objectives, activities, projects, and the accompanying PowerPoint® presentations.

PowerPoint® presentations align with the Lesson Plans and learning objectives and include photographs and illustrations to visually reinforce the key points in each chapter. Additional PowerPoint® presentations are provided by the authors and highlight specific topics in the chapters.

Student Learning Objectives (SLOs) support the chapter learning objectives and provide a method for learning and assessing students' comprehension of specific concepts within a topic. They also can be used for group work to encourage students to work together to achieve comprehension of forensic knowledge and techniques.

Chapter Activities and Capstone Project Worksheets support the chapter activities and Capstone Projects included in the text. Teacher Notes (TNs) are also available to provide direction on setting up and conducting the activity or project, as well as assessing student progress.

Testing Powered by Cognero, a flexible online system, provides chapter-by-chapter quizzes and enables teachers to

- author, edit, and manage test bank content from multiple sources.
- create multiple test versions in an instant.
- deliver tests from teacher/school-specific learning management system (LMS) or classrooms.

Additional Activities and Resources include lab activities based on specific chapters and provide alternatives for the activities in the text or an opportunity for enrichment.

The list of additional Activities found on the Companion Site include:

Chapter 6: Fingerprints
- Act 6-8 ACT Print Variations

Chapter 7: DNA Profiling
- Act 7-6 ACT Design and Build a Human DNA Structure (NEW)

Chapter 8: Blood and Blood Spatter
- Act 8-8 ACT Antigens and Antibodies Kinesthetic Activity

Chapter 9: Forensic Toxicology
- Act 9-4 ACT Urine Prescription Drug Test
- Act 9-5 ACT Drug Research and Presentation
- Act 9-6 ACT Drug Residue on Money
- Act 9-7 ACT Drug Testing Debate
- Act 9-8 ACT Toxin Case Study
- Act 9-9 ACT Pre-Testing, Evidence Reliability and Validity (NEW)

Chapter 10: Handwriting Analysis, Forgery, and Counterfeiting
- Act 10-4 ACT Landmark Handwriting Cases
- Act 10-5 ACT President's Signature Activity

Chapter 11: Forensic Entomology
- Act 11-5 ACT Processing a Crime Scene for Forensic Insect Evidence
- Act 11-6 ACT Jigsaw Research
- Act 11-7 ACT Calculating Accumulated Degree Hours (ADH)
- Act 11-8 ACT Forensic Entomology Case Study (NEW)

Chapter 12: Death: Manner, Mechanism, Cause
- Act 12-5 ACT Chicken Decomposition (NEW)
- Act 12-6 ACT Student Projects (NEW)

Chapter 13: Soil Evidence
- Act 13-7 ACT Grain Size and Velocity (NEW)
- Act 13-8 Japanese Fire Balloon Podcast (NEW)
- Act 13-9 Sand Theft Podcast (NEW)

Chapter 15: Glass Evidence
- Act 15-5 ACT Case Study Using Conchoidal Fractures (NEW)

Chapter 18: Firearms and Ballistics
- Act 18-5 ACT Sectional Density of Rifle Bullets
- Act 18-6 ACT Kinetic Energy of a Projectile

Also included are forensic books of interest for further exploration and links to other resources offered by the authors on their website.

National and State Standard Correlations illustrate how content in *Forensic Science: Fundamentals and Investigations 3e* align to the **NGSS** and several current state standards.

Visit ngl.cengage.com or contact your sales consultant for access to the NGLSync teacher dashboard.

MINDTAP FOR FORENSIC SCIENCE: FUNDAMENTALS AND INVESTIGATIONS 3E

The MindTap for *Forensic Science: Fundamentals and Investigations 3e* features an integrated course offering a complete digital experience for the student and teacher. This MindTap is highly customizable and combines the enhanced e-book along with interactivities, lab activities, auto-graded quizzing, and virtual simulations to enable students to directly analyze and apply what they are learning and allow teachers to measure skills and outcomes with ease.

- A Guide: Relevant interactivities combined with prescribed readings, featured multimedia, and quizzing to evaluate progress will guide students from basic knowledge and comprehension to analysis and application.
- Personalized Teaching: Teachers are able to control course content—hiding, rearranging existing content, or adding and creating own content to meet the needs of their specific program.
- Promote Better Outcomes: Through relevant and engaging content, assignments, and activities, students are able to build the confidence they need to ultimately lead them to success. Likewise, teachers are able to view analytics and reports that provide a snapshot of class progress, time in course, engagement, and completion rates.

Enhanced e-book includes highlighting and note-taking features, read-speaker, both English and Spanish definitions at point of reference and hyperlinked figures and tables to increase comprehension.

Interactivities include chapter PowerPoint® presentations, flashcards with select images, and other apps to enhance the learning experience.

Lab Activities and Capstone Projects are provided in an interactive format, allowing students to enter data directly online or print and upload files to their instructor for grading. The activities here include all those in the print student edition text, as well as those posted to the *Companion Site*.

Auto-graded quizzing comprised of various question types is integrated throughout the chapters, including matching, true-false, multiple-choice, and scenario-based questions.

Virtual Lab Simulations are integrated into the chapters as well as a final project at the end of the learning path. Interactive labs in the chapters reinforce chapter concepts while *The Death of Rose Cedar* Virtual Lab can be used as a final assessment for the course. As students work through individual lab activities included in the virtual case, they will record their findings within an auto-graded assignment. After they are completed and have recorded the data, there is a post-assessment covering the topics and techniques used within the virtual lab.

Each lab activity included within *The Death of Rose Cedar* Virtual Lab includes the following:

- Background information
- Clear instructions
- Three-dimensional crime scenes
- Toolkit
- Lab assessments
- Critical-thinking questions
- Research activities

ABOUT THE AUTHORS

Anthony (Bud) Bertino taught high school and community college science to students for over 40 years. He has taught biology, chemistry, physical science, ecology, and AP Biology and has served as a science supervisor at Canandaigua Academy. His awards include Outstanding Biology Teacher (NY, NABT), Woodrow Wilson Fellowship Award, Tandy Scholars' Award, and Outstanding Teaching Award from the University of Rochester. He has served as an AP Biology reader, consultant, and trainer for the College Board presenting week-long workshops around the country. Bud has presented week-long coursework for John Hopkins Center for Talented Youth (CTY) program and has served as an adjunct professor at Finger Lakes Community College and as a clinical supervisor for both the University of Albany (NY) Graduate School of Education and the College of St. Rose. Bud has been an attendee, curriculum developer, and presenter for the Cornell Institute for Biology Teachers (CIBT) and the Howard Hughes Medical Institute (HHMI). He is co-author of "Where's the CAT," and author of "The Cookie Jar Mystery" (forensic activities for elementary and after-school programs). His activities on money-saving techniques have been published in *The Science Teacher* (NSTA publication) and *The Forensic Teacher* magazine.

Patricia Nolan Bertino taught high school science for over 34 years at Scotia-Glenville High School. She developed curricula and taught high school biology and forensic science biology. Her awards include Outstanding Biology Teacher (NY, NABT), Woodrow Wilson Fellowship Award, and the Tandy Scholars' Award. She served as a scientific consultant for Video Discovery, Neo Sci, Prentice Hall Biology Review books, and several other publishers. Patricia has had numerous articles published in magazines including the *NSTA Reports, STANYS Science Bulletin, The Forensic Teacher*, and *Women in Engineering*. Patricia attended, developed curricula, and was a frequent presenter for the Cornell Institute of Biology Teachers (CIBT) and the Howard Hughes Medical Institute (HHMI).

Patricia's professional involvement includes memberships in numerous professional organizations. She served as a corresponding secretary for her local teacher's union and served as the Subject Area Representative in Biology for the Eastern section of Science Teachers Association of New York State (STANYS).

The Bertinos have been and continue to be actively involved in professional development for teachers including the following:

- Presenting and developing curricula for the HHMI (14 years)
- Serving as co-directors and instructors of the Bertino Forensic Summer Institute (15 years) and the AP Summer Institute at Rensselaerville, NY (7 years)
- Co-presenting at over 300 workshops sessions in forensic science, AP biology, and biology at national, state, and regional conferences.

The Bertinos reside near Schenectady, NY.

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Chapter 1

Forensic Science and Observation

How Accurate Is Eyewitness Memory?

On December 6, 1981, Ann Meng, a young nursing student, was assaulted and raped in her apartment. She was alone in the apartment. Several weeks after her attack, Meng encountered Julius Earl Ruffin, an African American maintenance man at the medical school she attended. She notified police and told them she was certain that Ruffin was her attacker.

Ruffin's girlfriend testified that he was innocent and was with her at the time of the assault. DNA evidence was in its early use, and the results showed a link to a group that contained only 8 percent of all African American men. On October 1, 1982, after two hung jury verdicts, the third trial jury conducted by the Commonwealth of Virginia found Ruffin guilty. Ruffin was sentenced to five life terms for the crimes of burglary and rape.

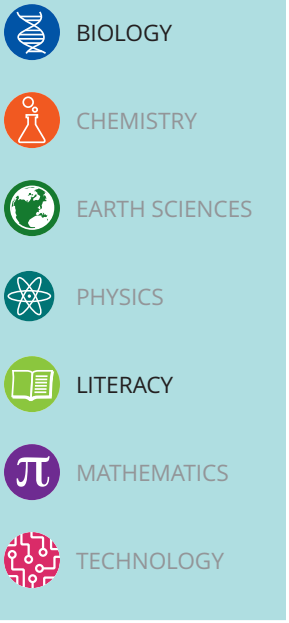
In 2002, Ann Meng was contacted by the State's attorney's office. A retesting of the DNA evidence showed that Earl Ruffin was not her attacker. He had spent 21 years in prison due to mistaken identity. How could this have happened?

How reliable is eyewitness identification?

LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

1.1 Describe the purpose of forensic science.
1.2 Explain the role and responsibilities of a forensic scientist.
1.3 Distinguish between observation and perception.
1.4 Distinguish between fact and opinion as they relate to eyewitness testimony.
1.5 Describe ways to improve observation skills.
1.6 Describe effective techniques that result in an accurate eyewitness interview.
1.7 Develop your observational skills and ability to assess the validity of eyewitness accounts of a crime.
1.8 Design an experiment that demonstrates how different factors influence our observational abilities.



KEY TERMS

- **analytical skill** the ability to identify a concept or problem, isolate its component parts, organize information for decision making, establish criteria for evaluation, and draw appropriate conclusions
- **deductive reasoning** deriving a conclusion from the facts using a series of logical steps
- **eyewitness** a person who has seen someone or something related to a crime and can communicate their observations
- **fact** a statement or information that can be verified
- **forensic science** using science to help resolve legal matters
- **hypothesis** a possible explanation of a question or problem based on prior knowledge or observation
- **logical** based on clear reasoning of the facts
- **observation** what a person perceives using their senses
- **opinion** personal belief founded on judgment rather than on direct experience or knowledge
- **perception** the brain's interpretation of a situation based on opinions, judgment, and personal experiences

Introduction

Forensics: the word conjures up images of the *CSI* television series, lab coats, and brightly lit laboratories. "Forensic" derives from the Latin word *forensis,* which means "of the forum." The ancient Roman forum was an open area where scholars would gather to debate issues. The forum was something like modern-day court. Crimes were solved by forum debates. Sides for the suspect and victim would give speeches, and the public would decide who gave the best argument.

However, debating is not forensic science. It is about the skill of observation to uncover evidence and discover the facts of a crime.

FIGURE 1-1 Processing a crime scene for evidence.

Source: FBI

What Is Forensic Science? *Obj. 1.1*

Forensic science is using science to help resolve legal matters, such as crimes. A forensic investigator is interested only in collecting and examining physical evidence, reporting results to law enforcement, and possibly testifying in court about their findings.

One of the most important tools of the forensic investigator is the ability to observe, interpret, and report findings clearly. Whether observing at a crime scene or examining collected evidence in the laboratory, the forensic examiner must be able to identify the evidence, document it, and determine its significance. The trained investigator collects all available evidence, without making judgments about its potential importance. That comes later. Knowing which evidence is significant requires the ability to recreate the series of events preceding the crime. The first step is careful and accurate observation (**Figure 1-1**).

What Do Forensic Scientists Do? *Obj. 1.2*

So, what do forensic scientists do? A good forensic scientist is skilled at making observations and applying scientific knowledge to analyze the crime scene. Their first task is to find the evidence and decide what needs to be collected, documented, packaged, examined, and tested. Part of collecting physical evidence includes collecting data. *Qualitative* data is subjective, descriptive data, such as color or shape. We collect qualitative data using our senses. *Quantitative* data is objective—numerical data that can be measured, such as weight, height, and mass. A forensic scientist must also be a good communicator who is able to convince a jury that their analysis is scientific, reliable, valid, and sufficient (**Figure 1-2**).

FIGURE 1-2 A forensic scientist acting as an expert witness in court.

AP Images/Dave Ellis, Pool

Police officers must also be trained to have good observation skills. Part of their training is learning to take in the entire scene before making a final assessment based on their observations. Forensic scientists and police are trained not only to observe but also to carefully analyze what they see. The ability to identify a concept or problem, isolate its component parts, organize information for decision making, establish criteria for evaluation, and draw appropriate conclusions is having **analytical skill**. Solving a crime depends on using this skill and requires patience and practice.

Table 1-1 illustrates significant events that have shaped investigative processes and procedures related to observation and analysis.

TABLE 1-1 Significant events in observation and analysis

1967	Paul Ekman discovers that human beings are capable of making over 10,000 facial microexpressions with 3,000 relevant to emotion and nonverbal communication.
1974	Elizabeth Loftus explains how misinformation can lead to false memories.
2012	Scott Fraser describes the fallibility of memory reconstruction.
2014	Pamela Meyer publishes a work on how to detect lying.
2016	Interrogation techniques are modified for eyewitnesses and suspects.

DID YOU KNOW?

High-ranking police officers in New York City are trained in observation skills at a local museum, the Frick Collection. The police learn to identify details in the paintings and draw conclusions about the paintings' subjects. They apply their new skills at crime scenes.

Another important skill is **deductive reasoning**—deriving a conclusion from the facts using a series of logical steps. Scientists have established a rigorous study procedure known as the *scientific method*. The steps include the following:

1. State the problem or question.
2. Propose a hypothesis based on prior knowledge or observation. A **hypothesis** is a possible explanation of a question or problem based on prior knowledge or observation. It is not a guess.
3. Conduct an experiment.
4. Collect data.
5. Analyze data.
6. Draw a conclusion based on the data.

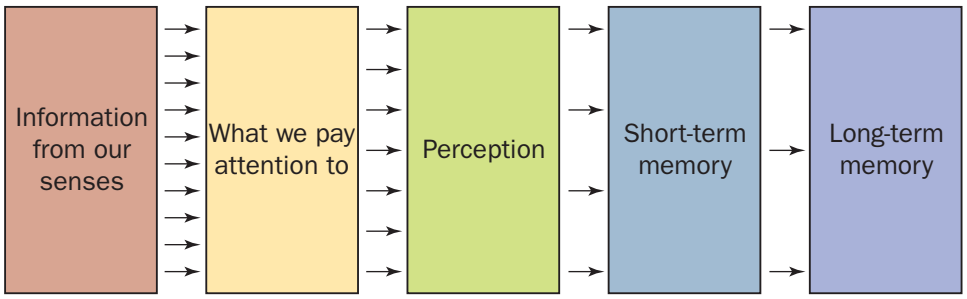
Another method is the *Claim Evidence Reasoning Model*. Scientific explanations can be analyzed using this model. The steps include the following:

1. Make observations.
2. Determine what question you want to answer.
3. Make a claim and an assertion based on evidence or observations.
4. Provide evidence, scientific data that supports the claim. Evaluate the evidence to determine if it is scientific, sufficient, reliable (consistent), and valid (properly collected and analyzed using accepted protocols and equipment or tools).
5. Provide reasoning or justification that links the claim with the evidence.

Observation and Perception *Obj. 1.3*

An **observation** is what a person perceives using their senses. Every single moment, we are gathering information about what is around us, through our senses—sight, taste, hearing, smell, and touch. We do this largely without thinking, and it is very important to our survival. Why are we not aware of all the information our senses are gathering at any time? The simple answer is that we cannot pay attention to everything at once. Instead of a constant flow of data cluttering up our thoughts, our brains select what information to take in; we unconsciously apply a filter (**Figure 1-3**). We simply pay attention to things that are more likely to be important. What is important to each of us varies and is affected by various factors, including changes to the environment. For example, if you are sitting in a room and everything is still, you are unlikely to be filled with thoughts about the color of the sofa, the shade of the light, or the size and shape of the walls. But if a cat walks in, or you hear a loud bang, you will perceive these changes in your environment. Paying attention to the details of your surroundings requires a conscious effort.

FIGURE 1-3 How information is processed in the brain.



It is difficult to believe, but our brains definitely play tricks on us. The sensory information that we observe is delivered to our brain. **Perception** is our brain's interpretation of our sensory observations after our brains have filtered and processed the information. Our perception is limited, and the way we view our surroundings may not accurately reflect what is really there. Perception has the potential to be faulty; it is not always accurate, and it does not always reflect reality. For example, our brains will fill in information that is not really there. If we are reading a sentence and a word is missing, we will often not notice the omission but instead predict the word that we think should be there and read the sentence as though it is complete. Short-term memory is stored for a brief period of time. The more a short-term memory is used, recalled, or repeated, the more likely it will become a part of long-term memory.

digging deeper

Can a can of Coke in the woods lead to a conviction? Can a smashed dial on a safe betray the suspect? Search online for a case study that demonstrates how good observation skills led to the solution of a crime. Be prepared to share your results with the class.

Our brains apply knowledge we already have about our surroundings to new situations. In experiments with food coloring, a creamy pink dessert is perceived to be strawberry flavored even though it is vanilla flavored. Our minds learn to associate pink with strawberries and apply that knowledge to new situations—even when it is wrong. An interesting aspect of our perception is that we believe what we see and hear, even though our ability to be accurate is flawed. People stick to what they think they saw, even after they have been shown that it is impossible.

If you are feeling like your brain is defective, do not worry. The brain, while faulty, is still good at providing us with the information we need to survive. Filtering information, filling in gaps, and applying previous knowledge to new situations are all useful traits, even if they do interfere sometimes. Understanding our limitations helps us improve our observation skills, which is extremely important in forensic science. Criminal investigations depend on the observation skills of all parties involved—the police investigators, the forensic scientists, and the witnesses.

Eyewitness Observation *Obj. 1.4*

One key component of any crime investigation is the observations made by witnesses. Not surprisingly, the perceptions of witnesses can be faulty, even though a witness may be utterly convinced of what they saw. Have you ever noticed that you can walk along the street or ride in a car and be totally unaware of your surroundings? You may be deeply involved in a serious conversation on your cell phone and lose track of events happening around you. Your focus and concentration may make an accurate accounting of events difficult.

Our emotional state influences our ability to see and hear what is happening around us. If people are very upset, happy, or depressed, they are more likely not to notice their surroundings. Anxiety also plays a big part in what we see and what we can remember. Our fear at a stressful time may interfere with an accurate memory. Victims of bank robberies often relate conflicting descriptions of the circumstances surrounding the robbery. Their descriptions of the criminals committing the robbery often are not consistent.

Nevertheless, eyewitness accounts of crimes can be valuable evidence (**Figure 1-4**). Bystanders who are unaware that they are watching a crime unfold are not subject to the anxiety *experienced* by victims and may provide valuable evidence. And some victims are less subject to the disruptive effects of anxiety on memory.

FIGURE 1-4 The use of "six packs" of photos (six-person photo collection) by law-enforcement agencies is under review. Some experts feel their use prejudices witnesses who want to be helpful and feel the suspect must be in the photo array. What is your opinion?

Mikael Karlsson/Alamy

Other factors affecting our observational skills include the following:

- Whether you are alone or with a group of people
- The number and types of people and/or animals in the area
- The type and level of activity occurring around you
- Visual capabilities
- State of health
- Fatigue and stress level
- Emotional involvement
- Distractions from use of electronic devices
- Disguises that may be in use
- Ability to make quick decisions
- Individual perception differences
- Amount of time something was observed
- Motivational or cognitive bias (seeing what we expect to see based upon past experience or what someone has told us)

All of these factors influence the accuracy of a witness's observations.

Eyewitness Accounts

What we perceive about a person depends, in part, on their mannerisms and gestures. How a person looks, walks, stands, and uses hand gestures all contribute to our image of their appearance. Think about your family members. How would you describe them? What makes them unique? We also form images of familiar places. Our homes, school, and other places we often visit (e.g., a favorite store or restaurant) are burned into our memories and easy to recognize and remember.

An **eyewitness** is a person who has seen someone or something related to a crime and can communicate their observations. Eyewitness accounts of crime-scene events vary considerably from one person to another. What you observe depends on your level of interest, stress, concentration, and the amount and kind of distraction present. Our prejudices, personal beliefs, and motives also affect what we see. Memory fades with time, and our brains tend to fill in details that we feel are appropriate but may not be accurate. These factors can decrease an eyewitness's accuracy in recalling a crime. However, the testimony of an eyewitness can be very powerful in persuading the jury one way or another.

When evaluating eyewitness testimony, the investigator must discriminate between **fact**, a statement or information that can be verified, and **opinion**, a personal belief founded on judgment rather than on direct experience or knowledge. What did the witness actually see? Often what we think we saw and what really happened differ. Someone fleeing the site of a shooting might look like a suspect but could merely be an innocent bystander running away in fear of being shot. Witnesses have to be carefully examined to ensure that they describe what they saw (eyewitness evidence), not what they thought happened (opinion).

After witness examination, the examiner tries to sequence the events (facts) of the crime into a **logical** pattern. The next step is to determine if this pattern of events is verified by the evidence and reinforced by the witness testimony.

The Innocence Project

The Innocence Project at the Benjamin N. Cardozo School of Law at Yeshiva University in New York was created by Barry C. Scheck and Peter J. Neufeld in 1992. Its purpose is to reexamine postconviction cases (individuals convicted and in prison) using DNA evidence to provide conclusive proof of guilt or innocence (**Figure 1-5**). After evaluating hundreds of wrongful convictions in the United States, the Innocence Project found that faulty eyewitness identification contributed up to 70 percent of those wrongful convictions. Eyewitness errors included mistakes in describing the age and facial distinctiveness of the suspect. These mistakes resulted from disguised appearances, too-brief sightings of the perpetrator, cross-gender and cross-racial bias, and changes in the viewing environment (from crime scene to police lineup).

FIGURE 1-5 Gary Dotson was the first individual shown to be innocent (exonerated) by the Innocence Project.

AP Images/Seth Perlman

Improving Observation Skills *Obj. 1.5*

We can apply what we know about how the brain processes information to improve our observation skills. Here are some basic tips:

1. *We know that we are not naturally inclined to pay attention to all of the details of our surroundings.* To be a good observer, we must make a conscious effort to examine our environment systematically. For example, if you are at a crime scene, you could start at one corner of the room and run your eyes slowly over every space, looking at everything you see. Likewise, when examining a piece of evidence on a microscope slide, look systematically at every part of the evidence.
2. *We know that we are naturally inclined to filter out information we assume is unimportant.* However, at a crime scene, we do not know what may turn out to be important. In this situation, we need to consciously observe everything, no matter how small or how familiar, no matter what our emotions or previous experiences. So, we train ourselves to turn off our filters and instead act more like data-gathering robots.
3. *We know that we are naturally inclined to interpret what we see, to look for patterns, and make connections.* To some degree, this inclination can lead to us jumping to conclusions. While observing, we need to be careful that we concentrate first and foremost on gathering all of the available information and leaving the interpretation until we have as much information as possible. The more information we have, the better our interpretations will be.

4. *We know that our memories are faulty.* While observing, it is important to write down and photograph as much information as possible (**Figure 1-6**). This will become very important later when we, or our investigating team members, are using our observations to try to piece together a crime. Documentation is also important when acting as an expert witness. A judge will only accept hair evidence that has been documented in writing and with photographs taken at the crime scene. The verbal testimony of a forensic scientist alone may not be entered into evidence without the proper documentation.

FIGURE 1-6 Documentation is an essential part of observation.

digging deeper

Observation is as much about finding evidence as it is about spotting patterns of criminal behavior. We know that, on average, most thieves who come in through a window will leave by a door. Search online for articles on patterns of criminal behavior. Research how those employed in airport security are adept at observing and interpreting human behavior to detect potential security risks.

Interview Techniques *Obj. 1.6*

Law-enforcement officers conduct interviews of eyewitnesses, suspects, victims, and the accused. The most effective interviewers provide minimal guidance but instead ask questions that may help the person reconstruct what occurred. It is important for the interviewer to conduct the interview without interjecting any biases. By avoiding gender-specific terms such as he or she, the interviewer does not provide any information that may influence the eyewitness's perception of what or who they saw. The goal is to play back the witness's memory, not reconstruct it for them.

Effective interview techniques include the following:

- Separate eyewitnesses as soon as possible to avoid witnesses influencing each others' stories or sharing untruths.
- Interview one person at a time so that no one else influences their memory of what occurred.
- Write down their observations during the interview or as soon as possible afterward.
- Ask questions to draw out details during the interview.

A good interviewer uses other techniques to determine if an eyewitness is telling the truth or if they are lying. If a witness is telling the truth, the account of what happened is consistent each time they tell the story. If the witness is lying, it is more difficult to repeat the events exactly the same. Methods used to identify if something is a truth or a lie include the following:

- Ask the interviewee to repeat their story several times. It is easier to repeat something that is true. If the person is making up the story, it is difficult to remember the lie.
- Ask the interviewee to recount the story in reverse order of events.
- Ask the interviewee questions on or off the topic to distract the individual. If they are lying, the additional questions make it difficult for the interviewee to keep the story straight.

Eyewitness accounts of an event are not always the same because our memories are influenced by so many factors. The goal of a forensic interviewer is to record someone's memory of an event before their memory may be affected by others and to determine if what a person is relating is truth or nontruth.

SUMMARY

- Forensic science is the application of science to help resolve legal matters.
- Forensic scientists find, examine, photograph, document, and evaluate evidence and provide expert testimony to courts.
- Observations at crime scenes are based on sensory input and are affected by factors that affect our ability to focus.
- Perceptions are our brain's interpretation of our observations.
- Facts are based on evidence, but opinions are based on what you perceive might have happened.
- Observational skills can be improved by limiting distractions and increasing your awareness of your surroundings.
- Effective interview techniques help the observer recall events in an unbiased way to provide the best eyewitness account.

Ekman, Paul. *Emotions Revealed*. 2nd ed. New York: Henry Holt and Company, 2007.

Huston, Philip, Michael Floyd, and Susan Carnicero. *Spy the Lie: Three Former CIA Officers Reveal Their Secrets to Uncloaking Deception*. New York: St. Martin's Press, 2012.

Case STUDIES

Lamar Johnson (2005)

In 2005, Lamar Johnson pleaded not guilty to killing Carlos Sawyer, who was shot and killed outside an elementary school in East Baltimore. Based on eyewitness testimony that Lamar Johnson resembled the killer, Lamar Johnson was sentenced to life in prison.

Lawyers from the Innocence Project discovered three other witnesses who independently confirmed that Johnson was not the gunman. One man said he saw the shooter and it was not Johnson. Another told investigators that he heard a different person confess to the killing. The third witness, a woman, said that the gunman ran past her after the shooting and it was not Lamar Johnson. Asked why they did not come forward earlier, they said they were afraid to testify.

The attorneys presented their evidence to Baltimore prosecutors. Together, both offices asked the court to free Lamar Johnson. After more than 13 years, Johnson was a free man. Police have reopened the investigation to find Sawyer's killer.

Lamar Johnson exonerated by the Innocence Project after 13 years in prison.

Courtesy of Mid-Atlantic Innocence Project

Frank Lee Smith (2000)

In a Florida case, death row inmate Frank Lee Smith died of cancer in January 2000 while in prison. He was convicted in 1986 of the rape and murder of an eight-year-old child, even though no physical evidence was found. He was found guilty largely on the word of an eyewitness. Four years after the crime, the eyewitness recanted her testimony, saying she had been pressured by police to testify against Smith. Despite this information, prosecutors vigorously defended the conviction and refused to allow Smith a post-conviction DNA test he requested. After his death, the DNA test exonerated him.

AP Images/Jamie Rector, Pool

Uriah Courtney
(2013)

In 2004, a young California woman called police claiming she was attacked near the 94 Freeway. She described her attacker, but the description was too vague for a sketch artist to complete a drawing. An additional nearby eyewitness picked Uriah Courtney from a six-pack lineup (photos of six possible suspects) with "60% certainty." At trial the victim testified she was positive in her identification of the accused. In 2010, the California Innocence Project became involved with this case. The DNA clothing evidence was reexamined, and a male profile detected in the national database CODIS, or Combined DNA Index System, of convicted offenders pointed to a new suspect. The man lived 3 miles from the crime scene and resembled Courtney. Uriah Courtney's conviction was vacated, and he was released in 2013. His wrongful incarceration cost was estimated at nearly $650,000.

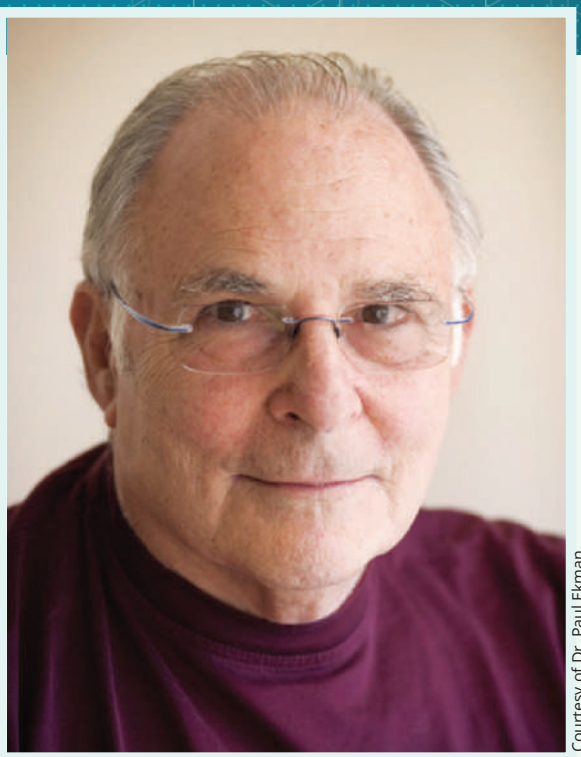
Think **CRITICALLY**

Review the case studies and the information on observation in the chapter. Then state in your own words how eyewitness evidence impacts a case.

Careers IN FORENSICS

Dr. Paul Ekman

FORENSIC PSYCHOLOGIST



Courtesy of Dr. Paul Ekman

Dr. Paul Ekman

Very few people can lie to Paul Ekman and get away with it. He can read faces like an open book, spotting the most subtle changes in expression that reveal if a person is lying. A psychologist who has spent the last 50 years studying faces, Ekman is a leading expert on facial analysis and deception. This skill puts him in high demand by law-enforcement groups around the world, such as the Federal Bureau of Investigation (FBI), Central Intelligence Agency (CIA), Scotland Yard, and Israeli Intelligence.

When looking for deception, Ekman watches for inconsistencies, such as facial expressions that are not consistent with what is being said. He can also detect what are called *microexpressions*—rapid changes in expression that last only a fraction of a second but reveal a person's true feelings. It is a rare talent to be able to spot these microexpressions. Only 1 percent of people are able to do so without training.

Ekman was the first to determine that a human face has 10,000 possible configurations and which muscles are used in each. He created the Facial Action Coding System. This atlas of the human face is used by a variety of people looking to decode human expression, including investigators, psychologists, and even cartoon animators.

Ekman has turned his expert gaze onto many famous faces. He thinks the mysterious Mona Lisa is flirting, and he can identify the exact facial muscles a witness uses when he lies in court. He has studied tapes of Osama bin Laden to see how his emotions changed leading up to the 9/11 terrorist attacks.

Ekman first became interested in facial expressions at the age of 14, after his mentally ill mother committed suicide. He hoped to help others like her by understanding emotional disorders. From his experience as a photographer, he realized that facial expressions would serve as a perfect tool for reading a person's emotions.

Ekman's early research led to a major discovery that changed how scientists view human expression. Experts used to believe that facial expressions were learned, but Ekman thought otherwise. He traveled around the world and found that facial expressions were universally understood, even in remote jungles where natives had never before seen a Westerner. It could mean only one thing: our expressions are biologically programmed. This opened the door for Ekman to study human expression in a completely new way.

Fifty years of groundbreaking research followed Ekman's discovery. He served first as chief psychologist for the U.S. Army and then as a Professor at the University of California. Now in his eighties, Ekman continues to train others to detect deception and improve safety and security. His work was the basis for the TV series *Lie to Me*.

Chapter 1 REVIEW

TRUE OR FALSE

1. The word *forensic* refers to the application of scientific knowledge to legal questions. *Obj. 1.1*
2. Good observation skills come naturally to investigators; they do not need to be trained. *Obj. 1.2*
3. If we remember seeing something happen, we can trust that it happened just as we think it did. *Obj. 1.3, 1.4*
4. The Innocence Project is an organization that seeks to get convicted killers out of prison. *Obj. 1.4*

MULTIPLE CHOICE

5. A forensic scientist is called to a court of law to provide *Obj. 1.2*
   a) facts.
   b) opinion.
   c) judgment.
   d) reflection.
6. The Innocence Project found that most faulty convictions were based on *Obj. 1.4*
   a) out-of-date investigating equipment.
   b) poor DNA sampling.
   c) inaccurate eyewitness accounts.
   d) officers not thoroughly observing a crime scene.

SHORT ANSWER

7. Explain why eyewitnesses are (a) separated before providing their account of what happened and (b) asked to repeat their story several times. *Obj. 1.6*
8. Summarize effective techniques to improve observational skills. *Obj. 1.5*
9. Discuss methods practiced by law enforcement that are used to obtain accurate eyewitness accounts. *Obj. 1.6*
10. Two people witness the same car accident. Each person provides an eyewitness account and is confident it is 100 percent accurate. However, the eyewitness accounts differ. Based on the information about observations and perceptions, explain how they can have two different accounts of the same event. *Obj. 1.3, 1.4*
11. Much can be learned about a person through observation. Form groups of four and choose one of the following categories to discuss. List observable clues that indicate each of the following about a person. Select one person to be the recorder. Other team members should share observations that would support their descriptions. *Obj. 1.3, 1.5*
    a) Occupation
    b) Family status
    c) Age
    d) Personality traits and habits

GOING FURTHER

1. View a TV crime show, listen to a TED talk, or read a book or article that describes why eyewitness accounts tend to be unreliable. Summarize the information and provide evidence to support the statement that eyewitness accounts are not the most reliable form of evidence.
2. Design and prepare a crime scene including various types of physical evidence. The crime scene can be presented as a written description, photograph, projected image, or poster. Ask your classmates to examine your crime scene, make observations about the crime scene, and list what they observe.

BIBLIOGRAPHY

Books and Journals

Arkowicz, Hal, and Scott O. Liliendfield. "Why Science Tells Us Not to Rely on Eye Witness Accounts." *Scientific American*, January 1, 2010.

Bhattacharjee, Yudhijit. "Why We Lie." *National Geographic*, June 2017, 30–39.

DiSpezio, Michael. *Classic Critical Thinking Puzzles*. New York: Sterling Publishing Company, 2005.

Ekman, Paul. *Emotions Revealed, 2nd Edition*. New York: Henry Holt & Company, 2007.

Huston, Philip, Michael Floyd, and Susan Carnicero. *Spy the Lie: Three Former CIA Officers Reveal Their Secrets to Uncloaking Deception*. New York: St Martin's Press, 2012.

Loftus, E. F. *Eyewitness Testimony*. Cambridge, MA: Harvard University Press, 1996.

Meyer, Pamela. *Lie Spotting: Proven Techniques to Spot Lying*. New York: St. Martin's Press, 2010.

Munsterbe, Hugo. *On the Witness Stand: Essays on Psychology and Crime*. South Hackensack, NJ: Fred Rothman and Company, 1981.

Thompson-Cannino, Jennifer, and Ronald Cotton. *Picking Cotton: Our Memoir of Injustice and Redemption*. New York: St. Martin's Griffin, 2009.

United States. *Federal Rules of Evidence*. New York: Gould Publications, a division of LexisNexis, 1991.

Internet Resources

How Stuff Works, http://www.howstuffworks.com
"How Lie Detectors Work" (30:21 minutes)

TED Talks

Fraser, Scott. "Why Eyewitnesses Get It Wrong." April 6, 2014. (20:50 minutes)
Loftus, Elizabeth. "How Reliable Is Your Memory?" June 2013. (17:36 minutes)
Meyer, Pamela. "How to Spot a Liar." July 2011. (18:50 minutes)

The Innocence Project, www.innocenceproject.org

YouTube

"Are You a Good Eyewitness?", https://www.youtube.com/watch?v=iav4n6X9jGo (4:00 minutes)
Awareness Test Card Trick. "The Mentalist—Cards Awareness Test" https://www.youtube.com/watch?v=YcTgjR5iV1Y (00:58 minutes)
Awareness Test Gorilla Basketball. "The Monkey Business Illusion" https://www.youtube.com/watch?v=IGQmdoK_ZfY (1:42 minutes)
"Effective Interrogation Technique 1 3", https://www.youtube.com/watch?v=SDt2Kez7WZc (14:52 minutes)
"Forensics—Making a Case: Interviewing Suspects" https://www.youtube.com/watch?v=JGRNWM8RvGQ (10:20 minutes)
60 Minutes. "Picking Cotton." Part 1, https://www.youtube.com/watch?v=u-SBTRLoPuo (13:02 minutes)
60 Minutes. "Picking Cotton." Part 2, https://www.youtube.com/watch?v=WFRiDtUbeAQ (13:08 minutes)
"The Eyewitness Test: How Do You Stack Up?" https://www.youtube.com/watch?v=x6fRH5MLBIU (6:20 minutes)
"The System: Eyewitness Testimony", https://www.youtube.com/watch?v=kd5pCui6_Ss (49:50 minutes)

ACTIVITY 1–1

Learning to See *Obj. 1.3, 1.4, 1.5, 1.7*

Objectives:

By the end of this activity, you will be able to:

1. Describe some of the problems in making good observations.
2. Improve your observational skills.

Time Required to Complete Activity:

25 minutes

Materials:

Act 1-1 WKST *Photograph 1*
Act 1-1 WKST *Photograph 2*
Act 1-1 WKST *Photograph 3*
Pen or pencil

SAFETY PRECAUTIONS:

None

Procedure:

1. Your teacher will provide you with Act 1-1 WKST *Photograph 1* and a question sheet.
2. Study *Photograph 1* for 15 seconds.
3. When directed by your teacher, turn over the photograph and answer as many of the questions as you can without looking at the photo.
4. Repeat the process for Act 1-1 WKSTs *Photographs 2 and 3*.
5. Discuss the answers to the following questions with your classmates.

Classroom Discussion:

1. Did everyone answer all of the questions correctly?
2. If everyone viewed the same photograph, list some possible reasons their answers differed.

Final Analysis:

1. Did your ability to see more detail and answer more questions correctly improve with practice? Explain your answer.
2. Do you consider yourself a good observer? Explain your answer.

ACTIVITY
1–2

You Are an Eyewitness! *Obj. 1.3, 1.4, 1.5, 1.7*

Objectives:

By the end of this activity, you will be able to:

1. Assess the validity of eyewitness accounts of a crime.
2. Test your own powers of observation.

Time Required to Complete Activity:

45 minutes

Materials:

Act 1-2 WKST *Jane's Restaurant*
Act 1-2 WKST *Jane's Questions*

SAFETY PRECAUTIONS:

None

Procedure:

1. Your teacher will provide you with a copy of Act 1-2 WKST *Jane's Restaurant,* the crime scene.
2. Study the image for three minutes.
3. Your teacher will provide you with Act 1-2 WKST *Jane's Questions*. When given the signal, answer as many questions about *Jane's Restaurant* as you can without looking at the illustration.

Questions:

1. How well did you do in remembering the details in this picture?
2. What do the results of this activity say, if anything, to you about the usefulness of eyewitness accounts in a court?
3. What factors influenced your observations?
4. How could you improve your observation skills?

ACTIVITY
1–3

What Influences Our Observations?

Obj. 1.3, 1.4, 1.5, 1.7, 1.8

Objectives:

By the end of this activity, you will be able to:

1. Test your ability to make observations.
2. Design an experiment involving a television commercial or magazine ad that demonstrates how different factors influence one's ability to observe.

Time Required to Complete Activity:

45 minutes

Materials:

Television commercial (taped or online) or magazine ad
Act 1-3 WKST *Observations*
Act 1-3 WKST *Form A Scientific Method*
Act 1-3 WKST *Form B Claim-Evidence-Reasoning*
Pen or pencil

SAFETY PRECAUTIONS:

None

Introduction:

After viewing a television or magazine ad, compare your ability to describe the commercial or magazine ad by answering specific questions about what you have observed.

Procedure:

PART A: EVALUATE YOUR OBSERVATION SKILLS

1. View a television commercial or magazine ad.
2. Answer the questions on the *Observations* worksheet.

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PART B: STUDENT-DESIGNED COMMERCIAL ACTIVITY

Design an activity that would demonstrate how different factors influence our ability to observe. Refer to the suggested factor list and select one factor that you will investigate.

1. Will the number of people in the room affect someone's observational skills?
2. Will someone's observational skills be affected if they are listening to music while making the observation?
3. Are men less observant of the surrounding environment if the commercial features an attractive woman?
4. Are women less observant of the surrounding environment if the commercial features a handsome man?
5. Are young people less observant of an older person in a commercial as opposed to a younger person?
6. Are older people less observant of younger people in a commercial as opposed to an older person?
7. Will famous people (e.g., actors, actresses, singers, and athletes) in a commercial encourage someone to watch the commercial and therefore be more observant of the product information?
8. Does ethnicity affect someone's ability to recognize someone of a different ethnic group?
9. Does the color of someone's clothing make the person more noticeable?
10. Are bald men more difficult to recognize than men who have hair?
11. If the person wears a hat, does that make them more difficult to recognize or more likely to be recognized?
12. Does a person's style of clothing make them more or less noticeable (e.g., are there differences in responses regarding a man wearing a suit as opposed to a man wearing jeans)?
13. Does the presence of a beard make someone less noticeable or more noticeable?
14. Is an overweight person less likely to be observed than someone of normal weight?

After selecting a factor to be tested, complete either Act 1-3 WKST *Form A Scientific Method* or Act 1-3 WKST *Form B Claim-Evidence-Reasoning*.

Form A: Scientific Method

Include the following information in your experimental design:

1. Question
2. Hypothesis
3. Experimental design
   a. Control
   b. Variable

4. Observations
   a. What you will measure and how you will measure it
   b. Data tables with your measurements
5. Conclusion based on your data

Form B: Claim-Evidence-Reasoning

1. State your question.
2. Describe what you will do to collect evidence that will be used to support your claim, or site the source of your evidence.
3. Your evidence should be based on observations and data. Evaluate your evidence and answer the following questions. Is your evidence:
   a. scientific?
   b. reliable?
   c. valid?
4. Based on your observations and data, state a claim or conclusion that answers your original question.
5. Cite the evidence from your data or observations that support your claim, or describe evidence that has been already scientifically documented to support your claim.
6. Reasoning: Write a paragraph that connects your claim and evidence to show how your data links to your claim.

Chapter 2

Crime-Scene Investigation and Evidence Collection

Lessons from the JonBenet Ramsey Case

The 1996 homicide investigation of six-year-old JonBenet Ramsey provides valuable lessons in proper crime-scene investigation procedures. From this case, we learn how important it is to secure a crime scene. Key forensic evidence can be lost forever without a secure crime scene.

In the Ramsey case, the police in Boulder, Colorado, allowed extensive contamination of the crime scene. Police first thought JonBenet had been kidnapped because of a ransom note allegedly found by her mother. For this reason, the police did not search the house until seven hours after the family called 9-1-1. The first responding police officer was investigating the alleged kidnapping, so he did not think to open the basement door and did not discover the body of the murdered girl.

Believing the crime was a kidnapping, the police blocked off JonBenet's bedroom with yellow and black crime-scene tape to preserve evidence her kidnapper may have left behind. But they did not seal off the rest of the house, which was also part of the crime scene. The victim's father, John Ramsey, discovered his daughter's body in the basement of the home. He covered her body with a blanket and carried her to the living room. In doing so, he contaminated the crime scene and may have disturbed evidence. That evidence might have identified the killer.

Once the body was found, family, friends, and police officers remained close by. The Ramseys and visitors were allowed to move freely around the house. One friend helped clean the kitchen, wiping down the counters with a spray cleaner—possibly wiping away evidence. Many hours passed before police blocked off the basement room. A pathologist did not examine the body until more than 18 hours after the crime took place.

Officers at this crime scene obviously made serious mistakes that may have resulted in the contamination or destruction of evidence. To this day, the crime remains unsolved.

Paul Sakuma/AP/Shutterstock.com

The Ramsey Home in Boulder, Colorado

LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

2.1 Describe the goals of crime-scene investigation.
2.2 Describe the roles and responsibilities of the types of professionals present at a crime scene.
2.3 Summarize Locard's Principle of Exchange.
2.4 Distinguish between different types of evidence.
2.5 List the seven steps (seven S's) of a crime-scene investigation.
2.6 Describe how a crime scene is secured.
2.7 Describe the various methods of documenting a crime scene.
2.8 Describe the proper technique in collecting and packaging trace evidence.
2.9 Explain how to map an outdoor crime scene.
2.10 Describe how evidence from a crime scene is analyzed.
2.11 Identify ways to determine if a crime scene was staged.
2.12 Identify several advances in technology that have improved crime-scene investigation.
2.13 Examine a crime scene for trace evidence as part of a crime scene investigation.
2.14 Apply the seven steps (seven S's) of crime-scene investigation to a crime scene.

KEY TERMS

- **chain of custody** the documented and unbroken transfer of evidence
- **circumstantial evidence** (indirect evidence) evidence used to imply a fact but not support it directly
- **class evidence** material that connects an individual or thing to a certain group (see individual evidence)
- **crime-scene investigation** a multidisciplinary approach in which scientific and legal professionals work together to solve a crime
- **crime-scene reconstruction** a hypothesis of the sequence of events from before the crime was committed through its commission
- **datum point** a permanent, fixed point of reference used in mapping a crime scene
- **direct evidence** evidence that (if authentic) supports an alleged fact of a case
- **first responder** the first safety official to arrive at a crime scene
- **individual evidence** a type of evidence that identifies a particular person or thing
- **paper bindle** a folded paper used to hold trace evidence
- **primary crime scene** the location where the crime took place
- **reliable evidence** evidence that is consistent when retested
- **secondary crime scene** a location other than the primary crime scene, but that is related to the crime; where evidence is found
- **subdatum point** one of several reference points of known coordinates marked from a measurable distance and direction from the datum point
- **trace evidence** small but measurable amounts of physical or biological material found at a crime scene
- **triangulation** a technique used to record evidence location from two fixed reference points
- **valid evidence** evidence (testimony, exhibits, demonstrative evidence, and documentary material) that is properly collected and documented and that truthfully supports a claim based on objective, scientific data from reliable sources

Introduction

It is almost impossible for a crime to be committed without the perpetrator leaving behind some type of evidence. Something as small as a hair, fibers, pollen, fingerprints, or human cells can help the police link a suspect to the crime scene or help to reconstruct the crime. Because many forms of evidence are small and easily lost or contaminated, it is crucial that a crime-scene investigators (CSIs) secure the crime scene. CSIs are trained to recognize, document, photograph, and collect all forms of evidence. They systemically process the crime scene to ensure all evidence is collected and ultimately accepted by the court. Solving the crime depends on piecing together the evidence to form a picture of what happened at the crime scene.

Crime-Scene Investigation *Obj. 2.1*

The goal of a **crime-scene investigation** is to recognize, document, photograph, and collect evidence at the scene of a crime. Solving the crime depends on piecing together the evidence to form a picture of what happened at the crime scene.

There are stringent guidelines for evidence acceptability (and expert witness testimony). These guidelines require evidence to be sufficient and scientific using quantitative, objective data. The evidence must be **reliable** (consistent when retested) and **valid** (properly collected and analyzed using accepted protocols). Evidence that is not valid, scientific, or properly collected, or is subjective, will not be acceptable in court.

The National Academy of Science Report in 2009 stated that evidence and evidence testing needs to be more scientific. That resulted in the formation of Scientific Working Groups (SWGs) for different types of evidence. SWG was composed of scientists, CSIs, professors, and other forensic professionals. Together, they revised and standardized protocols and recommendations to improve upon evidence collection and testing. Laboratory equipment used in forensic labs now need to be certified. SWGs evolved in the Organization of Scientific Area Committees (OSACs). Their work continues today but only on voluntary basis due to reductions in government funding.

The Crime-Scene Investigation Team *Obj. 2.2*

Who is involved in a crime-scene investigation? The team is made up of legal and scientific professionals who work together to solve a crime. Professionals at the scene of a crime may include police officers, detectives, CSIs, district attorneys, medical examiners, and scientific specialists.

- *Police officers* are usually the first to arrive at a crime scene. They secure the scene and direct activity. Most police officers are trained in basic forensic techniques. Officers must have a working knowledge of evidence collection so that they do not inadvertently compromise the evidence. They may be asked to collect evidence, especially in small police departments that do not have a CSI unit.

Police officers in small towns or communities might bag trace evidence, dust for fingerprints, or use tape to collect hairs or fibers.

- *District attorneys* may be called to the scene to determine whether a search warrant is necessary for the CSIs.
- *Crime-scene investigators* document the crime scene in detail and collect physical evidence. They record the data, sketch the scene, and take photos of the crime scene.
- *Medical examiners* (or coroners) determine the manner of death: *natural, accidental, homicide, suicide,* or *undetermined*.
- *Detectives* interview witnesses, CSIs, and specialists to obtain evidence that will help them reconstruct the crime scene.
- *Specialists*, such as forensic scientists and other specialists, may be consulted if the evidence requires their expertise. A forensic anthropologist studies human bones to determine factors such as sex, age, height, weight, and ethnic background of the victim. A botanist might be able to determine the time of year or region of the world in which a crime took place by studying plant material, including pollen that may have been left at a crime scene. An entomologist might be able to estimate the time since death, or *postmortem interval*, by studying insects colonizing a body. A forensic pathologist autopsies the body and determines the cause of death.

Locard's Principle of Exchange *Obj. 2.3*

Whenever two people come into contact with each other or with an object, a physical transfer occurs. Hair, skin cells, clothing fibers, pollen, glass fragments, debris from a person's clothing, makeup, or any number of different types of material can be transferred from one person or object to another. To a forensic examiner, these transferred materials constitute what is called **trace evidence**. Some common examples of trace evidence are the following:

- Pet hair on clothes or rugs
- Hair on brushes
- Fingerprints on a glass
- Soil tracked into homes or buildings on shoes
- A drop of blood on a T-shirt
- A used facial tissue
- Paint chips
- Broken glass fragments
- A fiber from clothing

The first person to note this was Dr. Edmond Locard, director of the world's first forensic laboratory in Lyon, France. He established several important ideas that are still a part of forensic studies today. Locard's Principle of Exchange states that when a person comes into contact with an object or another person, a cross-transfer of physical evidence can occur. The exchanged materials indicate

that the two entities were in contact. Trace evidence can be found on both entities because of this cross-transfer. This evidence that is exchanged bears a silent witness to the criminal act. Locard used transfer (trace) evidence from under a female victim's fingernails to help identify her attacker.

The second part of Locard's Principle states that the *intensity, duration*, and *nature* of the entities in contact determine the extent of the transfer. For example, more transfer would occur if two individuals engaged in a fistfight than if a person simply brushed past another person. However, exchanges are not always useful evidence. Finding a fingerprint on an object or a hair on a surface does not provide clues as to *when* the exchange occurred.

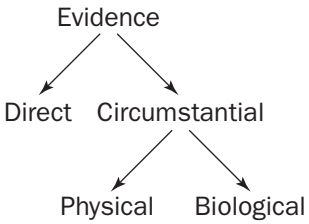
Types of Evidence *Obj. 2.4*

Evidence can be classified into two types: direct evidence and circumstantial evidence (**Figure 2-1**). **Direct evidence** includes firsthand observations such as eyewitness accounts or police dashboard video cameras. For example, a witness states that she saw a defendant pointing a gun at a victim during a robbery. In court, direct evidence involves testimony by a witness about what that witness personally saw, heard, or did. Confessions are also considered direct evidence.

Circumstantial evidence is indirect evidence that can be used to imply a fact but does not prove it. No one, other than the suspect and/or victim, actually knows when circumstantial evidence is produced. Circumstantial evidence found at a crime scene may provide a link between a crime scene and a suspect. For example, finding a suspect's gun at the site of a shooting is circumstantial evidence of the suspect's presence there.

Circumstantial evidence can be subdivided or classified into either physical or biological in nature (Figure 2-1). Physical evidence includes impressions such as fingerprints, footprints, shoe prints, tire impressions, and tool marks. Physical evidence also includes glass, soil, fibers, weapons, bullets, and shell casings. Biological evidence includes DNA in tissue, bodily fluids, hair, plants, pollen, and natural fibers. Most physical evidence, with the exception of fingerprints, reduces the number of suspects to a specific, smaller group of individuals. Biological evidence such as blood or DNA may make the group of suspects very small. In the case of DNA, it may reduce the group to a single individual, which is more persuasive in court. Trace evidence is a type of circumstantial evidence, examples of which include hair found on a brush, fingerprints on a glass, blood drops on a shirt, and soil tracked into a house (**Table 2-1**).

FIGURE 2-1 Classification of types of evidence.



DID YOU KNOW?

It is relatively easy to recover DNA from cigarette ends found at the scene of a crime.

TABLE 2-1 Common examples of trace evidence

Animal or human hair
Fingerprints
Soil or plant material (including pollen)
Body fluids such as mucus, semen, saliva, or blood
Fiber or debris from clothing
Paint chips, broken glass, or chemicals such as drugs or explosives

Evidence is characterized as being either class evidence or individual evidence. **Class evidence** narrows an identity to a group of persons or things. Knowing the ABO blood type of a sample of blood from a crime scene tells us that one of many persons with that blood type may have been there. It also allows us to exclude anyone with a different blood type. **Individual evidence** narrows an identity to a single person or thing. Individual evidence typically has such a unique combination of characteristics that it could only belong to one person or thing, such as a fingerprint or DNA.

The Seven S's of Crime-Scene Investigation *Obj. 2.5, 2.6, 2.7, 2.8*

The crime-scene investigation team needs to follow established protocols when dealing with a crime scene. Later, when presented for court proceedings, juries feel more confident if they can easily understand the steps involved in securing, collecting, documenting, and storing evidence and the collection of testimony from witnesses. These techniques can be summarized as the seven S's.

Step 1: Securing the Scene

Securing the scene is the responsibility of the first responding law-enforcement officer (**first responder**). The safety of all individuals in the area is the first priority. Preservation of evidence is the second priority. This means the officer protects the area within which the crime has occurred, restricting all unauthorized persons from entering. Transfer, loss, or contamination of evidence can occur if the area is left unsecured (Locard's Principle of Exchange). The first officer on the scene keeps a security log of all those who visit the crime scene. The officer collects pertinent information and requests any additional requirements for the investigation. They may ask for more officers to secure the area. Depending on the nature of the crime, the first responding officer may request various teams of experts to be sent to the crime scene.

Step 2: Separating the Witnesses

Separating the witnesses is the next priority. Witnesses must not be allowed to talk to each other. Crime-scene investigators will compare the witnesses' accounts of the events. Witnesses are separated so that they do not work together to create a story (collusion).

The following questions need to be asked of each witness:

- When did the crime occur?
- Who notified law enforcement?
- Who is the victim?
- Can the perpetrator be identified?
- What did you see happen?
- Where were you when you observed the crime scene?

DID YOU KNOW?

Crime-scene investigation teams do not clean up the scene. This dirty job often falls to the victim's family. Professional crime-scene cleaners can be hired to do this job.