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introduction to FORENSIC SCIENCE & Criminalistics

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To all the highly committed and largely unrecognized professionals who labor in forensic science laboratories throughout the nation. Former Attorney General John Ashcroft stated the case for their importance well in remarks made at the 2004 Plenary Session of the American Academy of Forensic Sciences annual meeting.

Excerpts from the Remarks of Hon. John Ashcroft, Attorney General of the United States, to the American Academy of Forensic Sciences, Dallas, Texas, February 18, 2004

We have the privilege, the opportunity, and the responsibility to protect the lives and liberty of the American people. This means preventing and punishing the predatory and lawless; detecting, disrupting and deterring those who would harm Americans; and, all the while, honoring the Constitution and the rule of law. . . .

The American Academy of Forensic Sciences has become a critical part of our nation's effort to provide equal protection under the law for every citizen.

Few groups have had as profound an impact on justice as the forensic science community.

The men and women in this room save lives. Your knowledge, your expertise, and your dedication to the truth bring justice to the guilty and a measure of peace to victims.

Forensic science is no longer on the fringes of criminal investigations. Science is solving cases that would otherwise remain unsolved. Science is identifying the guilty with a certainty that protects the innocent at the same time.

Forensic science plays no favorites. It cuts through prejudice. It validates truth. And to the extent that it speeds the arrest of criminals, it helps prevent crime, cutting short the careers of habitual offenders. . . .

A free nation is built on a fundamental trust in the citizen. And our free institutions, in turn, depend on the public's trust in the justice system. Thanks in part to advances in technology, Americans have grown more confident in law enforcement and more cooperative in the battle against crime. That is why the Department of Justice has been so supportive of proven forensic science and seeks to push forward new forensic advances. . . .

The war against terror reminds us all what an extraordinary vision founded this nation.

The war on terror has reminded us that there are those who oppose freedom, who abhor tolerance and new ideas, and who distrust this nation's fundamental belief that every life has potential and every life is precious. This shared vision is why we defend the rule of law. It is why we seek to punish the guilty. It is why we wish to take heart when the innocent are exonerated.

Your towering accomplishments—often beginning with the tiniest molecules of evidence—have had a profoundly powerful effect: protecting the integrity of the law and vindicating the suffering of victims.

dedication

Preface

Forensic science has become something of a household word in the past decade or so. Forensic DNA analysis, perhaps the most important development in forensic science ever, regularly makes the news now. For a number of years, probably beginning with cable television's interest in covering high-profile criminal trials, and the O.J. Simpson trial in particular, forensic science has become a regular feature on documentary as well as on news programs. And, in recent years, network television has featured prime-time programming that has forensic science as a focus; the *CSI* series is no doubt the most widely recognized.

The mass exposure to forensic science through media creates a danger of incorrect or misleading impressions and information through sensationalism and "artistic license." Under these circumstances, there is a need to provide good, reliable sources of information on the subject. Many college and university students throughout the country take introductory forensic science courses. The majority of them want to learn something about the subject, and perhaps how investigators, police, and attorneys make use of the information it can provide. They do not intend to be forensic scientists. There has never been a forensic science textbook directly aimed at these students, who are our citizens future, jurors, police officers, investigators, and lawyers. This is that book. It has a structure reflecting an underlying philosophy about forensic science as a science and as a profession. Appropriate pedagogic features have been incorporated. And the authors have vast and varied experience as forensic scientists and teachers.

The book was written for students to use in an undergraduate college or university course for nonmajors. It comfortably fits into a one-semester schedule. The book is primarily an introduction to what is often called "criminalistics." Think of criminalistics as comprising the activities and specialty areas found in a modern, full-service forensic science laboratory.

Organization

The whole book is organized along the lines of the criminalistics concepts of identification, individualization, and reconstruction. After introductory material and orientation to the subject, we move from crime scene investigation and reconstruction pattern analysis to categories of evidence for which individualization is the goal. Finally, types of evidence having identification as the primary goal of laboratory analysis are treated.

Following the introductory material in Part One, the book is divided into four more parts, each with two or more chapters. Those parts reflect the underlying philosophy of the book's order and organization. Part Two covers crime scene analysis and reconstruction patterns. Part Three treats another kind of pattern evidence; namely, pattern evidence, the primary goal of which is often individualization. Part Four covers biological evidence analysis and forensic DNA typing. Although biological evidence fits into the category of "evidence for individualization," the subject has become so important that it warrants separate treatment. Part Five involves evidence often called "chemical" and "trace." With these classes, identification and possibly quantitation is all that the lab is generally required to do.

The chapters on particular types of evidence (such as blood, drugs, etc.) all have an internal organization: the subject matter and background are introduced and explained; strategies and methods for collecting and packaging that type of evidence are enumerated and explained; and finally, the methods used for the forensic examination of that type of evidence, results that can be expected, and the strengths and limitations of the tests are presented and discussed.

Pedagogy

Even though the book was written for students who have little or no science or chemistry background, some basic concepts in scientific measurement and methods are necessary to fully understand all the material. Understanding the basic concepts will help students understand the science behind forensic science. Each chapter contains ***More on the Science*** boxes that take the students further into the methods or techniques that are described and may enrich the reading of the text for students who have more science background. We have tried to arrange the boxes so that a basic understanding of the subject does not require them.

In addition, there is an appendix called "Scientific Tools of the Trade—Methods of Forensic Science," which provides students with brief introductions to metric system measurement, the basic concepts of physical properties, and the chemical makeup of matter, elements, molecules, light and its interactions with matter, and an introduction to various instrumental methods.

Real-world forensic cases from our collective experience, and from the experience of other forensic scientists, are presented at the beginning of each chapter. Each case contains some of the basic topics covered in the chapter, so that students can see how the concepts are applied to real-world forensic investigation. The cases are designed to illustrate how the evidence discussed in that chapter can figure importantly in sorting out a real case. In addition, we have placed short case studies throughout the chapters of the book to help illustrate specific points and reinforce the potential utility of the evidence.

Each chapter is well illustrated with photographs and figures from the case files of the authors. This way, students can actually see how to dust for fingerprints or what the different types of bloodstain patterns look like.

Collectively, we have spent nearly 100 years practicing and teaching forensic science, and we do hope that the book manages to convey some of the sense of excitement and commitment that we still feel about our work!

Supplements

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For the Instructor

- *Instructor's Manual*—detailed chapter outlines, lecture notes, and teaching tips.
- *Test Bank*—a complete source of questions for each chapter of the text.
- *PowerPoint Slides*—chapter-specific slide shows featuring many of the illustrations from the text.
- *Online Learning Center Web site*—password-protected access to downloadable supplements and other important instructor support materials and additional resources.
- *Course Management Systems*—whether you use WebCT, Blackboard, e-College, or another course management system, McGraw-Hill will provide you with a cartridge that enables you either to conduct your course entirely online or to supplement your lectures with online material. And if your school does not yet have one of these course management systems, we can provide you with PageOut, an

easy-to-use tool that allows you to create your own course Web page and access all material on the Online Learning Center.

- *Primis Online*—a unique database publishing system that allows instructors to create a customized text from material in this text or elsewhere and deliver that text to students electronically as an e-book or in print format via the bookstore.

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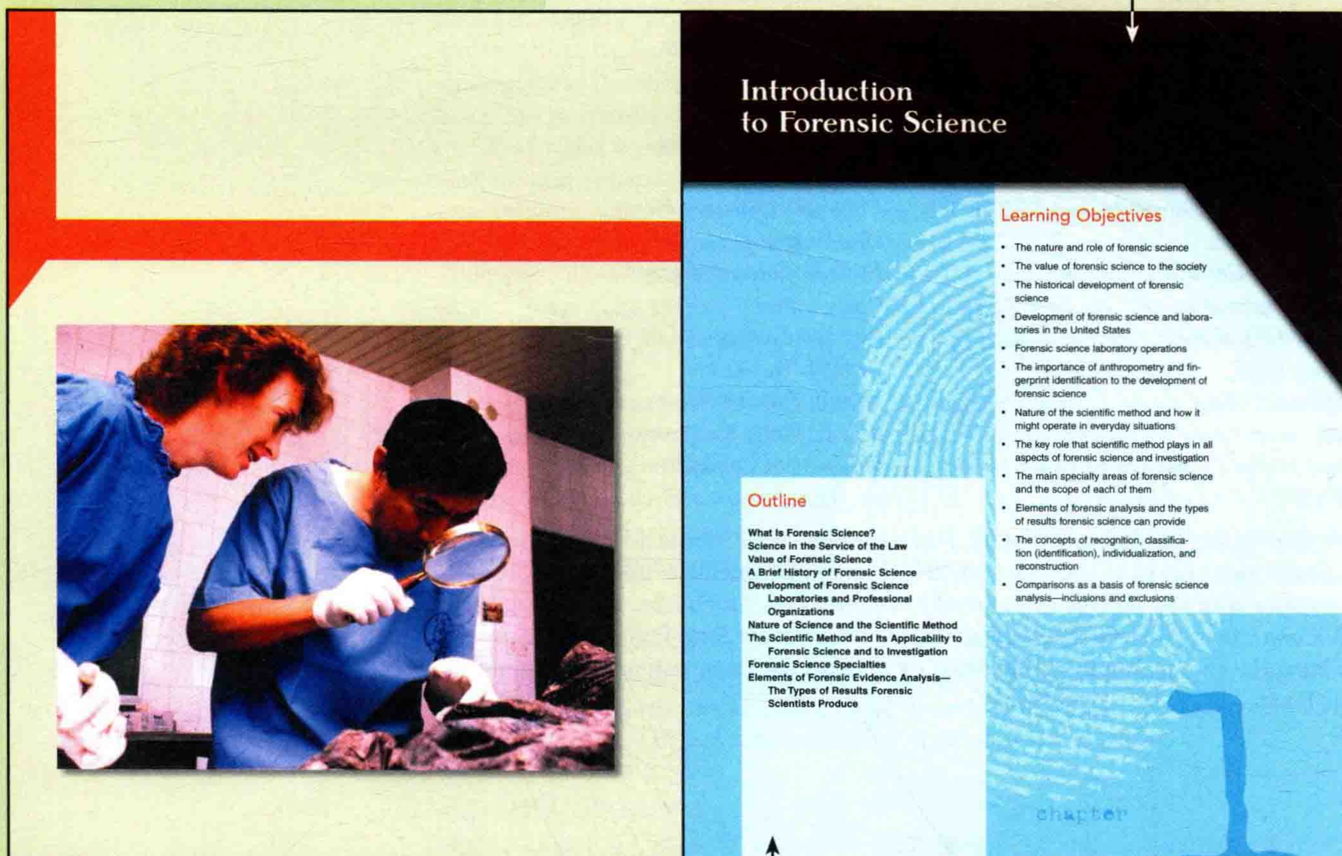
Learning Objectives

Learning Objectives provide students with learning goals for mastering the content in each chapter.



Introduction to Forensic Science

Learning Objectives

- The nature and role of forensic science
- The value of forensic science to the society
- The historical development of forensic science
- Development of forensic science and laboratories in the United States
- Forensic science laboratory operations
- The importance of anthropometry and fingerprint identification to the development of forensic science
- Nature of the scientific method and how it might operate in everyday situations
- The key role that scientific method plays in all aspects of forensic science and investigation
- The main specialty areas of forensic science and the scope of each of them
- Elements of forensic analysis and the types of results forensic science can provide
- The concepts of recognition, classification (identification), individualization, and reconstruction
- Comparisons as a basis of forensic science analysis—inclusions and exclusions

Outline

What Is Forensic Science?
Science in the Service of the Law
Value of Forensic Science
A Brief History of Forensic Science
Development of Forensic Science Laboratories and Professional Organizations
Nature of Science and the Scientific Method
The Scientific Method and Its Applicability to Forensic Science and to Investigation
Forensic Science Specialties
Elements of Forensic Evidence Analysis—The Types of Results Forensic Scientists Produce

chapter 1

Chapter Outlines

The Chapter Outlines provide an overview of the major sections in each chapter.

Lead Case

State V. Richard Crafts (This case has sometimes been called the "Wood Chipper Case")

In November of 1986, a flight attendant for Pan American World Airways named Helle Crafts returned to New York's John F. Kennedy International Airport from a routine international flight. She and another flight attendant, who both lived in Newtown, Connecticut, and were friends, took a limousine ride home. The limousine dropped Mrs. Crafts off at her home, and she and her flight attendant friend agreed to call one another later. Helle Crafts was never seen again.

Later, and into early December, the flight attendant friend tried to contact Helle without success. A private investigator named Oliver Mayo, who had been hired by Mrs. Crafts to investigate the possible extramarital activities of her husband, Richard, was also trying to find Helle. He had gathered unequivocal incriminating evidence of an extramarital affair against her husband, Richard, and Mayo wanted to give the information to Mrs. Crafts and collect his fee. When the local police were contacted, they did not show much interest in the case, indicating that Mrs. Crafts was an adult, that she hadn't been missing that long, and that she would probably turn up. Ultimately, the state attorney's office was contacted and an investigation by the state police was initiated.

Richard Crafts was a pilot for Eastern Airlines and flew a regular New York to Miami run. He was also a part-time officer in the local police department. The couple had three children, and because they were in the airline industry and required to travel so much, they had a live-in nanny.

Investigation by the state police showed that the morning after Helle returned from the international trip, Richard had risen early and told the nanny to take the children to the grandparents. Further investigation revealed that he had rented a large, diesel-powered wood chipper from a dealership a week earlier. (See Figure 1.1.) This large model wood chipper was one of only two in the state, and the only one in the southwestern area. The rental agent remembered Richard, because he had come to rent the machine driving a small passenger vehicle. The agent had told him the car was not powerful enough to pull the wood chipper, so Richard had then gone out and rented a U-Haul truck to use to pull the wood chipper. The agent also remembered that the wood chipper had been returned in the cleanest condition that he could ever remember.

Richard did own a wooded lot in Newtown. It was not, therefore, illogical for him to go and rent the chipper, except that all this activity was taking place during a major snowstorm in that part of the state. The storm had most people off the roads and at home, and many institutions were temporarily closed. A state snowplow driver reported seeing a U-Haul truck towing a large wood chipper headed toward Lake Zoar, a man-made lake (reservoir)—but he could not see who was driving. This activity took place the next night after Helle Crafts had returned home and gone missing.

The state police were suspicious that Helle might have met with foul play, and that Richard might be involved, but the evidence

Richard Crafts.

Figure 1.1 The diesel-powered wood chipper believed to have been used by Richard Crafts to dispose of portions of his wife's body following her murder.

Figure 1.2 Some of the numerous human bone fragments recovered in and near the wooded lot owned by Crafts on the shore of Lake Zoar; all the recovered fragments were human, and originated from the head, hands, or the feet.

was sketchy. Thinking the wood chipper might somehow be involved, an extensive search of the area along Lake Zoar was conducted. Thinking the worst—that maybe Helle had been killed and the wood chipper used to dispose of her remains—the state police, with the help of criminalists and a forensic odontologist from the forensic laboratory, searched for skeletal or other remains. With winter arriving, heavy snow covered the leaves that had fallen to the ground. The investigators and forensic scientists melted away the snow inch by inch as they searched, because the leaves and debris had to be separated from things underneath them. Large quantities of leaves, debris, and anything else on the ground were placed in oil drums filled with water to float off the leaves and light plant material. The water was then emptied through narrow mesh sieves to capture any small items that might have been present on the ground.

After some days searching, the forensic investigation team recovered the following (Figure 1.2):

- A human tooth
- A dental restoration
- 56 small pieces of bone, and 2,660 strands of human hair
- A portion of a human finger with some friction ridge skin
- A toenail painted with red nail polish

Now convinced they were handling a
the state police and the forensic laborato
forensic team to try and establish what h

A state police dive team search in
resulted in the recovery of a gasoline-po
not very old, and its fuel tank was still hal
number had been filed down to prevent r
number restoration in the laboratory reve
records showed that this chain saw had be
Crafts a few years previous. He had us
purchase record was still available. The
Richard had rented the U-Haul truck and
were extensively searched for evidence.

Wood chips were recovered from th
truck. The chain saw blade was carefull

bits of blood, tissue, fragments of head hair, and some bluish-green fibers. There was blood on some of the fibers.

The forensic issues in the case can be summarized as follows:

- Were the skeletal remains recovered those of Helle Crafts?
- Could a cause and manner of death be established? Was this a homicidal death?
- If the remains were of Helle Crafts, and if the death was homicidal, could Richard be implicated?

The forensic aspects of the investigation of this case involved many specialties: pathology, odontology, bone identification (physical anthropology), criminalistics, trace and materials evidence comparisons (such as the nail polish), wood chip comparisons, biological evidence, hair and fiber, toolmarks, and handwriting comparisons.

The evidence gathered is shown in the table on the next page, along with the forensic testing used for its examination, and the conclusions reached. Note that some of the findings are conclusive, but others are circumstantial.

The tooth and restoration identity were definite, so the remains recovered on the shoreline were those of Helle. The pathologist ultimately ruled the death a homicide based in part on

Lead Case

Hit-and-Run Death of a State Police Lieutenant

One morning early, a Connecticut state police lieutenant, commander of the Troop A barracks, was driving to work along Interstate 84 between Hartford and Waterbury. He noticed a disabled motorist pulled over on the shoulder of the road. Although he was not a patrol officer, and had no obligation to stop, he pulled over to assist the motorist. In accordance with protocol, he pulled the police cruiser up behind the disabled vehicle, engaged the emergency light bar, and exited the car. According to the motorist, his vehicle, the lieutenant's vehicle, and the lieutenant, were off the roadway and on the shoulder.

While the lieutenant was out of his vehicle, he was struck by a passing tractor-trailer rig, thrown a considerable distance, and probably died almost immediately. The tractor-trailer rig did not stop.

Word of the mishap was quickly relayed to state police who rushed to the scene of the hit-and-run and deployed considerable manpower to locate and stop the truck. The major crime squad and a team from the laboratory also helped in the hit-and-run scene investigation.

State police located and stopped a tractor-trailer rig that fit the description that had been given by the motorist. They were able to stop the rig before it could cross the bridge into New York State.

The major crime squad and laboratory team carefully examined the tractor-trailer for evidence. On the front portion of the trailer at what would be just about shoulder height for the state police lieutenant, the lab investigators found a nearly perfect mirror-image dust impression of the Connecticut state police shoulder patch worn on both shoulders of the uniform (see photos below).

The dust impression sealed the case from both criminal and civil points of view. The truck driver was convicted of hit-and-run manslaughter and sentenced to prison time. The company that owned the truck was sued civilly on behalf of the state police lieutenant's family, and the jury came back with a multimillion-dollar award for the lieutenant's wife and young family.

This case starkly illustrates the extraordinary value that physical pattern evidence can have sometimes, because it can be so clear, intuitive, and correspondingly convincing.

(a) (b) (c)

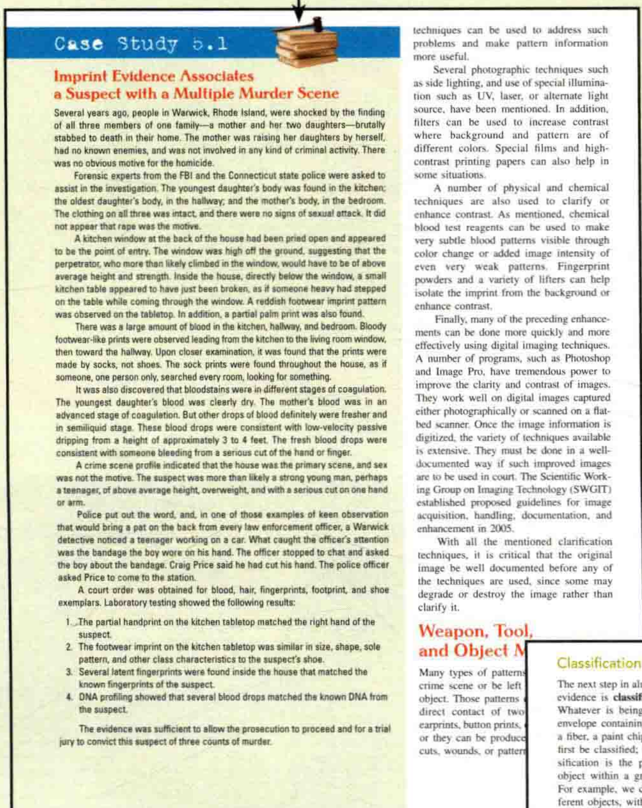
(A) The trailer (number 160) thought to be involved in the hit-and-run showed a dust-ike smudge near the corner of the trailer. (B) Closer inspection revealed a near perfect mirror image of the Connecticut State Police shoulder patch that resulted from the trailer hitting the lieutenant. (C) The uniform shirt with the actual shoulder patch worn by the lieutenant on the morning of his untimely death.

Lead Cases

Lead Cases are presented at the beginning of each chapter and offer ***Real-world forensic cases*** from the authors' collective experience, and from the experience of other forensic scientists. Each case contains some of the basic topics covered in the chapter, so that students can see how the concepts are applied to real-world forensic investigation.

Case Study Boxes

Case Study Boxes provide short cases and appear throughout each chapter to help illustrate specific points and reinforce the potential utility of the evidence.



Case Study 5.1

Imprint Evidence Associates a Suspect with a Multiple Murder Scene

Several years ago, people in Warwick, Rhode Island, were shocked by the finding of all three members of one family—a mother and her two daughters—brutally stabbed to death in their home. The mother was raising her daughters by herself, had no known enemies, and was not involved in any kind of criminal activity. There was no obvious motive for the homicide.

Forensic experts from the FBI and the Connecticut state police were asked to assist in the investigation. The youngest daughter's body was found in the kitchen; the oldest daughter's body, in the hallway; and the mother's body, in the bedroom. The clothing on all three was intact, and there were no signs of sexual attack. It did not appear that rape was the motive.

A kitchen window at the back of the house had been pried open and appeared to be the point of entry. The window was high off the ground, suggesting that the perpetrator, who more than likely climbed in the window, would have to be of above average height and strength. Inside the house, directly below the window, a small kitchen table appeared to have just been broken, as if someone heavy had stepped on the table while coming through the window. A reddish footwear imprint pattern was observed on the tabletop. In addition, a partial palm print was also found.

There was a large amount of blood in the kitchen, hallway, and bedroom. Bloody footwear-like prints were observed leading from the kitchen to the living room window, then toward the hallway. Upon closer examination, it was found that the prints were made by socks, not shoes. The sock prints were found throughout the house, as if someone, one person only, searched every room, looking for something.

It was also discovered that bloodstains were in different stages of coagulation. The youngest daughter's blood was clearly dry. The mother's blood was in an advanced stage of coagulation. But other drops of blood definitely were fresher and in semiliquid stage. These blood drops were consistent with low-velocity passive dripping from a height of approximately 3 to 4 feet. The fresh blood drops were consistent with someone bleeding from a serious cut of the hand or finger.

A crime scene profile indicated that the house was the primary scene, and sex was not the motive. The suspect was more than likely a strong young man, perhaps a teenager, of above average height, overweight, and with a serious cut on one hand or arm.

Police put out the word, and, in one of those examples of keen observation that would bring a pat on the back from every law enforcement officer, a Warwick detective noticed a teenager working on a car. What caught the officer's attention was the bandage the boy wore on his hand. The officer stopped to chat and asked the boy about the bandage. Craig Price said he had cut his hand. The police officer asked Price to come to the station.

A court order was obtained for blood, hair, fingerprints, footprint, and shoe exemplars. Laboratory testing showed the following results:

1. The partial handprint on the kitchen tabletop matched the right hand of the suspect.
2. The footwear imprint on the kitchen tabletop was similar in size, shape, sole pattern, and other class characteristics to the suspect's shoe.
3. Several latent fingerprints were found inside the house that matched the known fingerprints of the suspect.
4. DNA profiling showed that several blood drops matched the known DNA from the suspect.

The evidence was sufficient to allow the prosecution to proceed and for a trial jury to convict this suspect of three counts of murder.

techniques can be used to address such problems and make pattern information more useful.

Several photographic techniques such as side lighting, and use of special illumination such as UV, laser, or alternate light source, have been mentioned. In addition, filters can be used to increase contrast where background and pattern are of different colors. Special films and high-contrast printing papers can also help in some situations.

A number of physical and chemical techniques are also used to clarify or enhance contrast. As mentioned, chemical blood test reagents can be used to make very subtle blood patterns visible through color change or added image intensity of even very weak patterns. Fingerprint powders and a variety of lifters can help isolate the imprint from the background or enhance contrast.

Finally, many of the preceding enhancements can be done more quickly and more effectively using digital imaging techniques. A number of programs, such as Photoshop and Image Pro, have tremendous power to improve the clarity and contrast of images. They work well on digital images captured either photographically or scanned on a flatbed scanner. Once the image information is digitized, the variety of techniques available is extensive. They must be done in a well-documented way if such improved images are to be used in court. The Scientific Working Group on Imaging Technology (SWGIT) established proposed guidelines for image acquisition, handling, documentation, and enhancement in 2005.

With all the mentioned clarification techniques, it is critical that the original image be well documented before any of the techniques are used, since some may degrade or destroy the image rather than clarify it.

Weapon, Tool, and Object M

Many types of patterns
crime scene or be left
object. Those patterns
direct contact of two
earprints, button prints,
or they can be produce
cuts, wounds, or patter

Classification (Identification)

The next step in almost any examination of evidence is **classification (identification).** Whatever is being examined—a glassine envelope containing white powder, a hair, a fiber, a paint chip, a bloodstain—it must first be classified; that is, identified. Classification is the process of placing that object within a group of similar objects. For example, we can recognize many different objects, with quite different appearance, and still classify them all as chairs. It might be a very broad group or a highly specific group. Classifying things is not "individualizing" them.

With some types of evidence, generally the ones we will group under the heading of "chemical evidence" (illicit drugs, gunshot residue, etc.), examination in the forensic lab consists exclusively of classification. Chemical or instrumental techniques are required to establish these classifications, and the courts require that this be done to sustain a prosecution. Note that sometimes, items are classified in the laboratory as a means of establishing the corpus delicti of a crime (see earlier). Demonstrating that fire debris contains an ignitable liquid residue that could be an accelerant material helps establish that arson may have been committed. Demonstrating that semen is present on a vaginal swab taken from a sexual assault complainant corroborates that penetration occurred. The laboratory must establish these crucial facts if cases are going to be properly proven.

Case Study 1.2

Simple Classification of a Common Object Can Be an Important First Step in Formulating a Hypothesis about a Case

A knife is found near the victim at the scene of a homicide. The first thing that the investigator does, sometimes largely unconsciously, is classifying that knife. It appears to be a kitchen knife with a 7-inch blade and a 3-inch handle. The blade is pointed and is narrow and not tapered. The handle is wood and fastened with two rivets, where the shaft of the blade is fastened into the wood of the handle. If the investigator is familiar with kitchen knives he/she may further categorize (classify) it as a "boning knife." Collecting this knife and sending it to a crime laboratory will result in more detailed measurements of width and length and perhaps description of the metal of the blade and the wood of the handle.

The initial description (classification/identification) alone may be useful to the medical examiner in determining if the knife was the weapon used in the crime. If, however, the investigator moves into the kitchen and discovers that there is a knife block with six slits and five knives and that the empty slit is a narrow one, the classification of the knife becomes more investigatively important. If the knife found near the victim is indeed the missing knife from the block, the hypothesis is that this is not a premeditated crime, but one of opportunity. This is all done just from a careful classification of the knife. An individualization that this is the one and only knife from this set is likely to be impossible, since the manufacturer probably made tens of thousands of these sets. The block and its knives are packaged separately and sent to the forensic science laboratory for further examination.

Careful measurement of the knife and comparison to the other knives of the set may disclose that they are not consistent (disassociation). The knife is a few millimeters wider than the slot, and the rivets in the handle are steel, not brass as in the rest of the set. The hypothesis must be reevaluated. It is not necessarily false. Perhaps the original knife was lost or broken and someone in the household purchased a replacement knife of similar type and discovered it would not fit in the slit. It was, therefore, kept in a nearby drawer. On the other hand, perhaps the killer brought a knife along to commit the murder. The important point is that a careful and complete classification of the evidence is critical to the investigation of the case, and jumping to conclusions may cause serious detours on the road to a solution of the case.

An important result of the classification, or the association, process is exclusion from the class, or disassociation. The "negative association" has the advantage of being an absolute in most instances. When significant differences from other items in the class are found, the object is excluded and is clearly not in the class. As one compares two objects and tries to see if they are in the same very small class, one can never be sure that one more comparison might not remove them from the same class. The same problem does not exist with elimination or disassociation (also see later under Individualization).

classification (identification)
To place things into groups according to their basic characteristics.

One common problem in understanding forensic results is that the word *identification* can mean *classification* in one context, but it is also used to mean *individualization* in another context. Identifying a small piece of material, such as a paint chip, is a classification. Identifying a fingerprint, or a person, is an individualization. We will use the term "identification" to mean individualization in the pattern evidence chapters and in discussing the identification of persons, because that is the terminology that those specialists regularly use. We will use "classification" or "classification (identification)" to mean placing an item or person into a group when dealing with other items of physical evidence.

Marginal Glossary Terms

Marginal Glossary Terms highlight important terms for students to remember.

More on the Science

Everyday Examples of Applying the Scientific Method

Many applications of scientific method are quite mundane. If you were to spill some water on the ground, when you returned a couple of hours later you would probably observe that the water had disappeared. The first person who made that observation didn't understand the concept of evaporation but knew there was a puddle there and then some time later there was no puddle there. Something had happened. We know that the water passed from the liquid phase to the gas phase and as the air circulated the water dissipated. You might also observe that on a hot day it tends to disappear a little faster than on a cold day. Perhaps there is a correlation between temperature and the rate in which things pass from the liquid phase to the gas phase.

Let's say we never had high school science so we propose a simple set of experiments to test our hypothesis that when water evaporates, heat seems to be involved. How could you test this? Start with the hypothesis that heat has something to do with water passing from liquid phase to gas phase and dissipating. Go to the kitchen and measure out one cup of water and place it in a pot. Place the pot on a burner and turn on the burner. If you have an electric stove, you have numbered positions, so you can turn it to position two, for example. Measure how long it takes for the water to evaporate. Let's say it takes 15 minutes for the water to disappear. Next measure another cup of water and place it in the cooled pot, put it on the burner, and set the burner at position five (a higher heat setting). Measure the time until the water is gone; you may notice that instead of taking 15 minutes, it takes only 11 minutes. This is one simple test of the hypothesis that the more heat one puts into the water, the faster it disappears.

Another example that virtually everyone who drives has experienced at one time or another is the timing of traffic lights on a stretch of road with many intersections. We've all driven late at night when traffic is light and we've been anxious to get home. What's going to happen if you're in a big hurry and try to drive 70 mph? Besides risking being arrested, you will be stopped by virtually every traffic light. It will seem as if there is a traffic light every 15 feet and the trip will seem to take forever. It is common knowledge that some great force—actually the traffic department—regulates traffic lights.

In the past, clocks were located in the poles of traffic lights to control the action of the lights; however, today they are controlled by computers. The point is that there should be some speed at which you can travel that will allow you to go through a series of lights, maybe 10 or 15 lights, and make them all. You can guess that that speed is not going to be 70 mph because the traffic department does not want you to go 70 mph. The magic speed is probably not going to be 15 mph, either, because the traffic department gets judged on how well it moves traffic along.

How do we use scientific method to answer this question? The hypothesis is that these lights are timed for a particular speed. Therefore, you can try to travel the course at a steady speed. For example, you can try 42 mph and see what happens. You will probably make three or four lights and then get stopped; make a few more and get stopped again. The next experiment is perhaps at 37 mph. Carefully observe the results and try to see if you miss fewer lights. Try a series of speeds based on how well you seem to be avoiding red lights. You will probably find that the lights are timed fairly close to the speed limit. It will not necessarily be the speed limit, and it may change with the time of day.

Here is one last illustration, which you might call the "shower caper." Let's say a family moved into their first house and within the first two weeks, much of the kitchen ceiling fell on their heads while they were eating breakfast in the kitchen. The preteen daughter was taking a shower upstairs in the hall bathroom, which was right over the kitchen. As it turned out, it wasn't really her

Careful Observation

The importance of the words *careful observation* cannot be overemphasized. The first step in the scientific method is being receptive and inquisitive. Anyone can be a careful observer. Observations of events and phenomena in the natural world and curiosity about what is behind them have been the driving force behind the development of science.

Make Logical Suppositions to Explain the Ob

The point of scientific inquiry is to try to understand natural natural world. So, the second step is to take an "educated guess" The educated guess is usually called a **hypothesis.** The essen hypothesis is that it must be composed of *experimentally testab* dictions can be made based on the truth of the hypothesis. If th certain things that follow from it must be true, and experiments the predictions.

hypothesis
An as yet unproven attempt to develop an explanation for an observation or series of related observations.

More on the Science

Each chapter contains ***More on the Science*** boxes that take the students further into the methods or techniques that are described and may enrich the reading of the text for students who have more science background.

existing bloody surface with motion. A swipe pattern is created by a bloody object contacting another surface with motion (Figures 4.4C).

An *arterial spurt* pattern results when an artery is cut or severed, and blood is literally pumped out of the body by the beating heart and onto a nearby surface. The repeated spurts cause a rather characteristic pattern. These patterns generally contain quite a bit of blood. In addition, an individual with a seriously severed artery is losing blood at such a rate that he or she will not be able to move too far and, without immediate and extreme medical intervention, will die fairly quickly.

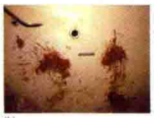
Cast-off (also called *arc swing*) patterns result when a bloody object is swung through space and throws off droplets onto a nearby surface (Figure 4.4D). These patterns may be seen on ceilings or walls, even occasionally on floors. The most common action causing such a pattern is repeated use of blunt force on a person who is bleeding. This pattern was noted on the ceiling of the van in the lead case for this chapter.

Running patterns are just what the name says. Blood hits a vertical surface, but the volume is sufficiently high that gravity causes the droplet to run. Note that blood can only run down. As obvious as that statement is, it is sometimes quite helpful in reconstructing events from blood patterns.

Secondary spatter patterns result when blood drops fall into a preexisting pool of blood. As each drop hits the liquid surface, it can cause small droplets to splash upward, and some of these may hit a nearby vertical surface (Figure 4.4E). The

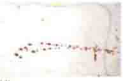
Figure 4.3
A straight-line reconstruction from a high/medium velocity blood spatter pattern. The straight lines formed by string are arranged at the angles of incidence calculated for selected droplets in the pattern. These lines converge approximately to a point. In this case, a person committed suicide in a bathroom by placing the muzzle of a shotgun in his mouth and firing. The blood pattern reconstruction confirms that the source of the blood was approximately in the position of the victim's head. The strings project outward from the wall into the room. (Courtesy of Timothy Palmbach, University of New Haven)

(a)



(b)

(c)



(d)

(e)

Figure 4.4A-E
A—Low velocity dripping pattern produced when the blood source is moving with respect to the target surface. The direction of movement can sometimes be discerned from the pattern.
B—Contact transfer pattern where a person's bloody hair made contact with the vertical surface. (Courtesy of Timothy Palmbach, University of New Haven)
C—Swipe pattern. (Courtesy of Timothy Palmbach, University of New Haven)
D—Cast off pattern. (Courtesy of Timothy Palmbach, University of New Haven)
E—Secondary spatter pattern. Blood dripping onto a hard floor surface causes a secondary spatter pattern on the nearby vertical surface. In this controlled setup, blood was dripping from 4 feet above the floor. The scale on the right side of the target is marked off in centimeters.

Photographs and Figures

Each chapter is well illustrated with photographs and figures from the case files of the authors. This way, students can actually see how to dust for fingerprints or what the different types of bloodstain patterns look like.

End of Chapter Elements

Each chapter closes with a summary, list of key terms, review questions, and further references.

Summary

Fingerprints comprise one of the oldest kinds of forensic evidence. Their individuality has been recognized for hundreds of years, and they have been used in criminal identification for most of the 20th century. Fingerprints are formed before birth and are permanent and unchanging throughout life. The patterns are not completely explainable through genetics, because identical twins have distinguishable fingerprints. The basic fingerprint patterns are arches, loops, and whorls. There are variations within these basic patterns. Individual characteristics within the friction ridge skin that makes up fingerprints are called minutiae; the most common are ridge endings and bifurcations.

The use of fingerprints for personal identification was developed in Europe and by Europeans working in India and Asia. The first systematic biometric system for criminal identification was called anthropometry and was developed by Bertillon in France. It consisted of a set of body measurements. Bertillon's system was supplanted by fingerprints when it was realized that there could be duplicate Bertillon measurements in different individuals. Fingerprints as a means of criminal identification were adopted by the London Metropolitan Police and by the police in Argentina, after which their use in criminal investigations spread all over the world. Classification systems for 10-print cards were devised by Vucetich and by Henry and were used for decades until Automated Fingerprint Identification Systems (AFISs) were developed. AFISs enabled searching large files for single prints and revolutionized the use of fingerprints for criminal identification. AFIS databases also enabled the use of fingerprints for verification of identity—this is an example of fingerprints as biometrics. Law enforcement AFISs contain fingerprints of known persons and fingerprints of unknown origin from unsolved cases (forensic file).

Evidentiary prints may be visible, plastic, or latent. Enhancement, or visualization, procedures are used to make latent prints visible and suitable for comparisons. They include physical methods (such as powder or SPR), chemical methods (such as ninhydrin or iodine fuming or Super Glue), and special illumination techniques (such as alternate light sources and lasers) and combination methods. Bloody fingerprints can require special techniques of enhancement. It may also be important to decide on the relative importance of the blood (for DNA typing) and the fingerprint. Fingerprints on sticky tape also require special techniques. Systematic approaches involve using a series of enhancement methods serially, such that the least destructive techniques are used first.

Fingerprint identification is based on fingerprints being unchangeable throughout life, and being individual. The entire process involved is termed ACE-V, for analysis, comparison, evaluation, and verification. The overall patterns and ridge flow of a fingerprint are known as "level I" features, minutiae are known as "level II," and ridge relationships and pore sizes and distributions are known as "level III." Fingerprints can often be matched to an individual using level I and level II detail. An examiner can also exclude someone as the depositor of a fingerprint. Of course, sometimes evidence fingerprints are of poor quality and therefore unsuitable for comparison.

The primary professional organization for fingerprint examiners is the International Association for Identification, which publishes the *Journal of Forensic Identification*. More recently, there has been a Scientific Working Group on friction ridge pattern comparisons. Research is ongoing to try and systematically establish fingerprint individuality.

Other patterns for personal identification include palm and sole prints. They are examined like fingerprints. Bite marks may contain individuality as well, reflecting the individual characteristics of the teeth that made them. They are compared by forensic dentists. Skeletal patterns that are examined by forensic anthropologists can help narrow down the identity of skeletal remains. Forensic radiologists can sometimes identify people from a comparison of pre- and postmortem X-rays. Occasionally, lip or ear prints have been examined in criminal cases, and voice patterns have considerable individual character as well.

Fingerprints (and Bertillon's system of measurements) are examples of biometrics. Today, biometrics also includes eye (iris or retinal) patterns and various facial patterns. Biometrics is coming into use more and more as a method of verification of identity. These methods are considered superior to "paper" forms of identification and less subject to loss and forgery.

In mass disasters, where identification of remains cannot be done by direct viewing, fingerprints and dental identification are the preferred methods. DNA typing may also be used, but it is more complicated and time-consuming.

Key Terms

friction ridge skin (p. 126)
basic fingerprint patterns: arches, loops, and whorls (p. 126)
minutiae (p. 126)
anthropometry (bertillonage) (p. 127)
classification system (p. 129)
AFISs (p. 130)
visible (patent) print (p. 132)
plastic (impression) print (p. 132)
latent print (p. 132)
development (enhancement, visualization) (p. 132)
powder dusting (p. 134)
magnetic brush technique (p. 134)
small particle reagent (SPR) (p. 134)
iodine fuming (p. 135)
ninhydrin (p. 135)
Super Glue (cyanoacrylate) (p. 137)
dye stains (p. 137)
physical developer (p. 137)
alternate light source (p. 138)
laser (p. 138)
suitability for examination (p. 142)
ACE-V method (p. 142)
level I, level II, and level III detail (p. 142)
biometrics (p. 146)

Review Questions—Short Answer

1. What are fingerprints? Why are they useful in criminal investigation?
2. What is an AFIS? Why is it valuable?
3. What are the main types of evidentiary prints that might be found at scenes?
4. What are some physical methods for enhancing latent fingerprints?
5. What are some chemical methods for enhancing latent fingerprints?
6. What are some special illumination methods for enhancing latent fingerprints?
7. How might bloody fingerprints be enhanced?
8. What is the basis for fingerprint identification? What are the main principles?
9. What are some other patterns useful in person identification?
10. What are the major methods of identifying human remains in mass disasters?

Fill-in-the-Blank & Multiple Choice

1. One important characteristic of friction ridge patterns is that they __________ between birth and death.
2. The three basic fingerprint patterns are (1) arch, (2) __________, and (3) __________.
3. Fingerprints found at crime scenes or on evidence can be divided into three broad categories (not classifications) based on their appearance and physical makeup: (1) ____________, (2) patent (visible), and (3) ____________.
4. When a latent fingerprint is compared with a known inked print, and according to the numerical rule, the number of points of comparison required to correspond before a positive identification can be declared is
   a. enough to satisfy the expert latent examiner.
   b. at least eight.
   c. at least twelve.
   d. the pattern and 10 minutiae.
5. Computerized fingerprint search systems match fingerprints by comparing the relative positions of
   a. core and delta.
   b. pattern center and all bifurcations.
   c. all individualizable minutiae.
   d. bifurcations and ridge endings.

Further References

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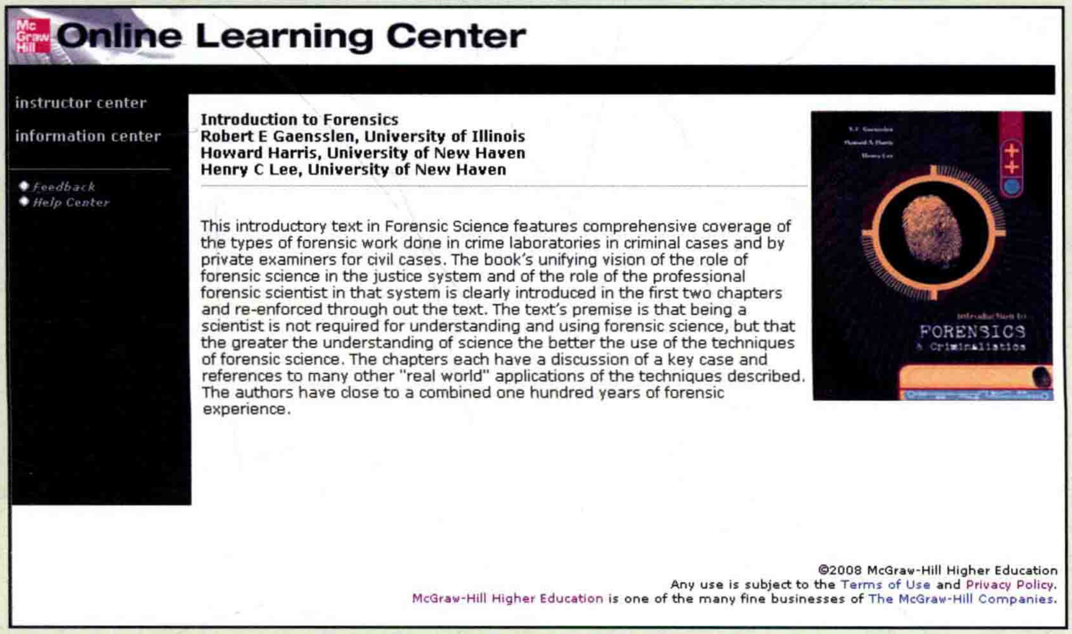
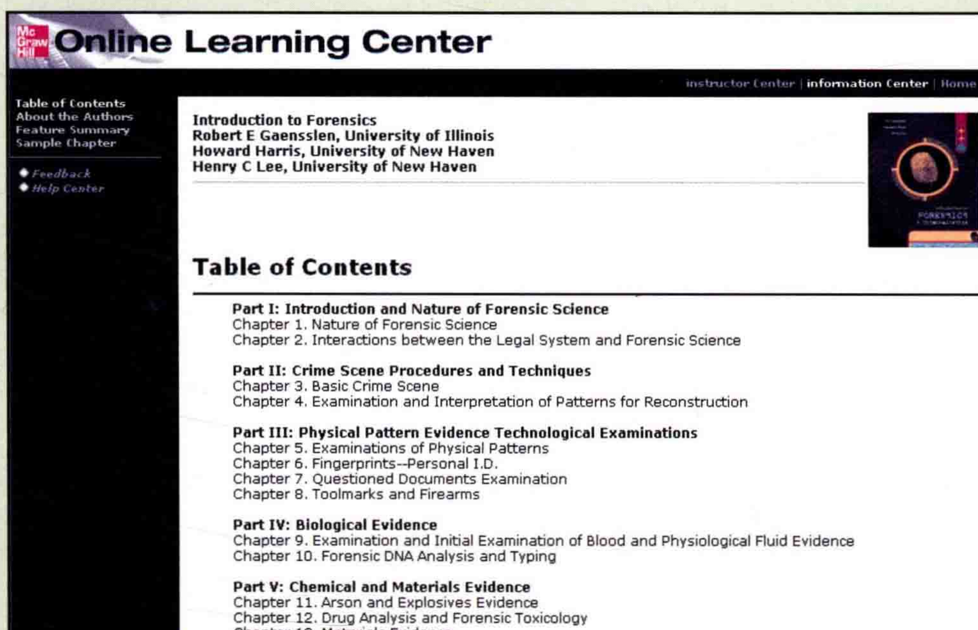


Online Learning Center Web site

Book-specific Web site features chapter quizzes to help students prepare for exams, flashcards to help students master vocabulary, and an interactive glossary.



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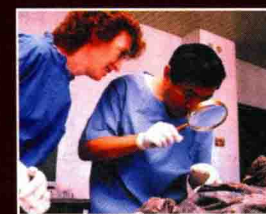

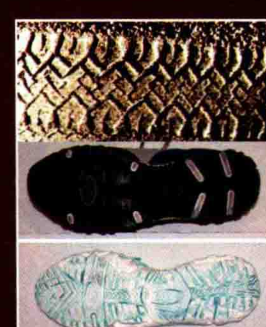

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