5 Physical Evidence

AP Photo/Nick Ut

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- **• Explain the difference between the identification and comparison of physical evidence.**
- **• Define and contrast individual and class characteristics of physical evidence.**
- **• Appreciate the value of class evidence as it relates to a criminal investigation.**
- **• List and explain the function of national databases available to forensic scientists.**

THE GRIM SLEEPER

The killing spree began in 1985 in Los Angeles, California, and apparently ended in 1988. All but one of the serial killer’s eight victims were black females. Many of his victims were prostitutes with whom he would have sexual contact before strangling or shooting them. In 2002, the killing resumed. The attacker was dubbed the “Grim Sleeper” because he appeared to have taken a fourteen-year hiatus from his crimes. By 2007, three more females were added to his list of victims. What proved particularly frustrating to investigators was that, even though this killer left behind

DNA evidence at many of his crime scenes, a search of the DNA databases proved fruitless in establishing an identification. If the killer had been convicted of criminal activities in the past, they never resulted in the collection of his DNA and its placement in the California database. Finally, in 2010, police arrested and identified Lonnie David Franklin Jr. as the Grim Sleeper. The arrest of Franklin came about through a familial DNA search, which trolls through the DNA database looking for partial DNA matches that could be linked to a close relative in the file. One prisoner—Franklin's son Christopher—shared a strong familial pattern with the serial killer. Investigators used DNA collected off a discarded pizza crust eaten by Lonnie Franklin to link his DNA to the Grim Sleeper's victims.

Examination of Physical Evidence

Physical evidence is usually examined by a forensic scientist for identification or comparison.

IDENTIFICATION

The purpose of **identification** is to determine the physical or chemical identity of a substance with the most certainty that existing analytical techniques will permit. For example, the crime laboratory is frequently asked to identify the chemical composition of preparations that may contain illicit drugs such as heroin, cocaine, or barbiturates. It may be asked to identify gasoline in residues recovered from the debris of a fire, or it may have to identify the nature of explosive residues—for example, dynamite or TNT. Also, the identification of blood, semen, hair, or wood would, as a matter of routine, include a determination of species origin. For example, did a bloodstain originate from a human or a dog or cat? Each of these requests requires the analysis and ultimate identification of a specific physical or chemical substance to the exclusion of all other possible substances.

identification

The process of determining a substance's physical or chemical identity.

The process of identification first requires adopting testing procedures that give characteristic results for specific standard materials. Once these test results have been established, they may be permanently recorded and used repeatedly to prove the identity of suspect materials. For example, to ascertain that a particular suspect powder is heroin, the test results on the powder must be identical to those that have been previously obtained from a known heroin sample.

Second, identification requires that the number and type of tests used to identify a substance be sufficient to exclude all other substances. This means that the examiner must devise a specific analytical scheme that will eliminate all but one substance from consideration. Hence, if the examiner concludes that a white powder contains heroin, the test results must have been comprehensive enough to have excluded all other drugs—or, for that matter, all other substances—from consideration.

Simple rules cannot be devised for defining what constitutes a thorough and foolproof analytical scheme. Obviously, each type of evidence requires a unique test, and each test has a different degree of specificity. Thus, one substance could conceivably be identified by one test, whereas another may require the combination of five or six different tests to arrive at an identification. Because the foresic scientist has little or no control over the quality and quantity of the specimens received, a standard series of tests cannot prevent all possible problems and pitfalls. So the forensic scientist must determine at what point the analysis can be concluded and when the criteria for positive identification has been satisfied; for this, he or she must rely on knowledge gained through education and experience. Ultimately, the conclusion will have to be substantiated beyond any reasonable doubt in a court of law.

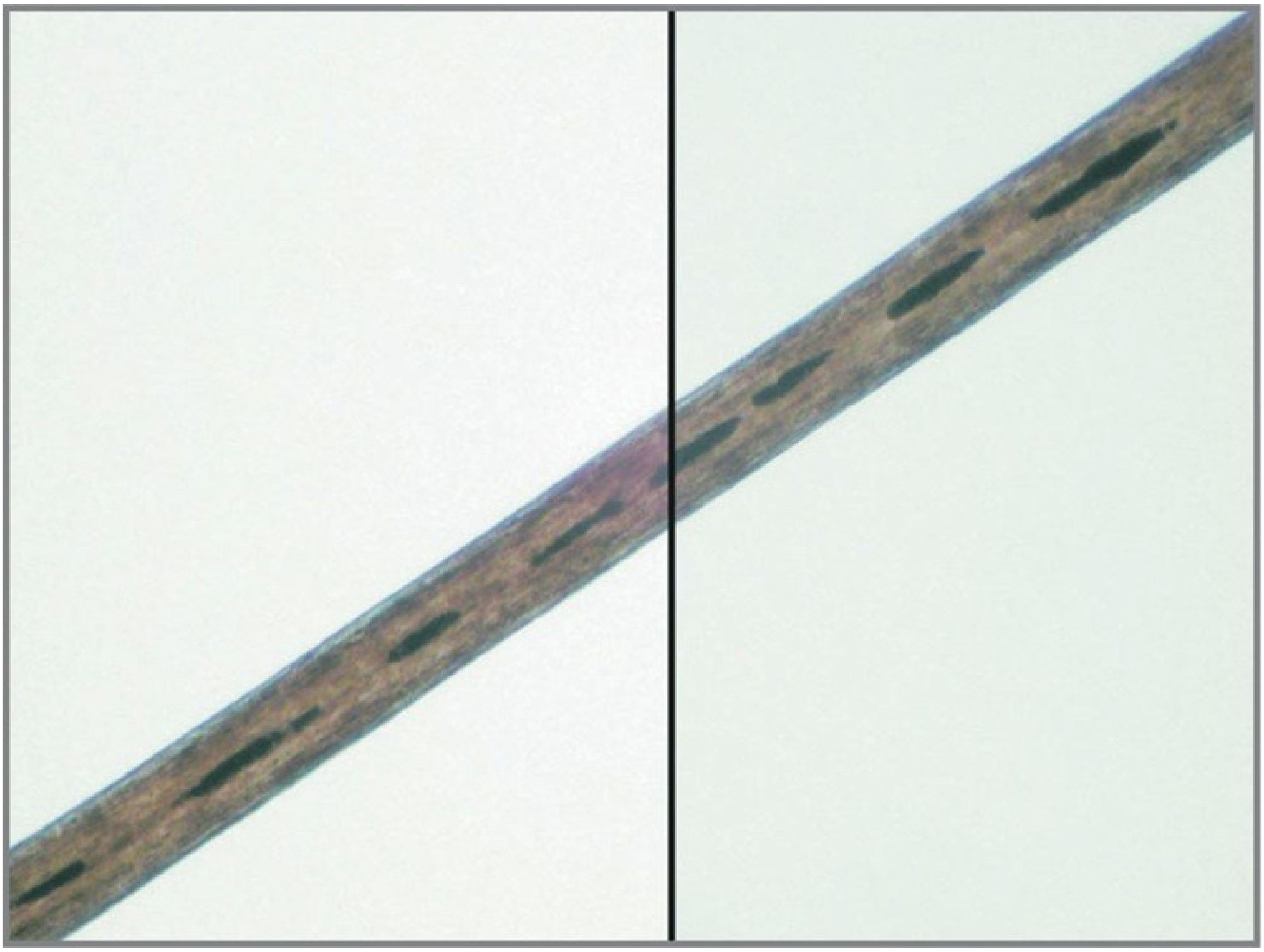
COMPARISON

A **comparison** analysis subjects a suspect specimen and a standard, or reference, specimen to the same tests and examinations to ultimately determine whether they have a common origin. For example, the forensic scientist may link a suspect to a particular location by noting the similarities of a hair found at the crime scene to hairs removed from the suspect's head (see Figure 5-1). Or a paint chip found on a hit-and-run victim's garment may be compared with paint removed from a vehicle suspected of being involved in the incident.

comparison

The process of ascertaining whether two or more objects have a common origin.

FIGURE 5-1 A side-by-side comparison of hairs.



Courtesy Chris Palenik, Microtrace LLC, Elgin, IL, www.microtracescientific.com

The forensic comparison is actually a two-step procedure. First, combinations of select properties are chosen from the suspect and the standard/reference specimen for comparison. The question of which and how many properties are selected depends on the type of materials being examined. (This subject will receive a good deal of discussion in forthcoming chapters.) The overriding consideration must be the ultimate evidential value the conclusion will have.

Once the examination has been completed, the forensic scientist must draw a conclusion about the origins of the specimens. Reaching this conclusion is the second objective. Do they come from the same source or not? Certainly, if one or more of the properties selected for comparison do not agree, the analyst will conclude that the specimens are not the same and therefore could not have originated from the same source. Suppose, on the other hand, that all the properties do compare and the specimens, as far as the examiner can determine, are indistinguishable. Does it logically follow that they came from the same source? Not necessarily.

To comprehend the evidential value of a comparison, one must appreciate the role that probability has in ascertaining the origins of two or more specimens. Simply defined, *probability* is the frequency of occurrences of an event. If a coin is flipped a hundred times, in theory we can expect heads to come up fifty times. Hence, the probability of the event (heads) occurring is fifty in one hundred. In this case, probability is the odds that a certain match will occur when two specimens are compared.

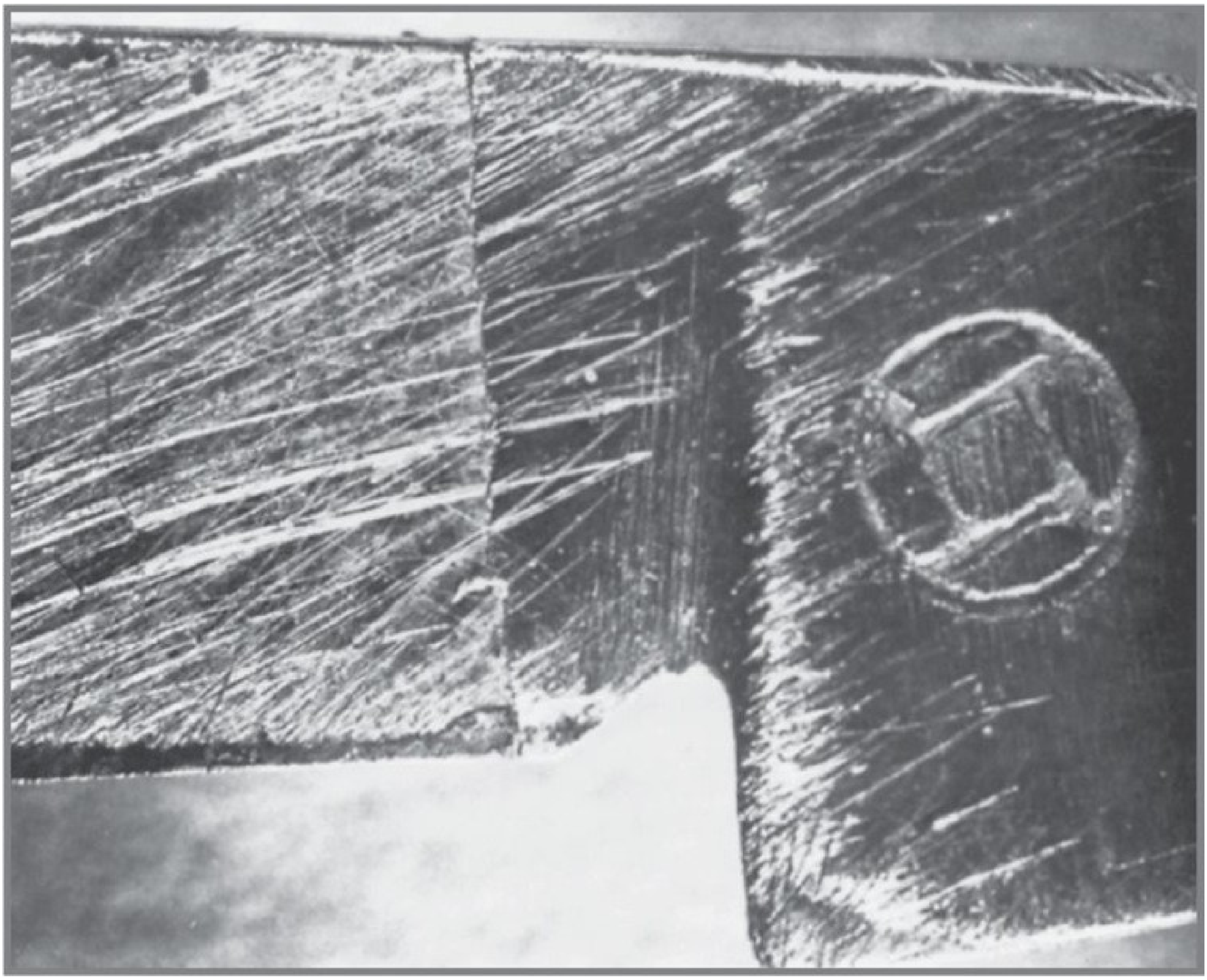
INDIVIDUAL CHARACTERISTICS

Evidence that can be associated with a unique common source with an extremely high degree of probability is said to possess **individual characteristics**. Examples of such associations are the matching ridge characteristics of two fingerprints, matching random striations (markings) on bullets or tool marks, matching irregular and random wear patterns in tire or footwear impressions, consistent handwriting characteristics, the fitting together of the irregular edges of broken objects in the manner of a jigsaw puzzle (see Figure 5-2), or matching striation marks running across plastic bags that were made sequentially (see Figure 5-3).

individual characteristics

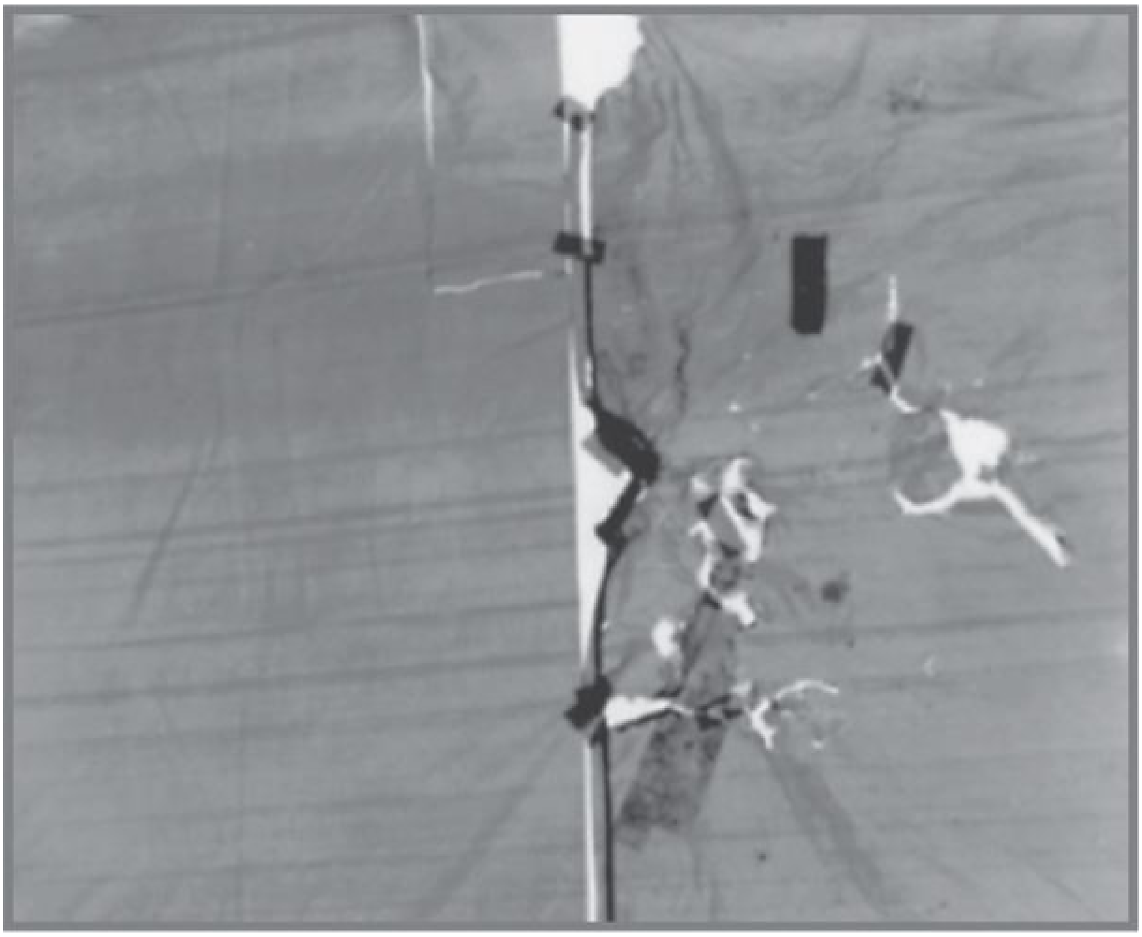
Properties of evidence that can be attributed to a particular source with an extremely high degree of certainty.

FIGURE 5-2 The body of a woman was found with evidence of beating about the head and a stablike wound in the neck. Her husband was charged with the murder. The pathologist found a knife blade tip in the wound in the neck. The knife blade tip was compared with the broken blade of a penknife found in the trousers pocket of the accused. Note that, in addition to the fit of the indentations on the edges, the scratch marks running across the blade tip correspond in detail to those on the broken blade.



Courtesy Centre of Forensic Sciences, Ministry of Community Safety and Correctional Services, Toronto, Canada

FIGURE 5-3 The bound body of a young woman was recovered from a river. Her head was covered with a black polyethylene trash bag (shown on the right). Among the items recovered from one of several suspects was another black polyethylene trash bag (shown on the left). A side-by-side comparison of the two bags' extrusion marks and pigment bands showed them to be consecutively manufactured. This information allowed investigators to focus their attention on one suspect, who ultimately was convicted of the homicide.



Courtesy George W. Neighbor

In all of these cases, it is not possible to state with mathematical exactness the probability that the specimens are of common origin; it can be concluded only that the probability is so high as to defy mathematical calculations or human comprehension. Furthermore, the conclusion of common origin must be substantiated by the practical experience of the examiner. For example, the French scientist Victor Balthazard determined mathematically that the probability of two individuals having the same fingerprints is one out of 1×10^{60}, or 1 followed by sixty zeros. This probability is so small as to exclude the possibility of any two individuals having the same fingerprints. This contention is supported by the experience of fingerprint examiners who, after classifying millions of prints over the past hundred years, have never found any two to be exactly alike.

CLASS CHARACTERISTICS

One disappointment awaiting the investigator unfamiliar with the limitations of forensic science is the frequent inability of the laboratory to relate physical evidence to a common origin with a high degree of certainty. Evidence is said to possess **class characteristics** when it can be associated only with a group and not with a single source. Here again, probability is a determining factor. For example, if we compare two single-layer automobile paint chips of a similar color, their chance of originating from the same car is not nearly as great as when we compare two paint chips with seven similar layers of paint, not all of which were part of the car’s original color. The former will have class characteristics and can be associated with, at the most specific, one car model (which may number in the thousands); the latter may be judged to have individual characteristics and thus has a high probability of originating from one specific car.

class characteristics

Properties of evidence that can be associated only with a group and not with a single source.

Blood offers another good example of evidence that can have class characteristics. For example, suppose that two blood specimens are compared and both are found to be of human origin, type A. The frequency of occurrence of type A blood in the US population is approximately 26 percent—hardly a basis for establishing the common origin of the specimens. However, if other blood factors are also determined and are found to compare, the probability that the two blood specimens originated from a common source increases. Thus, if one uses a series of blood factors that occur independently of each other, then one can apply the **product rule** to calculate the overall frequency of occurrence of the blood in a population. In this case, the product rule states that multiplying together the frequency of each factor present and occurring independently in a blood sample will determine how common blood containing that combination of factors is in the general population.

product rule

A formula for determining how frequently a certain combination of characteristics occurs in a population. The product rule states that one must first determine the probability of each characteristic's occurring separately and indepentently, then multiply together the frequencies of all these independently occurring characteristics. The result is the overall frequency of occurrence for that particular combination of characteristics.

For example, in the O. J. Simpson murder case, a bloodstain located at the crime scene was found to contain a number of factors that compared to O. J.'s blood:

Blood Factors	Frequency
A	26%
EsD	85%
PGM 2+2–	2%

The product of all the frequencies shown in the table determines the probability that any one individual possesses such a combination of blood factors. In this instance, applying the product rule, 0.26 × 0.85 × 0.02 equals 0.0044. Thus, only 0.44 percent, or less than 1 in 200 people, would be expected to have this particular combination of blood factors. These bloodstain factors did not match either of the two victims, Nicole Brown Simpson or Ronald Goldman, thus eliminating them as possible sources of the blood. Although the forensic scientist did not definitively link the bloodstains to one person (in this case, O. J. Simpson), this analysis provided data that permitted investigators and the courts to better assess the evidential value of the crime-scene stain.

As we will discuss in Chapter 15, the product rule is used to determine the frequency of occurrence of DNA profiles developed from blood and other biological materials. Importantly, modern DNA technology provides enough factors to allow an analyst to individualize blood, semen, and other biological materials to a single person.

Quick Review

- • Two methods used by forensic scientists when examining physical evidence are identification and comparison.
- • Identification is the process of determining a substance's chemical or physical identity to the exclusion of all other substances (e.g., drugs, explosives, petroleum products, blood, semen, and hair species).
- • A comparison analysis determines whether a suspect specimen and a standard/reference specimen have a common origin.
- • Evidence that can be linked to a common source with an extremely high degree of probability is said to possess individual characteristics.
- • Evidence that is associated with an entire group is said to have class characteristics.
- • The overall frequency of occurrence of an event, such as a match between two substances, can be determined by multiplying the frequencies of all independently occurring instances related to that event. This is known as the product rule.

Significance of Physical Evidence

One of the current weaknesses of forensic science is the inability of the examiner to assign exact or even approximate probability values when comparing most class physical evidence. For example, what is the probability that a nylon fiber originated from a particular sweater, or that a hair came from a particular person's head, or that a paint chip came from a car suspected to have been involved in a hit-and-run accident? Very few statistical data are available from which to derive this information, and in a society that is increasingly dependent on mass-produced products, the gathering of such data is becoming an increasingly elusive goal.

One of the primary endeavors of forensic scientists must be to create and update statistical databases for evaluating the significance of class physical evidence. Of course, when such information—for example, the population frequency of blood factors—is available, it is used; but, for the most part, the forensic scientist must rely on personal experience when interpreting the significance of class physical evidence.

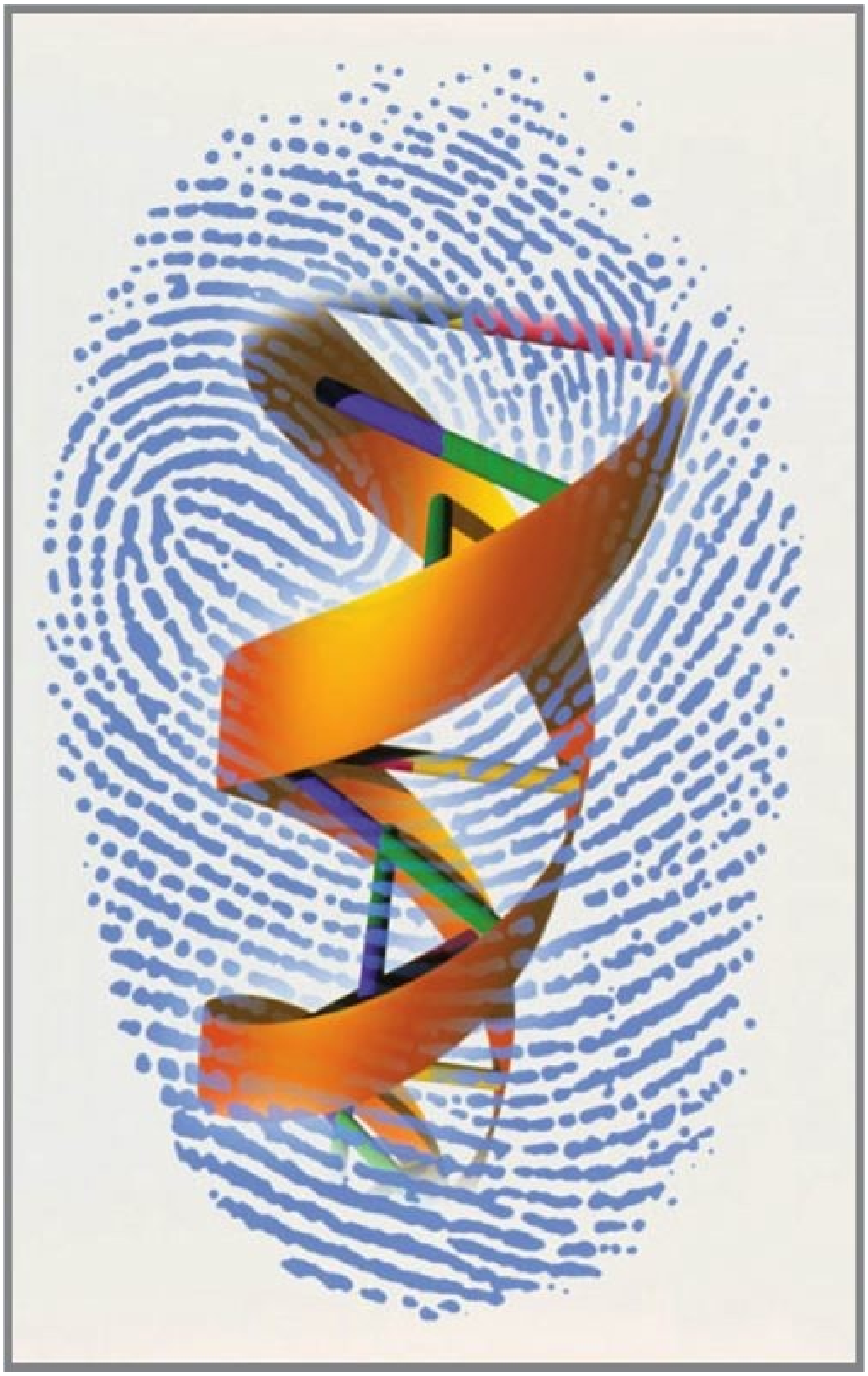
People who are unfamiliar with the realities of modern criminalistics are often disappointed to learn that most items of physical evidence retrieved at crime scenes cannot be linked definitively to a single person or object (Figure 5-4). Although investigators always try to uncover physical evidence with individual characteristics—such as fingerprints, tool marks, and bullets—the chances of finding class physical evidence are far greater. To deny or belittle the value of such evidence is to reject the potential role that criminalistics can play in a criminal investigation.

In practice, criminal cases are fashioned for the courtroom around a collection of diverse elements, each pointing to the guilt or involvement of a party in the criminal act. Often, most of the evidence gathered is subjective, prone to human error and bias. The believability of eyewitness accounts, confessions, and informant testimony can all be disputed, maligned, and subjected to severe attack and skepticism in the courtroom. Under these circumstances, errors in human judgment are often magnified by the defense to detract from the credibility of the witness.

ASSESSING THE VALUE OF EVIDENCE

The value of class physical evidence hinges on its ability to corroborate events with data in a manner that is, as nearly as possible, free of human error and bias. It is the thread that binds together other investigative findings that are more dependent on human judgments and, therefore, more prone to human failings. The fact that scientists have not yet learned to individualize many kinds of physical evidence means that criminal investigators should not abdicate or falter in their pursuit of all investigative leads. However, the ability of scientists to achieve a high degree of success in evaluating class physical evidence means that criminal investigators can pursue their work with a much greater chance of success.

FIGURE 5-4 A computer-generated image of DNA superimposed on a fingerprint, representing two of the most frequently found individualized items of evidence at crime scenes.



Courtesy Alfred Pasieka\Photo Researchers, Inc.

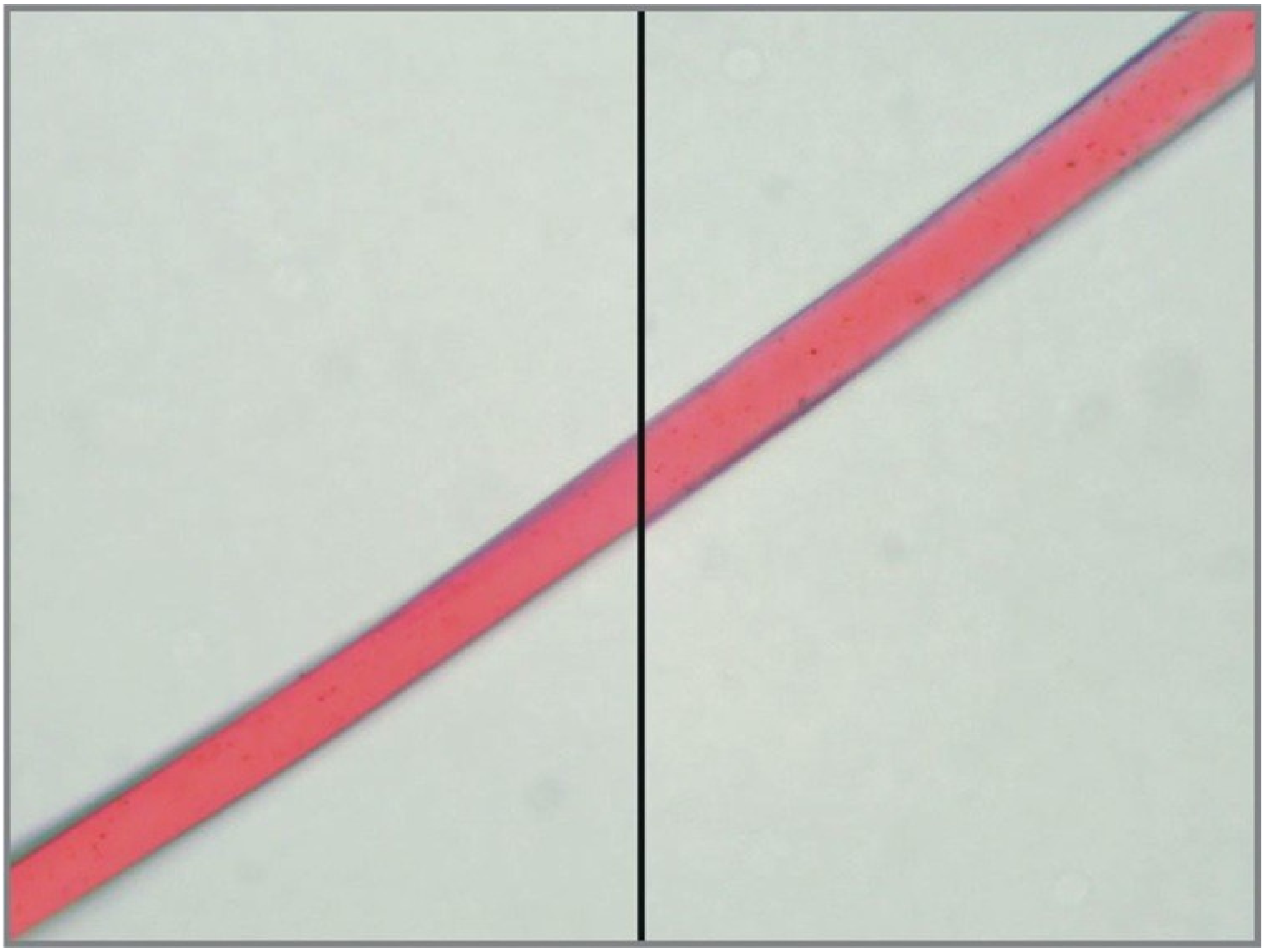
Again, defining the significance of an item of class evidence in exact mathematical terms is usually a difficult if not impossible goal. Although class evidence is by its very nature not unique, meaningful items of physical evidence, such as those listed at the beginning of this chapter, are extremely variable in reality. Select, for example, a colored fiber from an article of clothing and try to locate that exact color on the clothing of random individuals you meet, or select a car color and try to match it to that of other cars you see on local streets. It will be difficult to find a match. Furthermore, keep in mind that a forensic comparison goes beyond a mere color comparison and involves examining and comparing a variety of chemical and/or physical properties (see Figure 5-5). The chances are low of encountering two indistinguishable items of physical evidence at a crime scene that actually originated from different sources. Obviously, given these circumstances, only objects that exhibit significant variability are appropriate for classification as physical evidence.

In the same way, when one is dealing with more than one type of class evidence, their collective presence may lead to an extremely high certainty that they originated from the same source. As the number of objects linking an individual to a crime increases, the probability of involvement increases dramatically. A classic example of this situation can be found in the evidence presented at the trial of Wayne Williams. Williams was charged with the murders of two individuals in the Atlanta, Georgia, metropolitan area; he was also linked to the murders of ten other boys and young men. An essential element of the state's case involved the association of Williams with the victims through a variety of fiber evidence. Actually, twenty-eight types of fibers linked Williams to the murder victims, evidence that the forensic examiner characterized as "overwhelming."

CAUTIONS AND LIMITATIONS IN DEALING WITH PHYSICAL EVIDENCE

In further evaluating the contribution of physical evidence, one cannot overlook one important reality in the courtroom: The weight or significance accorded physical evidence is a determination left entirely to the "trier of fact," usually a jury of laypeople. Given the high esteem in which scientists are generally held by society and the infallible image of forensic science created by books and television, scientifically evaluated evidence often takes on an aura of special reliability and trustworthiness in the courtroom. Often, physical evidence, whether individual or class, is accorded great weight during jury deliberations and becomes a primary factor in reinforcing or overcoming lingering doubts about guilt or innocence. In fact, a number of jurists have already cautioned against giving carte blanche approval for admitting scientific testimony without first considering its relevance to the case. Given the potential weight of scientific evidence, failure to take proper safeguards may unfairly prejudice a case against the accused.

FIGURE 5-5 A side-by-side comparison of fibers.



Courtesy Chris Palenik, Microtrace LLC, Elgin, IL, www.microtracescientific.com

Physical evidence may serve also to exclude or exonerate a person from suspicion. For instance, if type A blood is linked to the suspect, all individuals who have types B, AB, and O blood can be eliminated from consideration. Because it is not possible to assess at the crime scene what value, if any, the scientist will find in the evidence collected or what significance such findings will ultimately have to a jury, the thorough collection and scientific evaluation of physical evidence must become a routine part of all criminal investigations.

Just when an item of physical evidence crosses the line that distinguishes class from individual is difficult to determine and is often the source of heated debate and honest disagreement among forensic scientists. How many striations are necessary to individualize a mark to a single tool and no other? How many color layers individualize a paint chip to a single car? How many ridge characteristics individualize a fingerprint, and how many handwriting characteristics tie a person to a signature? These questions defy simple answers. The task of the forensic scientist is to find as many characteristics as possible to compare one substance with another. The significance attached to the findings is decided by the quality and composition of the evidence, the case history, and the examiner's experience. Ultimately, the conclusion can range from mere speculation to near certainty.

There are practical limits to the properties and characteristics the forensic scientist can select for comparison. Carried to the extreme, no two things in this world are alike in every detail. Modern analytical techniques have become so sophisticated and sensitive that the criminalist must define the limits of natural variation among materials when interpreting the data gathered from a comparative analysis. For example, we will learn in Chapter 14 that two properties, density and refractive index, are best suited for comparing two pieces of glass. But the latest techniques that have been developed to measure these properties are so sensitive that they can even distinguish glass originating from a single pane of glass. Certainly this goes beyond the desires of a criminalist trying to determine only whether two glass particles originated from the same window. Similarly, if the surface of a paint chip is magnified 1,600 times with a powerful scanning electron microscope, fine details are revealed that could not be duplicated in any other paint chip from the very same painted surface. Under these circumstances, no two paint chips, even those coming from the same surface, could ever compare in the truest sense of the word. Therefore, practicality dictates that such examinations be conducted at a less revealing, but more meaningful, magnification (see Figure 5-6).

Distinguishing evidential variations from natural variations is not always an easy task. Learning how to use the microscope and all the other modern instruments in a crime laboratory properly is one thing; gaining the proficiency needed to interpret the observations and data is another. As new crime laboratories are created and others expand to meet the requirements of the law enforcement community, many individuals are starting new careers in forensic science. They must be cautioned that merely reading relevant textbooks and journals is no substitute for experience in this most practical of sciences.

Quick Review

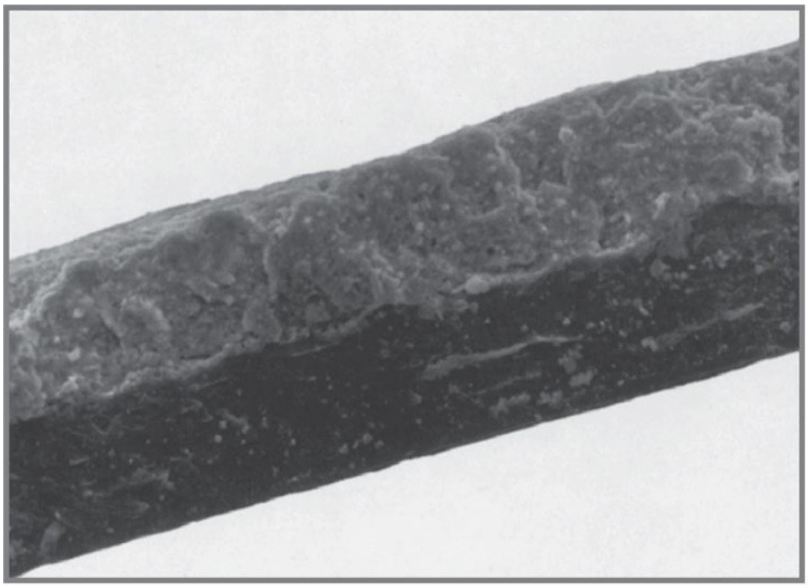
- • The value of class physical evidence lies in its ability to corroborate events with data in a manner that is, as nearly as possible, free of human error and bias.
- • As the number of objects linking an individual to a crime scene increases, so does the likelihood of that individual's involvement with the crime.
- • A person may be exonerated or excluded from suspicion if physical evidence collected at a crime scene is found to be different from standard/reference samples collected from that subject.

Forensic Databases

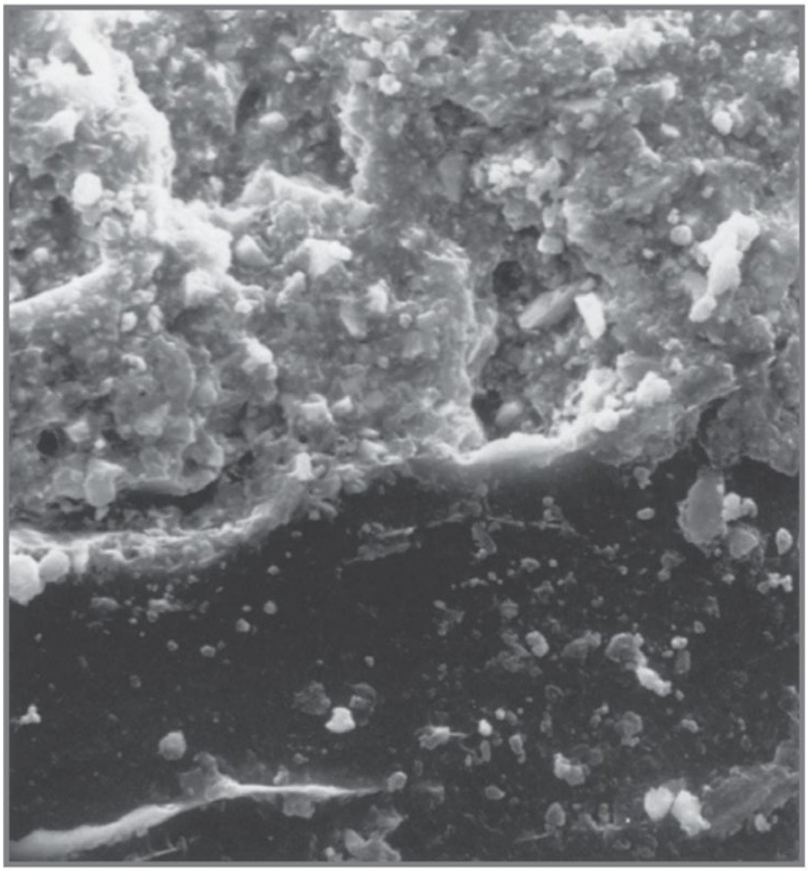
In a criminal investigation, the ultimate contribution a criminalist can make is to link a suspect to a crime through comparative analysis. This comparison defines the unique role of the criminalist in a criminal investigation. Of course, a one-on-one comparison requires a suspect. Little or nothing of evidential value can be accomplished if crime-scene investigators acquire fingerprints, hairs, fibers, paint, blood, and semen without the ability to link these items to a suspect. In this respect, computer technology has dramatically altered the role of the crime laboratory in the investigative process.

No longer is the crime laboratory a passive bystander waiting for investigators to uncover clues about who may have committed a crime. Today, the crime laboratory is on the forefront of the investigation seeking to identify perpetrators. This dramatic enhancement of the role of forensic science in criminal investigation has come about with the creation of computerized databases that not only link data from all fifty states but also tie together data from police agencies throughout the world.

FIGURE 5-6 (a) A two-layer paint chip magnified 244 times with a scanning electron microscope. (b) The same paint chip viewed at a magnification of 1,600 times.



(a)



(b)

FINGERPRINT DATABASES

The premier model of all forensic database systems is the *Integrated Automated Fingerprint Identification System* (IAFIS), a national fingerprint and criminal history system maintained by the FBI and launched in 1999. IAFIS contains the fingerprints and corresponding criminal history information of nearly 68 million subjects (i.e., 680 million fingerprint images), which are submitted voluntarily to the FBI by state, local, and federal law enforcement agencies.

A crime-scene fingerprint or latent fingerprint is a dramatic find for the criminal investigator. Once the quality of the print has been deemed suitable for the IAFIS search, the latent-print examiner creates a digital image of the print with either a digital camera or a scanner. Next, the examiner, with the aid of a coder, marks points on the print to guide the computerized search (see Figure 5-7). The print is then electronically submitted to IAFIS, and within minutes the search of all fingerprint images in IAFIS is completed; the examiner may receive a list of potential candidates and their corresponding fingerprints for comparison and verification (see Figure 5-8).

Many countries throughout the world have created *national automated fingerprint identification systems* that are comparable to the FBI's model. For example, a computerized fingerprint database containing nearly nine million ten-print records connects the Home Office and forty-three police forces throughout England and Wales.

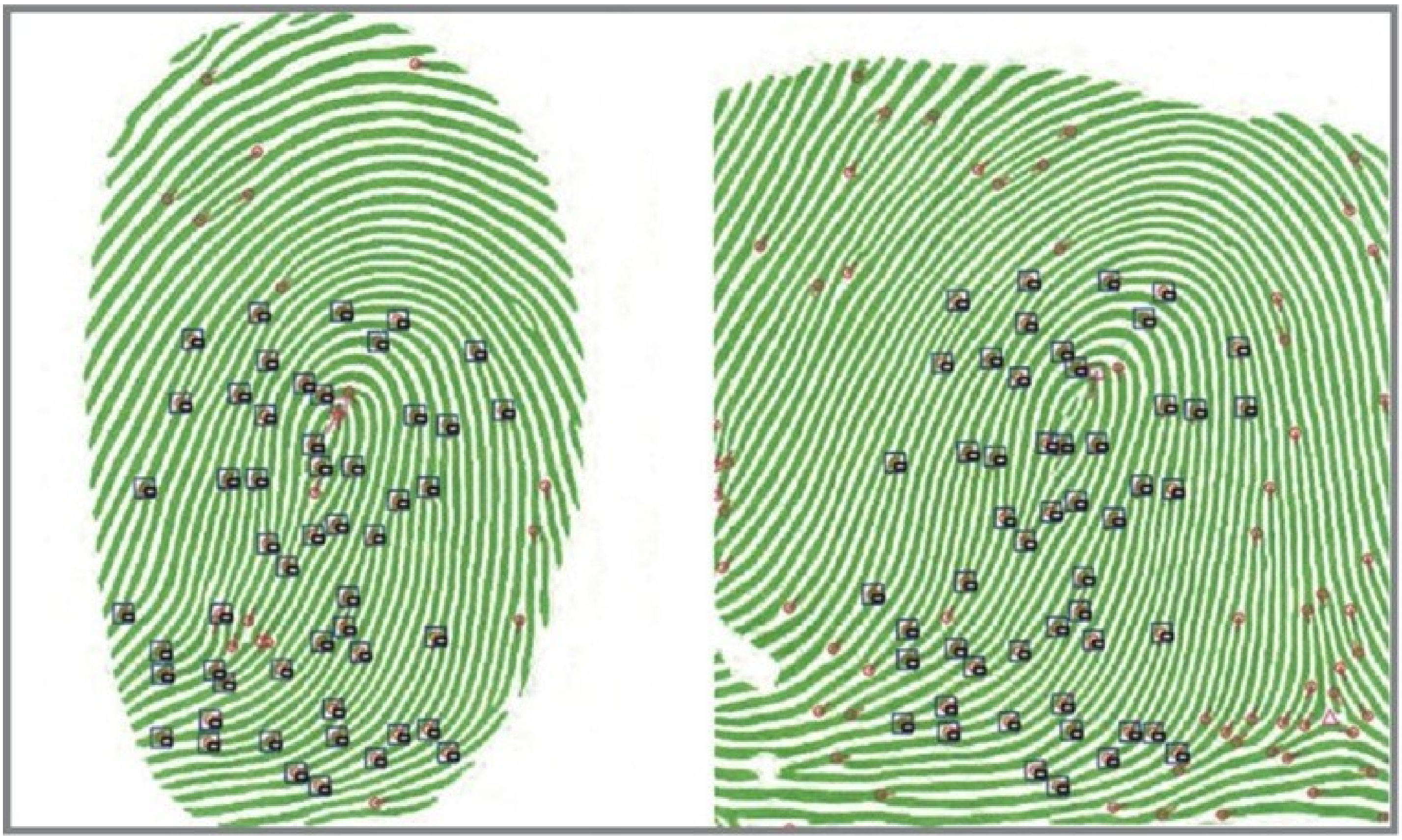
DNA DATABASES

In 1998, the FBI's *Combined DNA Index System* (CODIS) became fully operational. CODIS enables federal, state, and local crime laboratories to electronically exchange and compare DNA profiles, thereby linking crimes to each other and to convicted offenders. All fifty states have enacted legislation to establish a data bank containing DNA profiles of individuals convicted of felony sexual offenses (and other crimes, according to each state's statute).

FIGURE 5-7 A forensic scientist using the AFIS database

Mikael Karlsson\Arresting Images

FIGURE 5-8 The computerized search of a fingerprint database first requires that selected ridge characteristics be designated by a coder. The positions of these ridge characteristics serve as a basis for comparing the print against fingerprints on file.



Courtesy Sirchie Fingerprint Laboratories, Youngsville, NC, www.sirchie.com

CODIS creates investigative leads from two sources: the *forensic index* and the *offender index*. The forensic index currently contains about 380,000 profiles recovered from crime-scene evidence without a suspect. Based on a match, police in multiple jurisdictions can identify serial crimes, allowing coordination of investigations and sharing of leads developed independently. The offender index contains the profiles of nearly 10.5 million convicted or arrested individuals. The FBI has joined fifteen states that collect DNA from those awaiting trial and from detained immigrants. This information will be entered into an *arrestee index* database. Unfortunately, hundreds of thousands of samples are backlogged, still awaiting DNA analysis and entry into CODIS. Law enforcement agencies search this index against DNA profiles recovered from biological evidence found at unsolved crime scenes. This approach has been tremendously successful in identifying perpetrators because most crimes involving biological evidence are committed by repeat offenders.

CASE FILES

In 1975, police found Gerald Wallace's body on his living room couch. He had been savagely beaten, his hands bound with an electric cord. Detectives searched his ransacked house, cataloging every piece of evidence they could find. None of it led to the murderer. They had no witnesses. Sixteen years after the fact, a lone fingerprint, lifted from a cigarette pack found in Wallace's house and kept for sixteen years in the police files, was entered into the Pennsylvania State Police AFIS database. Within minutes, it hit on a match. That print, police say, gave investigators the identity of a man who had been at the house the night of the murder. Police talked to him. He led them to other witnesses, who led police to the man who was ultimately charged with the murder of Gerald Wallace.

CASE FILES

Fort Collins, Colorado, and Philadelphia, Pennsylvania, are separated by nearly 1,800 miles, but in 2001 they were tragically linked though DNA. Troy Graves left the Philadelphia area in 1999, joined the air force, and settled down with his wife in Colorado. Subsequently, a frenzied string of eight sexual assaults around the Colorado University campus set off a manhunt that ultimately resulted in the arrest of Graves. However, his DNA profile inextricably identified him as Philadelphia's notorious "Center City rapist." This assailant had attacked four women in 1997 and brutally murdered Shannon Schieber, a Wharton School graduate student, in 1998. His last known attack in Philadelphia was the rape of an 18-year-old student in August 1999, shortly before Graves left the city. In 2002, Graves was returned to Philadelphia, where he was sentenced to life in prison without parole.

Several countries throughout the world have initiated national DNA data banks. The United Kingdom's *National DNA Database*, established in 1995, was the world's first national database. Currently it holds more than four million profiles, and DNA samples can be taken for entry into the database from anyone arrested for an offense likely to involve a prison term. In a typical month, DNA matches link individuals in the database to 26 murders; 57 rapes and other sexual offenses; and 3,000 motor vehicle, property, and drug crimes.

OTHER DATABASES

The *National Integrated Ballistics Information Network* (NIBIN) maintained by the Bureau of Alcohol, Tobacco, Firearms and Explosives, allows firearms analysts to acquire, digitize, and compare markings made by firearms on bullets and cartridge casings recovered from crime scenes. The NIBIN program currently has 236 sites that are electronically joined to sixteen multistate regions.

The heart of NIBIN is the *Integrated Ballistic Identification System* (IBIS), comprising a microscope and a computer unit that can capture an image of a bullet or cartridge casing. The images are then forwarded to a regional server, where they are stored and correlated to other images in the regional database. IBIS does not positively match bullets or casings fired from the same weapon; this must be done by a firearms examiner. IBIS does, however, facilitate the work of the firearms examiner by producing a short list of candidates for the examiner to manually compare. Nearly 1.6 million pieces of crime-scene evidence have been entered in NIBIN, and more than 34,000 "hits" have been recorded, many of them yielding investigative information not obtainable by other means.

CASE FILES

After a series of armed robberies in which suspects fired shots, the sheriff's office of Broward County, Florida, entered the cartridge casings from the crime scenes into NIBIN. Through NIBIN, four of the armed robberies were linked to the same .40-caliber handgun. A short time later, sheriff's deputies noticed suspicious activity around a local business. When they attempted to interview the suspects, the suspects fled in a vehicle. During the chase, the suspects attempted to dispose of a handgun; deputies recovered the gun after making the arrests. The gun was test-fired, and the resulting evidence was entered into NIBIN, which indicated a possible link between this handgun and the four previous armed robberies. Firearms examiners confirmed the link by examining the original evidence. The suspects were arrested and charged with four prior armed robbery offenses.

CASE FILES

A 53-year-old man was walking his dog in the early morning hours. He was struck and killed by an unknown vehicle and later found lying in the roadway. No witnesses were present, and the police had no leads regarding the suspect vehicle. A metallic-gold-painted plastic fragment recovered from the scene and the victim's clothing were submitted to the Virginia Department of Forensic Science for analysis.

The victim's clothing was scraped, and several minute, metallic gold paint particles were recovered. The majority of these particles contained only topcoats, but one very minute particle contained two primer layers and a very limited amount of topcoat. The color of the primer surfacer layer was similar to that typically associated with some Fords. Subsequent spectral searches in the PDQ database indicated that the paint probably originated from a 1990 or newer Ford.

The most discriminating aspect of this paint was the unusual-looking metallic gold topcoat. A search of automotive repaint books yielded only one color that closely matched the paint recovered in this case. The color, Aztec Gold Metallic, was determined to have been used only on 1997 Ford Mustangs.

The results of the examination were relayed via telephone to the investigating detective. The investigating detective quickly determined that only 11,000 1997 Ford Mustangs were produced in Aztec Gold Metallic. Only two of these vehicles were registered and had been previously stopped in the jurisdiction of the offense. Ninety minutes after the make/model/year information was relayed to the investigator, he called back to say he had located a suspect vehicle. Molding from the vehicle and known paint samples were submitted for comparison. Subsequent laboratory comparisons showed that the painted plastic piece recovered from the scene physically fitted together with the molding on the car, and the paint recovered from the victim's clothing was consistent with paint samples taken from the suspect vehicle.

Source: Brenda Christy, Virginia Department of Forensic Science. Reprinted by permission.

The *International Forensic Automotive Paint Data Query* (PDQ) database contains chemical and color information pertaining to original automotive paints. This database, developed and maintained by the Forensic Laboratory Services of the Royal Canadian Mounted Police (RCMP), contains information about the make, model, year, and assembly plant of more than 13,000 vehicles, with a library of more than 50,000 layers of paint. Contributors to the PDQ include the RCMP and forensic laboratories in Ontario and Quebec, as well as forty US forensic laboratories and police agencies in twenty-one other countries. Accredited users of PDQ are required to submit sixty new automotive paint samples per year to be added to the database. The PDQ database has found its greatest utility in the investigation of hit-and-runs by providing police with possible make, model, and year information to aid in the search for the unknown vehicle.

FIGURE 5-9 The crime-scene footwear print on the right is being searched against eight thousand sole patterns to determine its brand and style.

Courtesy Foster & Freeman Limited, Worcestershire, UK, www.fosterfreeman.co.uk

The previously described databases are maintained and controlled by government agencies. There is one exception: a commercially available computer retrieval system for comparing and identifying crime-scene shoe prints known as *SICAR (Shoeprint Image Capture and Retrieval).*[1] SICAR's pattern-coding system enables an analyst to create a simple description of a shoe print by assigning codes to individual pattern features (see Figure 5-9). Shoe print images can be entered into SICAR via either a scanner or a digital camera. This product has a comprehensive shoe sole database (SoleMate®) that includes more than 22,000 footwear entries providing investigators with a means for linking a crime-scene footwear impression to a particular shoe manufacturer. A second database, TreadMate®, has been created to house tire tread patterns. Currently, it contains 6,000 records.

Quick Review

- • The creation of computerized databases for fingerprints, criminal histories, DNA profiles, markings on bullets and cartridges, automotive paints, and shoe prints has dramatically enhanced the role of forensic science in criminal investigation.
- • IAFIS is the Integrated Automated Fingerprint Identification System, a national fingerprint and criminal history database maintained by the FBI. IAFIS allows criminal investigators to compare fingerprints at a crime scene to an index of 680 million known prints. CODIS is the FBI's Combined DNA Index System. It enables federal, state, and local crime laboratories to electronically exchange and compare DNA profiles, linking crimes

to each other and to convicted offenders.

Forensic Palynology: Pollen and Spores as Evidence

Of the many plant species on earth, more than half a million produce pollen or spores. The pollen or spores produced by each species has a unique type of ornamentation and morphology. This means that pollen or spores can be identified and used to provide links between a crime scene and a person or object if examined by a trained analyst. This technique is called *forensic palynology* and includes the collection and examination of pollen and spores connected with crime scenes, illegal activities, or terrorism. Microscopy is the principal tool used in the field of forensic palynology.

CHARACTERISTICS OF SPORES AND POLLEN

In nature, pollen grains are the single-celled male gametophytes (reproductive cells) of seed-bearing plants. The pollen grain wall *(exine)* is durable because it protects and carries the “sperms” needed for plant reproduction. Spores consist of both the male and female gametes of plants such as algae, fungi, mosses, and ferns. Pollen-producing plants are either *anemophilous* (their pollen is dispersed by wind) or *entomophilous* (their pollen is carried and dispersed by insects or small animals). Fairly precise geographical locations can often be identified by the presence of different mixtures of airborne pollens produced by anemophilous plants. For example, it may be possible to identify a geographical origin using a profile of the pollen samples retrieved from a suspect’s clothing by analyzing the type and percentages of airborne pollen grains. Entomophilous plants usually produce a small amount of pollen that is very sticky in nature. Therefore, this type of pollen is very rarely deposited on clothing or other objects except by direct contact with the plant. This information is useful when reconstructing the events of a crime because it may indicate that the clothing, a vehicle, or other objects on which this pollen is found came into direct contact with plant types found at a crime scene.

ANALYSIS OF SPORES AND POLLEN

Both spores and pollen are microscopic in size and are produced by adult plants, then dispersed by the millions, and both can be analyzed using similar methods that use a variety of microscopic techniques. Using a compound light microscope with magnification capabilities up to 1,000×, analysts usually can identify pollen and spores as having come from a specific plant family or genus, and sometime even the unique species. However, often the pollen or spores of related species may look so similar that identification of the species is possible only by careful analysis using a scanning electron microscope (SEM) (see pp. 210-211 and Figure 5-10).

FIGURE 5-10 Allergenic pollen grains of ragweed. Common ragweed *(Ambrosia artemisiifolia)* is the most widespread of this genus in North America. Each ragweed plant is able to produce up to a billion grains of pollen over a season, and the plant is anemophilous (wind-pollinated). It is highly allergenic, has the greatest pollen allergen of all pollens, and is the prime cause of hayfever. The plant blooms in the northern hemisphere from about mid-August until cooler weather arrives. It usually produces pollen more copiously in wet seasons. Two species, *Ambrosia artemisiifolia*

and *A. psilostachya*, are considered among the most noxious to those prone to hay fever. The ragweed was accidentally imported to Europe during World War I; it has adapted to the different environment successfully and has spread widely since the 1950s. Hungary is currently the most heavily affected country in Europe (and possibly the entire world), especially since the early 1990s, when abandonment of communist-style collective agriculture left vast fields uncultivated and those fields were promptly invaded by ragweed. Enhanced SEM. Magnification: 1170X if the image is printed 10cm wide.

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Unique shapes, aperture type, and surface ornamentation are typically used to identify spore samples. Useful features for characterizing pollen grains include shape, apertures, and wall and surface sculpturing. Shapes of pollen grains include spheres, triangles, ellipses, hexagons, pentagons, and many other geometric variations. *Apertures* are the openings on pollen grains from which the pollen tube grows and carries the sperms to the egg to complete fertilization. *Sculpturing* of the pollen refers to the pattern of the pollen grain surface.

To avoid destruction or contamination of pollen evidence, early collection of forensic pollen samples for analysis is important and should be completed as soon as possible at a crime scene by a trained palynologist. This expert's first task is to calculate the estimated production and dispersal patterns of spores and pollen (called the *pollen rain)* for the crime scene or area of interest and, using that information, to produce a kind of "pollen fingerprint" of that location.

The information gained from the analysis of pollen and spore evidence has many possible uses. It can link a suspect or object to the crime scene or the victim, prove or disprove a suspect's alibi, include or exclude suspects, track the previous whereabouts of some item or suspect, or indicate the geographical origin of some item. In the past, pollen and spore evidence has been used to locate human remains and concealed burial sites, establish the season or time of death of a victim, locate the source areas of illegal drugs and fake pharmaceuticals, identify terrorists, and prove the perpetration of illegal poaching and the adulteration of commercial foods.

A case exemplifying the application of forensic palynology to a criminal investigation occurred when a victim was kidnapped, robbed, and then murdered in the eastern part of the American Midwest.[2] The victim's car was stolen but later abandoned when it got stuck in mud near a busy highway. The next night a drifter was arrested in a nearby town for breaking into a closed store. While in jail awaiting trial, the drifter told a fellow inmate about his car being stuck in the mud, stating that he would not be in jail but for that mishap. The other prisoner, hoping to work a deal for a lighter sentence, told this story to the sheriff.

During the investigation of the crime scene, one of the law enforcement agents noticed that there was a large field of mature corn growing between the dirt road where the stolen car had been abandoned in the mud and the nearby highway leading to the next town. The investigator wondered if traces of torn corn leaves on the suspect's clothing might link him to the crime scene. Fortunately, the drifter's shirt and pants had been removed and stored in sterile paper bags when he was arrested. As were all prisoners in that region, he had been given a pair of orange overalls to wear while in jail.

The shirt and pants were sent to a botanist, who was asked to search for traces of corn leaves on the clothing. The botanist was also a palynologist, and thus also collected samples and searched for traces of pollen. The pollen samples yielded the best results. The samples collected from the suspect's shirt revealed that the neck and shoulder region of the shirt had high concentrations of fresh corn pollen. The forensic sample collected from the pants also contained corn pollen but in lower numbers. The forensic pollen data indicated that the drifter had recently walked through a corn field similar to the one between the abandoned car and the highway. As he walked through the field, he had brushed against the blooming male tassels on the corn plants, which are about head high. This accounted for the large amount of corn pollen found on the shoulder and neck area of the shirt. Lesser amounts of corn pollen also fell on the drifter's pants as he walked through the field. While the suspect awaited trial, additional evidence and several fingerprints from the victim's farm also linked him to the murder.

Quick Review

- • Forensic palynology involves the collection and examination of pollen and spores connected with crime scenes, illegal activities, or terrorism. The microscope is the principal tool used in the field of forensic palynology.
- • The information gained from the analysis of pollen and spore evidence has many possible uses. It can link a suspect or object to the crime scene or the victim, prove or disprove a suspect's alibi, include or exclude suspects, track the previous whereabouts of some item or suspect, or indicate the geographical origin of some item.

CHAPTER REVIEW

- • Two methods used by forensic scientists when examining physical evidence are identification and comparison.
- • Identification is the process of determining a substance's chemical or physical identity to the exclusion of all other substances (e.g., drugs, explosives, petroleum products, blood, semen, and hair species).
- • A comparison analysis determines whether a suspect specimen and a standard/reference specimen have a

common origin.

- • Evidence that can be associated with a common source with an extremely high degree of probability is said to possess individual characteristics.
- • Evidence associated with only a group is said to have class characteristics.
- • The overall frequency of occurrence of an event, such as a match between two substances, can be obtained by multiplying the frequencies of all independently occurring instances related to that event. This is known as the product rule.
- • The value of class physical evidence lies in its ability to corroborate events with data in a manner that is, as nearly as possible, free of human error and bias.
- • As the number of objects linking an individual to a crime scene increases, so does the likelihood of that individual's involvement with the crime.
- • A person may be exonerated or excluded from suspicion if physical evidence collected at a crime scene is found to be different from standard/reference samples collected from that subject.
- • The creation of computerized databases for fingerprints, criminal histories, DNA profiles, markings on bullets and cartridges, automotive paints, and shoe prints has dramatically enhanced the role of forensic science in criminal investigation.
- • IAFIS is the Integrated Automated Fingerprint Identification System, a national fingerprint and criminal history database maintained by the FBI. IAFIS allows criminal investigators to compare fingerprints at a crime scene to an index of 680 million known prints. CODIS is the FBI's Combined DNA Index System. It enables federal, state, and local crime laboratories to electronically exchange and compare DNA profiles, linking crimes to each other and to convicted offenders.
- • Forensic palynology involves the collection and examination of pollen and spores connected with crime scenes, illegal activities, or terrorism. The microscope is the principal tool used in the field of forensic palynology.

KEY TERMS

class characteristics 107

comparison 104

identification 104

individual characteristics 105

product rule 107

REVIEW QUESTIONS

1.

The process of ________________determines a substance's physical or chemical identity with the most certainty that existing analytical techniques will permit.

2.

The number and type of tests needed to identify a substance must be sufficient to ________________all other substances from consideration.

3.

A(n) ________________analysis subjects a suspect and a standard/reference specimen to the same tests and examination for the ultimate purpose of determining whether they have a common origin.

4.

________________is the frequency of occurrence of an event.

5.

Evidence that can be traced to a common source with an extremely high degree of probability is said to possess ________________characteristics.

6.

Evidence associated with a group, not a single source, is said to possess ________________characteristics.

7.

True or False: One of the major deficiencies of forensic science is the inability of the examiner to assign exact or approximate probability values to the comparison of most class physical evidence. ________________

8.

Although databases are consistently updated so that scientists can assign probabilities to class evidence, for the most part, forensic scientists must rely on ________________when interpreting the significance of class physical evidence.

9.

The believability of ________________accounts, confessions, and informant testimony can all be disputed, maligned, and subjected to severe attack and skepticism in the courtroom.

10.

The value of class physical evidence lies in its ability to ________________events with data in a manner that is, as nearly as possible, free of human error and bias.

11.

The ________________accorded physical evidence during a trial is left entirely to the trier of fact.

12.

True or False: Given the potential weight of scientific evidence in a trial setting, failure to take proper safeguards may unfairly prejudice a case against the suspect. ________________

13.

True or False: Physical evidence cannot be used to exclude or exonerate a person from suspicion of committing a crime. ________________

14.

True or False: The distinction between individual and class evidence is always easy to make. ________________

15.

Modern analytical techniques have become so sensitive that the forensic examiner must be aware of the ________________among materials when interpreting the significance of comparative data.

16.

Students studying forensic science must be cautioned that merely reading relevant textbooks and journals is no substitute for ________________in this most practical of sciences.

17.

True or False: A fingerprint can be positively identified through the IAFIS database. ________________

18.

A database applicable to DNA profiling is the FBI's ________________.

19.

True or False: Both spores and pollen can be identified and used to link a crime scene to an individual.

____

20.

True or False: Spores can be characterized by shape and surface characteristics through a simple visual examination.

____

APPLICATION AND CRITICAL THINKING

1.

Arrange the following tasks in order, from the one that would require the least extensive testing procedure to the one that would require the most extensive. Explain your answer.

- a) Determining whether an unknown substance contains an illicit drug
- b) Determining the composition of an unknown substance
- c) Determining whether an unknown substance contains heroin

2.

The following are three possible combinations of DNA characteristics that might be found in an individual's genetic profile. Using the probability rule, rank each of these combinations from most common to least common. The number in parentheses after each characteristic indicates its percentage distribution in the population.

- a) FGA 24,24 (3.6%), TH01 6,8 (8.1%), and D16S539 11, 12 (8.9%)
- b) vWA 14,19 (6.2%), D21S11 30,30 (3.9%), and D13S317 12,12 (8.5%)

- c) CSF1PO 9,10 (11.2%), D18S51 14,17 (2.8%), and D8S1179 17,18 (6.7%)

3.

For each of the following pieces of evidence, indicate whether the item is more likely to possess class or individual characteristics. Explain your answers.

- a) An impression from a new automobile tire
- b) A fingerprint
- c) A spent bullet cartridge
- d) A mass-produced synthetic fiber
- e) Pieces of a shredded document
- f) Commercial potting soil
- g) Skin and hair scrapings
- h) Fragments of a multilayer custom automobile paint

4.

Which of the forensic databases described in the text contain information that relates primarily to evidence exhibiting class characteristics? Which ones contain information that relates primarily to evidence exhibiting individual characteristics? Explain your answers.

5.

An investigator at a murder scene notes signs of a prolonged struggle between the attacker and victim. Name at least three types of physical evidence for which the investigator would probably collect standard/reference samples, and explain why he or she would collect them.

ENDNOTES

1.

Foster & Freeman Limited, Worcestershire, UK, www.fosterfreeman.co.uk.

2.

V. M. Bryant and G. D. Jones, "Forensic Palynology: Current Status of a Rarely Used Technique in the United States of America," *Forensic Science International 163* (2006): 183-197.