

If physical evidence is to be useful in exonerating the innocent and pursuing suspects it must be treated in accordance with its importance. The evidence must be located, its position documented, be collected, be identified by marks/writing on it and/or on the package in which it is placed, and be transmitted to the evidence room or the crime laboratory while the collector maintains the chain of custody.¹ This chapter describes the proper protocols of dealing with various types of physical evidence. Adherence to approved procedures maintains the potential that the evidence can be a powerful part of the investigative process and avoids the embarrassment that careless handling is sure to bring. Even more serious is the possibility that but for the careless handling of evidence the prosecutor would have filed charges against a suspect.



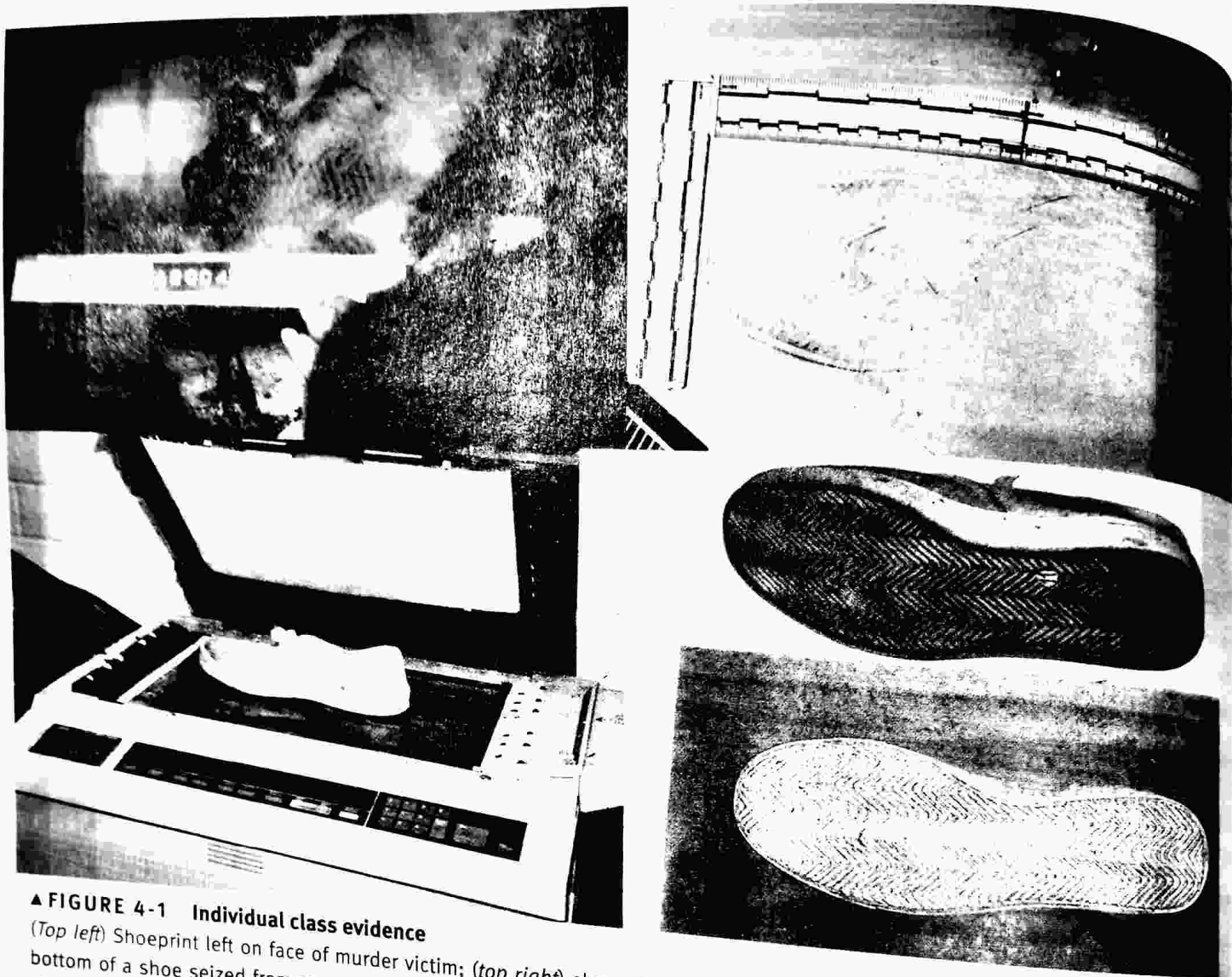
CHAPTER OUTLINE

- Introduction
- Class versus Individual Characteristics
- Comparison Samples
- Soil and Pollen
- Footwear, Foot, and Tires: Prints and Impressions
- Paint
- Glass
- Fiber, Cloth Fragments, and Impressions
- String, Cord, Rope, and Tape
- Fingerprints
- Forensic Odontology
- Hair
- Blood
- Lip Cosmetics, DNA, and Lip Prints
- Firearms
- Tool Marks
- Questioned Documents

CLASS VERSUS INDIVIDUAL CHARACTERISTICS

To fully appreciate the potential value of physical evidence, the investigator must understand the difference between class and individual characteristics. Characteristics of physical evidence that are common to a group of objects or persons are termed **class characteristics**. Regardless of how thoroughly examined, such evidence can be placed only into a broad category; an individual identification cannot be made because there is a possibility of more than one source for the evidence.² Examples of this type of evidence include all unworn Nike athletic shoes of a particular model, the new, unmarked face of a manufacturer's specific type of hammer, and soil. In contrast, evidence with **individual characteristics** can be identified, with a high degree of probability, as originating with a particular person or source (Figure 4-1).³ The ability to establish individuality distinguishes this type of physical evidence from that possessing only class characteristics. Some examples of evidence with individual characteristics are fingerprints, palm prints, and footprints.

Conceptually, the distinction between class and individual characteristics is clear. But as a practical matter, the crime scene technician or investigator often may not be able to make this differentiation and must rely on the results



▲ FIGURE 4-1 Individual class evidence

(Top left) Shoeprint left on face of murder victim; (top right) shoeprint left on hood of car at scene; (bottom right) duplicating the bottom of a shoe seized from suspect; (bottom left) wear patterns and slight nicks in the shoe's tread made it individual characteristic evidence. Additionally, DNA from blood caught in the shoe tread and the victim tied the shoe to contact with the victim. (Courtesy Detroit Michigan State Police)

yielded by crime laboratory examination (Figure 4-1). Thus, although the investigator must recognize that physical evidence that allows for individualization is of more value, he or she should not dismiss evidence that appears to offer only class characteristics through laboratory examination. Furthermore, a preponderance of class-characteristic evidence tying a suspect (or other items in the suspect's possession) to the scene strengthens the case for prosecution. Note also that occasionally class-characteristic evidence may be of such an unusual nature that it has much greater value than that ordinarily associated with evidence of this type. In an Alaska case, a suspect was apprehended in the general area where a burglary had been committed; the pry bar found in his possession contained white stucco, which was of considerable importance, since the building burglarized was the only white stucco building in that town.⁴ Finally, class-characteristic evidence can be useful in excluding suspects in a crime, resulting in a more effective use of investigative effort.

COMPARISON SAMPLES

Much of the work of forensic science involves comparing various types of samples. Special terms are used to refer to these samples, and you must know what they mean to communicate with the laboratory and understand reports. At the most general level, comparison samples may be from **known sources**; each of these two main categories has three subcategories.

Unknown or Questioned Samples

1. *Recovered crime scene sample whose source is in question:* This evidence may have been left, for example, by either victims or suspects. A typical question is "Whose fingerprints are on the window used as the point of entry?"
2. *Questioned evidence that may have been transferred to an offender during the commission of a crime and been*

taken away by him or her: When compared with the evidence from a known source, this evidence can be used to link the suspect to a person, vehicle, tool, or weapon. For example, the question might be "Do any of the hairs combed from the suspect's hair match those of the victim?"

3. *Evidence from an unknown or questioned source that can be used to link multiple offenses:* This material might link crimes that were committed by the same person, tool, or weapon. Assuming that a suspect is arrested at a murder scene with a pistol in his overcoat, the question raised could be "Did this gun fire the bullets recovered from the victims of a double homicide a week ago?"⁵

Known Samples

1. *Standard or reference sample:* This is material from a known or verifiable source. It is compared to similar material from an unknown source to determine whether an association or linkage exists between a crime scene, a victim, and the offender. For example, a sample of blood is taken under medical conditions from the suspect so that it can be compared with blood on the victim's shirt.
2. *Control or blank sample:* This is material from a known source that was uncontaminated by the crime (for example, carpet fibers taken from the far corner of a room in which a body was found). It is used to make sure that the material on which evidence was deposited—for instance, carpet fibers, under the body, on which there is blood, does not interfere with laboratory testing.
3. *Elimination sample:* This type of sample is taken from a source known to have had lawful access to the crime scene, such as a police officer, medical technician, or the occupant. It is compared with unknown samples of the same type from the scene so that matches can be eliminated, thereby highlighting non-matches. An example is elimination prints. If latent fingerprints recovered at a crime scene do not match the fingerprints of those who have lawful access to the area, they immediately become of investigative interest in terms of determining whose prints they are.⁶

SOIL AND POLLEN

Soil can be the natural accumulation of earth materials, such as weathering rocks, minerals, and decomposing plants, pollen, bacteria and fungus.⁷ It may also contain human-made materials, including pieces of brick, glass, and paint. By comparing color, texture, and composition in soil examinations, one can determine whether soils share a common origin.⁸ Although soil is class-characteristic evidence, its analysis can help focus investigations and discredit alibis:

A man was arrested and charged with the beating of a young girl. The scene of the crime was a construction site adjacent to a newly poured concrete wall. The soil was sand, which had been transported to the scene for construction purposes. As such, it had received additional mixing during the moving and construction process and was quite distinctive. The glove of the suspect contained sand that was similar to that found at the scene and significantly different in composition and particle size from that in the area of the suspect's home. This was important because the suspect claimed that the soil on the gloves came from his garden.⁹

An elderly woman was robbed and murdered in a Washington, D.C., park, and her body was found under a park bench. Within a short time, a suspect was apprehended as a result of a description given by a witness who had seen the person leaving the park on the night of the murder. It was obvious that the suspect had been involved in a struggle and had soil adhering to his clothing and inside his trouser cuffs. He claimed to have been in a fight in another part of the city and gave the location of the fight. Study of the soil near the park bench and of that collected from the scene of the alleged fight revealed that the soil from the suspect's clothing was similar to soil near the park bench but did not compare favorably with samples from the area of the described fight. These comparisons strongly suggested that the suspect had been in contact with the ground in that area and cast strong doubt on his statement that he had not been in the park for years. Furthermore, the lack of similarity between the clothing soil samples and those from the area in which he claimed to have been fighting questioned the validity of his alibi.¹⁰

The pollen in soil or on plants and grass can also be very significant in determining whether or not a suspect was at the scene:

In a case of alleged sexual assault, the pollen content of samples from a grassy crime scene were compared to pollen recovered from the suspect's clothes and shoes. A very strong correlation with the variety of pollens present on the suspect's clothing and the sample collected at the scene strongly supported the conclusion that the suspect was at the scene.¹¹

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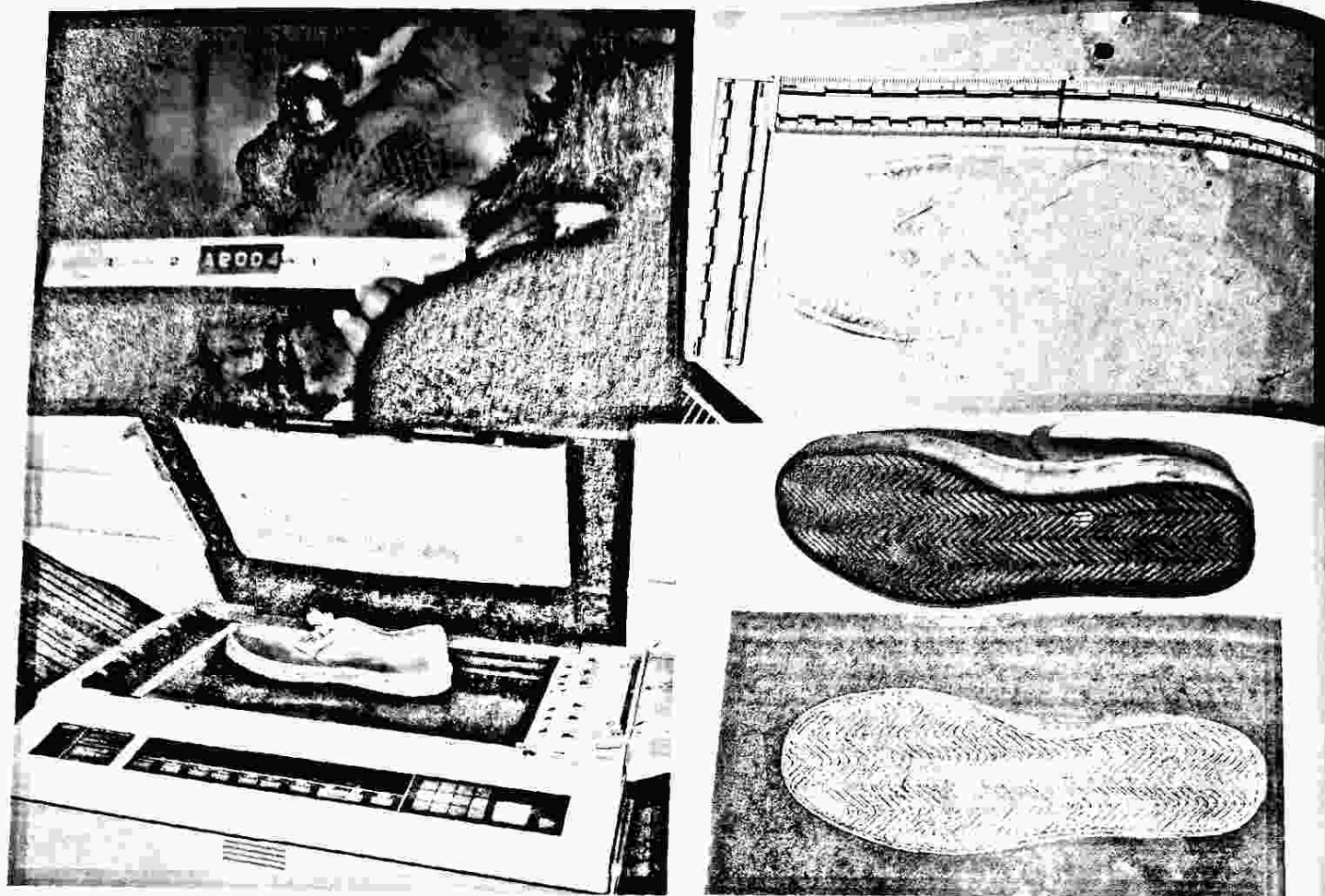
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Although soil and pollen are class-characteristic evidence, their specificity can approach the level of individual characterization:

In a rape case, the knees of the suspect's trousers contained encrusted soil samples; the sample from the right knee was different from that collected from the left. In examining the crime scene, investigators found two impressions in the soil corresponding to a right and a left knee; samples taken from these two impressions were different. The soil sample from the left-knee impression compared with that removed from the left trouser knee of the suspect, as did the right-knee impression and the right trouser knee soils. The significant difference in soil type between the two knee impressions and their consistency with samples obtained from the suspect's trousers strongly indicated his presence at the scene.¹²

LOCATING AND HANDLING SOIL EVIDENCE

Soil residues and smears on such surfaces as clothing, people, and vehicles may not be of sufficient quantity for analysis. Unless the suspects were apprehended at the scene or in very close proximity to it, the soil on their feet/shoe soles and the tires of their cars may have been contaminated, and therefore may not be of evidentiary value.¹³

Soil evidence may be important when the suspect drives or walks on unpaved areas, since it is picked up by tire treads or the bottom of shoes and the cuffs of pants. It may also be recovered in a number of other places, such as on the floorboard of the subject's car or on articles in the trunk of the vehicle, including shovels and blankets. In hit-and-run accidents, soil samples may be encountered, for example, in one unusual case, a solid soil sample in the rough shape of a triangle with 3-inch sides was found and later substantially matched to a space on the underside of the suspect's vehicle. The guidelines shown next should be followed in handling soil evidence:

1. Soil conditions at the scene can change, so gather the soil as quickly as sound action permits.
2. Collect soil not only from the crime scene but also from the logical points of access to, and escape from, the scene. Place the samples in clean plastic vials and labeled with the date, time, name of the crime scene technician, and the case number, if known.
3. Collect soil samples where there are noticeable changes in color, texture, and composition.
4. Collect soil samples from a depth that is consistent with the depth at which the questioned soil may

have originated. In most cases, samples will be a tablespoon of material taken no more than ½ inch from the surface.

5. When possible, collect soil samples from alibi areas, such as the worksite, yard, or garden of the suspect.
6. Make a detailed drawing or map documenting where and at what depth you collected each soil sample.
7. Do not remove soil adhering to shoes, clothing, and tools. Do not process tools for latent prints at this time. Air dry the soiled garments and package them separately in paper bags. Avoid jostling and transport to the crime lab for analysis and further processing.
8. Submit unknown or questioned soil and known samples in separate leak-proof containers such as film canisters or plastic pill bottles. Avoid the use of paper envelopes or glass containers. If there are lumps in the soil, pack it in a way that keeps the lumps intact.¹⁴
9. In packaging soil or other types of evidence, take care to avoid **cross contamination** of the samples.
10. Soil impressions made by footwear should be photographed to scale and cast before any soil samples are taken.
11. At indoor crime scenes, special vacuums may be used to collect soil samples from carpets and floors that may have been introduced by the suspect(s). Collect and document each procedure before transporting the contents to the crime lab.¹⁵

The guidelines for collecting pollen evidence are consistent with those for soil evidence. It may be necessary to take grass or other clippings from different heights.

FOOTWEAR, FOOT, AND TIRES: PRINTS AND IMPRESSIONS

Prints may be made from (1) footwear, including shoes, boots, and sandals; (2) the soles of feet; and (3) tires, and all are common types of evidence.¹⁶ These prints are formed when the soles of footwear, soles of feet, and tires are contaminated with foreign matter such as blood or dust and leave a print on a firm base, such as a floor, the seat of a chair, paper, or cloth (Figure 4-2).¹⁷ Such prints are called **residue prints**. In contrast, **impressions** result from footwear, feet, and tires treading in some moldable material, such as earth, clay, and snow.¹⁸ For residue prints and impressions the sequence is always photograph and then collect the evidence.

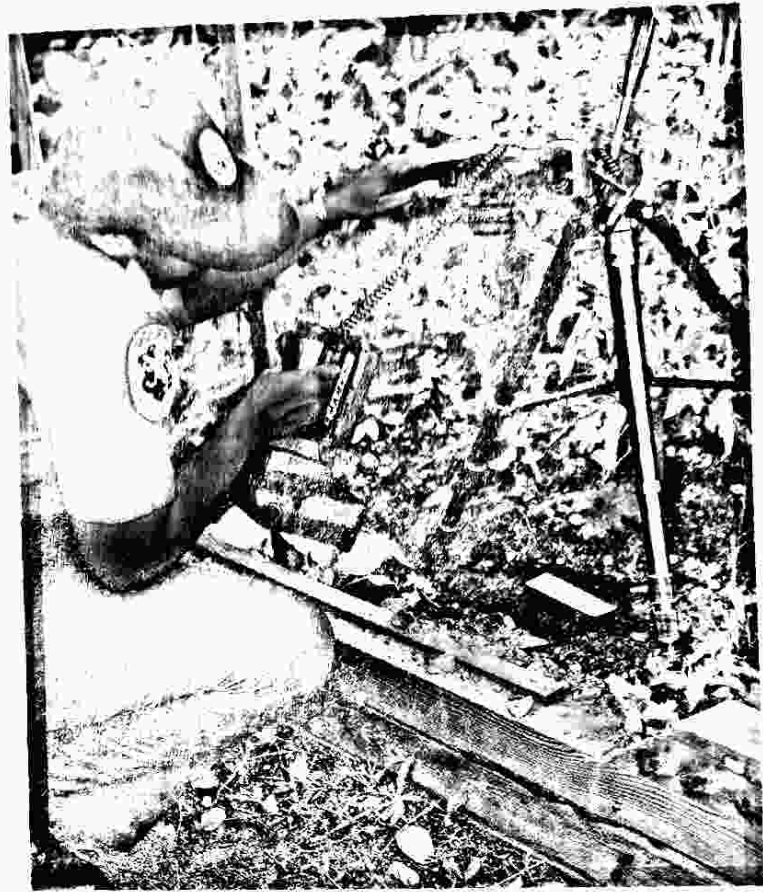
Residue and impression evidence can provide investigative leads, such as the number of suspects at the scene, where they walked in the scene, some indication of the



FIGURE 4-2

Tire print left on pedestrian victim's shirt by hit-and-run vehicle

Police located a potentially involved vehicle. Tire print and other physical evidence established it struck the pedestrian. However, the car's owner still needed to be put behind the wheel. Confronted with the evidence, he confessed. (Courtesy Seattle Washington State Police)



▲ FIGURE 4-3 Footwear impression photography

A crime scene technician documenting a footwear impression. The impression runs left to right, roughly between the front legs of the tripod. The white slip of paper "North" of the impression has the case number and other information on it. (Courtesy Nassau County, New York Police Department)

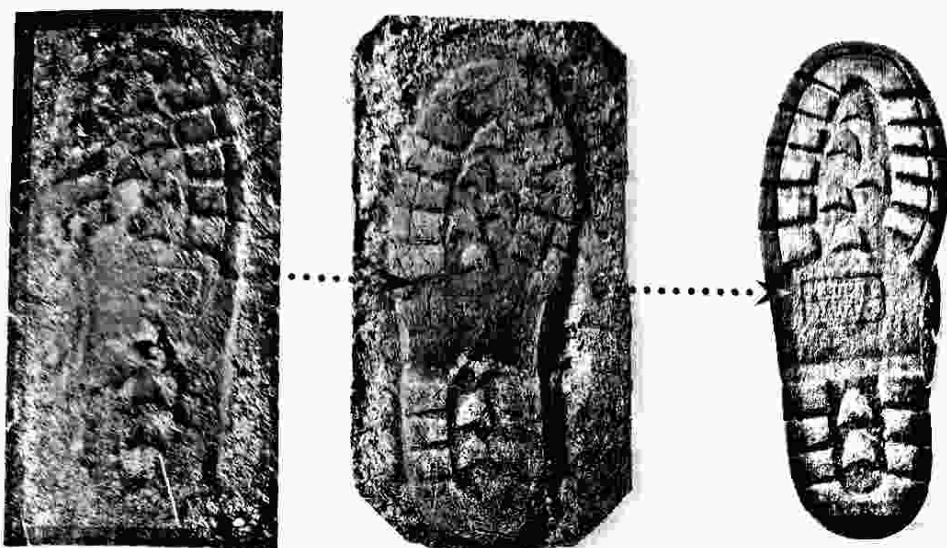
sequence of events, the direction taken by the suspects as they left the scene, the type and brand of shoe or tire, and the type of vehicle involved.¹⁹ Although European agencies report collecting footwear evidence in over 70% of their cases, its use in this country is much less, possibly due to a lack of awareness and proper training by crime scene technicians.²⁰

A number of software programs, such as SICAR, can compare footwear and tire evidence. **SoleMate** contains the records of 24,000 sports, work, and casual footwear. Its purpose is to identify footwear prints recovered at a crime scene. It is updated continuously and distributed on CD to users quarterly. **CrimeShoe** has a collection of 23,000 shoe and sole images representing 950 brands. Using the Internet, investigators can upload their prints. If CrimeShoe cannot make an identification or provide other relevant information there is no charge. **TreadMate** is a reference collection of 8,500 tires, available for a fee on CD issued annually.

PRESERVING RESIDUE PRINTS

Residue prints are two dimensional; they have a length and a width and no appreciable height. They may be from a dry origin, such as dust, or a wet one, for example, stepped in oil.²¹ Residue prints may or may not be readily visible. If they are not immediately apparent, turn off the lights and search for prints using a flashlight held close to, but obliquely from, the surface you are examining or use a forensic light source. When you find prints:

1. Take general crime scene photos showing the location of the prints.
2. Take photos from directly overhead using lighting and a tripod. A photo with a label near the print should be taken to correlate photos with the photo log (Figure 4-3). Subsequent shots should include a scale near the print. Ideally, "L"-shaped footwear/tire photographic scale should be used to capture



◀ **FIGURE 4-5**
Footwear impression

A footwear impression is found in the dirt, a cast is made, and its examination holds the potential to provide important investigative information or evidence, such as matching the footwear of someone in custody. (Courtesy SIRCHIE Fingerprint Laboratories, Inc.)

Otherwise, there will be a lap mark in the cast that is likely to cause a loss of detail.

Dental stone sets fairly rapidly. Die stone sets up quicker, in 12 to 15 minutes. Soil evidence should be collected from the bottom of the impression after the cast is removed.

If there is standing water in the impression, the following steps should be taken: (1) place a casting frame around the impression so that a cast 2 inches deep can be made; (2) gently sift dental stone that has not been mixed with water directly into the impression to a depth of about 1 inch; (3) add enough mixed dental stone to form a second 1-inch layer; and (4) allow the cast to set in place for at least 1 hour.²⁴

The crime scene technician or other person casting the footwear impression should enter her or his initials, the date, and other relevant details on the bottom of the cast before it dries.²⁵ For submission to the laboratory, wrap the cast in tissue, clean paper, packing peanuts, or multiple paper bags. The laboratory examiner will clean the cast and examine it after it has dried for 24–48 hours.

PRESERVING SHOE IMPRESSIONS IN SNOW

Dental stone is also the preferred material for casting impressions in snow, replacing the more difficult and time-consuming process of using sulfur, which had to be heated. Impressions in snow should first be photographed in the manner previously described; however, impressions in snow are difficult to photograph because of a lack of contrast.²⁶ To overcome this, lightly spray several layers of red-colored Snow Print Wax (SPW) or spray paint over the impression at a 45-degree angle from the surface (Figure 4-6). Pause briefly between layers to let the SPW dry; in addition to coloring the impression, SPW

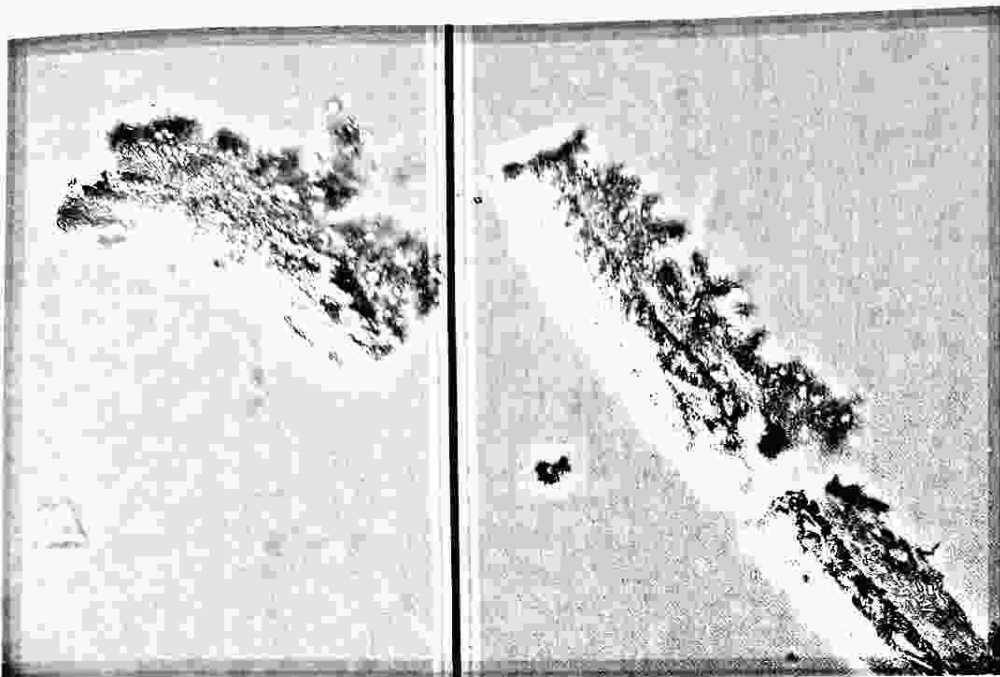
leaves a waxy surface on it that prevents the small amount of heat generated by the drying dental stone from erasing the fine details of the impression. To combat heat formation when casting in snow, use snow or cold-water mix in the dental stone.

The spray nozzle should be held 24 inches to 36 inches from the impression so the force of the aerosol doesn't alter it. An impression highlighted in this manner will absorb heat from the sun and should be shielded until ready to photograph and cast. Because some heat is generated when dental stone is mixed, a box should be placed over the cast for at least 1 hour as it dries.

PAINT

Paint evidence may be encountered in many types of investigation, but perhaps most commonly it is transferred from one source to another in burglaries and hit-and-run accidents. Paint is transferred as fresh smears, dried chips, or "chalking" from old, dry paint. Many burglaries involve a tool that was used to pry a door or window open, transferring paint from the building to the suspect's tools or clothing. In hit-and-run accidents, paint from the fleeing vehicle may be found on a pedestrian or another car.

In hit-and-run cases, the make and model of the involved vehicle might be identified by comparing paint evidence to the records in the FBI's National Automotive Paint File on original-manufacturer finishes. **Paint Data Query (PDQ)**, another database, is a global information system on the paint used by the original manufacturer. Each of the roughly 22 countries participating in this system maintains a central point of information; in



◀ **FIGURE 4-7**
Paint chip fracture match
 (Courtesy Texas Department of Public Safety)



◀ **FIGURE 4-8** Side view of a multilayered paint chip
 (Courtesy Wisconsin Dept of Justice - State Crime Laboratory)

they are often fragile. A clear solid plastic container is ideal for packaging a paint chip, because it can be seen. Paper envelopes are acceptable if they are properly sealed and protected from being bent or compressed.

The sheets placed under and over hit-and-run victims in the ambulance while they are being transported may also be a good source of paint evidence; the clothing and sheets may have fresh blood on them. These items should be allowed to air dry naturally in properly ventilated lockers. Before hanging these items in the lockers or other secure place, place fresh paper under the items so any evidence that falls as the drying occurs can be recovered. When dried, place the items separately in their own paper bag and submit them to the laboratory.

samples around each separate area that is involved with the incident.

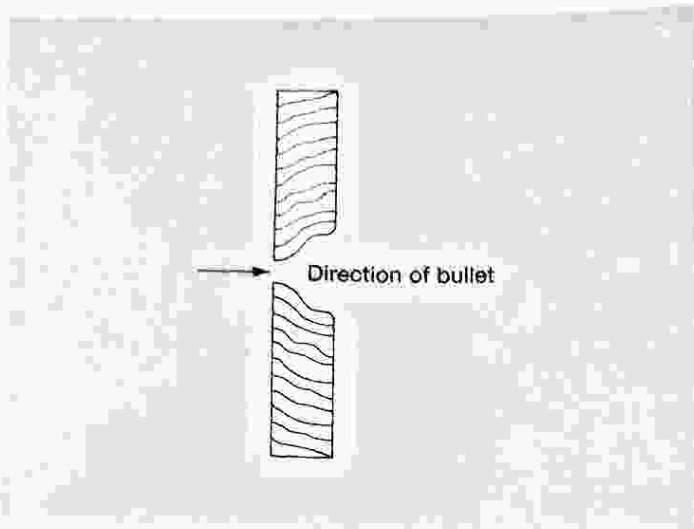
A new razor blade or evidence scalpel should be used for each paint chip recovered to avoid contamination. Burglary tools that may contain paint evidence should be carefully wrapped and submitted to the lab without disturbing the evidence. Similarly, the clothes of a burglary suspect arrested at the scene or in its vicinity and the clothes of a pedestrian hit-and-run victim should be submitted to the lab without attempting to collect paint evidence. Paint smears may also be useful, and it is desirable to submit the item on which the smear is found—for example, a car's bumper, to the laboratory.

Do not collect paint chips or particles with transparent tape or use it to fix the evidence to a card. Paint chips and particles should not be placed in plastic bags, because they will develop a static electrical charge that makes them hard to handle. Placing paint chips in cotton is not good practice, because separating them is difficult and

GLASS

Generally, glass is class-characteristic evidence, although in some fact situations it may be individual class. Glass is important as physical evidence because it is so common. Suspects may take it from the scene in their clothing or hair. Laboratory examination of glass evidence may be able to determine:

1. the type of glass, such as tempered or container;
2. the direction of force used to break the glass (Figure 4-9);
3. the direction and sequence of shots fired through a closed glass window;
4. similarity between evidence glass and standards;
5. a fracture physical match, establishing that the pieces were formerly joined (Figure 4-10).³⁰



▲ FIGURE 4-9
Determining the direction of a bullet's penetration of glass

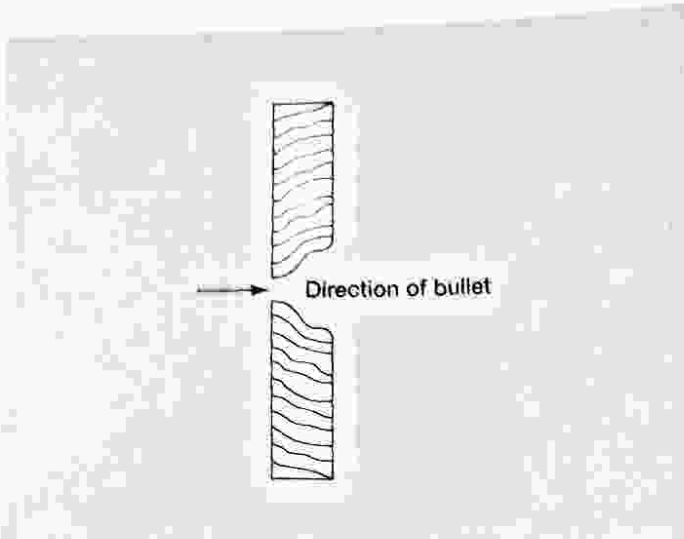
Police were called to a home where the occupant alleged that while standing in the living room someone standing outside of the house fired a shot at him. The complainant dropped to the floor, crawled to a nearby desk, and retrieved his revolver. After a short time he stood up and the person outside fired a sec-

ond and third time. At that point the complainant fired a single shot at the outsider, whom he recognized as a man who lived nearby. The alleged shooter had a different version of events. He was walking past the complainant's house and was shot at three times before he shot once in self-defense at the man in the house. All shots passed through the glass of a single window. Both men said there was "bad blood" between them.

Figure 4-11 illustrates the four bullet holes found in the window by the police. When a glass window is broken by a shot, both **radial fracture** and **concentric fracture** lines may develop. Radial fractures move away from the point of impact; concentric fracture lines more or less circle the same point. From Figure 4-9 we know that shot B came before shot A, because the radial and concentric fracture lines of shot B stop those of shot A. From 4-11, we know nothing of the relationship of holes C and D. However, as shown in Figure 4-9, we can determine the direction from which a bullet penetrated glass: on the side opposite the surface of initial impact, there will be a characteristic cone-shaped area. In the case being illustrated, shots A, B, and D all contained a cone-shaped characteristic on the inside of the window, indicating that these three shots had been fired from the outside. Shot C had the cone-shaped area on the outside, revealing that it had been fired from inside the house. Thus the physical evidence substantiated the complainant's statement.

► FIGURE 4-10
Glass fracture match of a rear tail light and assembly
Pieces of red tail light were found at the scene of a hit-and-run and matched with pieces still intact in the tail light assembly when the suspect vehicle was located. (Courtesy Mr. Ed Hueske and Ms. Sherry Bethune, Forensic Training and Consulting, LLC, 2007)





▲ FIGURE 4-9
Determining the direction of a bullet's penetration of glass

Police were called to a home where the occupant alleged that while standing in the living room someone standing outside of the house fired a shot at him. The complainant dropped to the floor, crawled to a nearby desk, and retrieved his revolver. After a short time he stood up and the person outside fired a sec-

ond and third time. At that point the complainant fired a single shot at the outsider, whom he recognized as a man who lived nearby. The alleged shooter had a different version of events. He was walking past the complainant's house and was shot at three times before he shot once in self-defense at the man in the house. All shots passed through the glass of a single window. Both man said there was "bad blood" between them.

Figure 4-11 illustrates the four bullet holes found in the window by the police. When a glass window is broken by a shot, both **radial fracture** and **concentric fracture** lines may develop. Radial fractures move away from the point of impact; concentric fracture lines more or less circle the same point. From Figure 4-9 we know that shot B came before shot A, because the radial and concentric fracture lines of shot B stop those of shot A. From 4-11, we know nothing of the relationship of holes C and D. However, as shown in Figure 4-9, we can determine the direction from which a bullet penetrated glass: on the side opposite the surface of initial impact, there will be a characteristic cone-shaped area. In the case being illustrated, shots A, B, and D all contained a cone-shaped characteristic on the inside of the window, indicating that these three shots had been fired from the outside. Shot C had the cone-shaped area on the outside, revealing that it had been fired from inside the house. Thus the physical evidence substantiated the complainant's statement.

► FIGURE 4-10
Glass fracture match of a rear tail light and assembly

Pieces of red tail light were found at the scene of a hit-and-run and matched with pieces still intact in the tail light assembly when the suspect vehicle was located. (Courtesy Mr. Ed Hueske and Ms. Sherry Bethune, Forensic Training and Consulting, LLC, 2007)



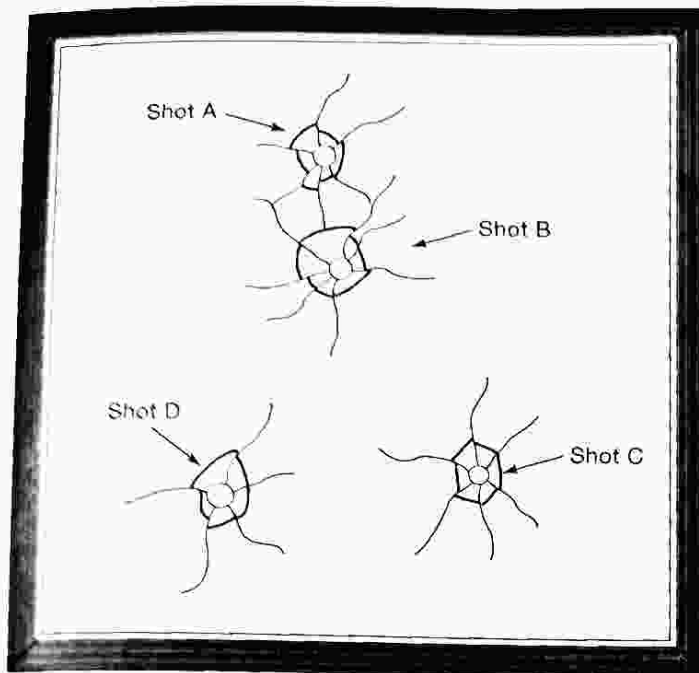


FIGURE 4-11 Bullet holes found in window

Walking a beat in a downtown business section in the late evening hours, a uniformed officer heard an alarm go off and saw an individual round the corner and run toward him at full speed. On seeing the officer, the individual started to double back the other way and then stopped. As the officer approached, the man started to flee, but he stopped when commanded to do so. The man then told the officer that he had observed two people standing in front of a jewelry store window take a brick from a shopping bag and throw it through the window. The person said that, on seeing this, he became frightened and ran. Subsequent investigation revealed that the person who had rounded the corner was in fact the perpetrator of the offense and that he had fled before obtaining any material from the display window, because a lookout had seen a police car responding to a call in an adjacent block and had given warning. Processing of the perpetrator's clothing revealed pieces of glass in the cuff of his pants sufficiently large to make fracture matches with glass at the scene.

It is essential that the crime scene technician and investigator understand the ways in which glass reacts to force. Often this knowledge is critical in determining whether a crime has been committed, establishing the sequence of action, and evaluating the credibility of statements given by parties at the scene. Before any glass or window pane is moved at all, it should be photographed

in detail to reflect the exact features of the existent glass fractures. Moving the evidence may cause fracture extensions that could change the conclusions of the investigator and laboratory analyst. At crime scenes involving automobiles, the utility of glass evidence may be compromised by rescue personnel working to free occupants and wreckers pulling involved vehicles to the side of the road.

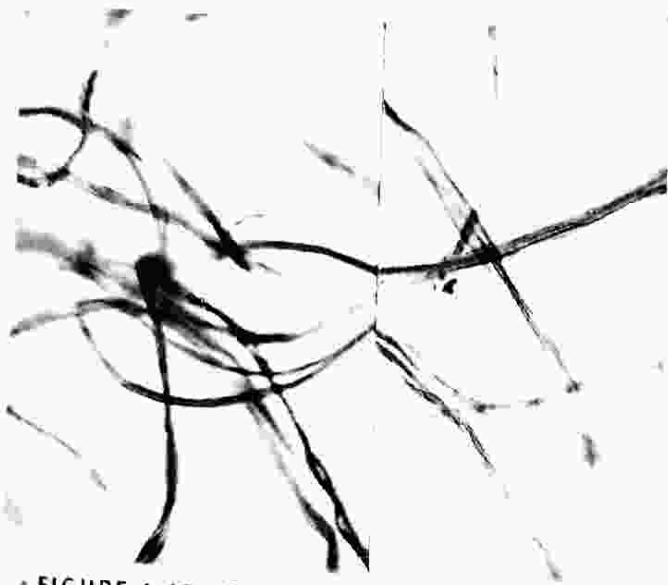
This example underscores the importance of the investigator's paying particular attention to determining what occurred between the time of the crime and the time he/she arrived at the scene. A key question that the investigator must attempt to answer with glass and other types of evidence is whether the position and characteristic of evidence could have been altered by the suspect, a witness, the victim, emergency medical personnel, or another officer. Stated differently, do not assume that the position of evidence you locate is in its original position.

HANDLING GLASS EVIDENCE

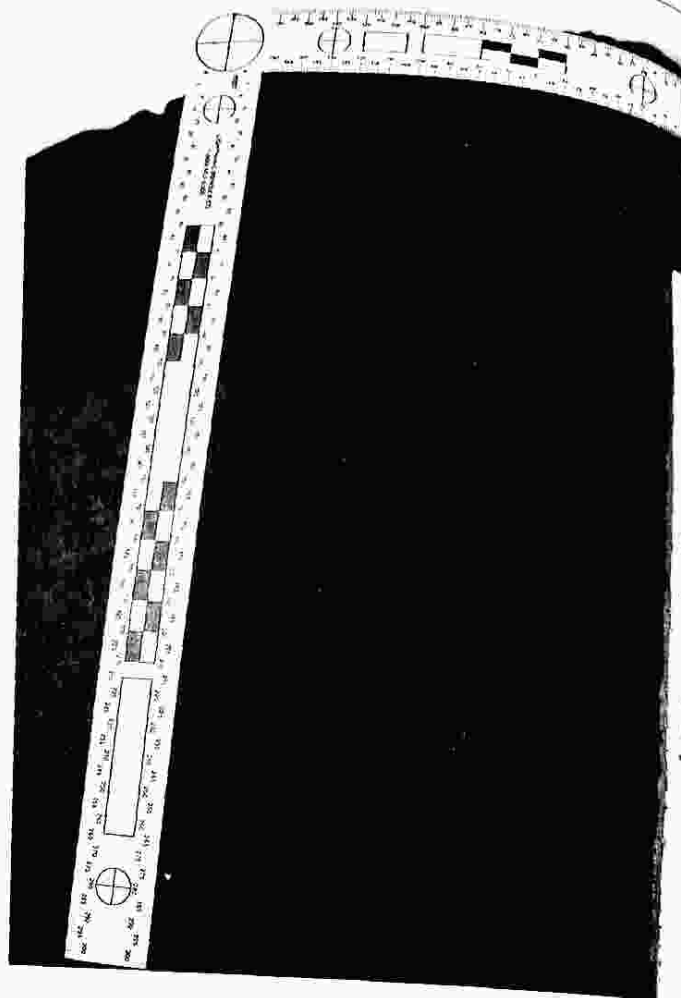
Ordinarily, if glass evidence is to be processed for fingerprints, it will be done in the laboratory.³¹ Tape should not be used to collect glass evidence in the field because it interferes with laboratory processing. As with other types of evidence, photography precedes the collection of glass evidence.

The physical properties used for comparison of known and questioned glass specimens are color, fluorescence, thickness, surface features, and curvature.³² If glass is being submitted for comparison purposes, that is, to determine whether the particles may have originated from a common source, they are ordinarily small, and the following precautions should be taken: (1) glass evidence from combing hair should be done over clean paper; (2) clothing and shoes should be packaged separately, and in no case should the victim's and suspect's items be comingled in any way; (3) if clothing items are wet, air dry them in the manner previously described; (4) glass may be embedded in the skin and open wounds of victims and suspects, and recovery by qualified medical personnel may be required; (5) submit weapons and tools without disturbing glass evidence; (6) samples of laminated glass—for example, windshields, should be labeled "inside" and "outside" and separately packaged in leak proof containers; (7) if a vehicle is involved, use a vacuum to collect the glass from each area of the vehicle; evidence collected from different areas should be packaged separately, and a new vacuum bag should be used for each new area processed; and (8) known and questioned glass samples, and evidence from victims and suspects, should be shipped separately to avoid contamination. These types of evidence should be wrapped in clean paper and sealed in a rigid container, such as a box, or if sufficiently small, a plastic container. Do not submit the evidence in a glass container.

If door, window, or other framed glass is to be submitted for possible fracture matches, submit the entire frame



▲ FIGURE 4-12 Comparison of cotton fibers
The victim, who was wearing a red shirt, was stabbed by a man. Fibers from the victim's shirt (*above*) were compared to fibers collected from the assailant's pants (*right*). The two sets of fibers were consistent in all respects, although this finding does not exclude other sources for the fibers on the assailant's pants. (Courtesy Chicago Police Department)



Cloth fragments may be found at the scene of violent crimes or along the perpetrator's point of approach to, or exit from, a crime scene (Figure 4-13). They may be found on such diverse points as a chain fence, the splintered edge of a wooden building, or protruding nails. In hit-and-run offenses, cloth fragments may be found in the grille or undercarriage of the striking vehicle. Cloth impressions are found infrequently in investigations, usually on wet paint or some surface of a vehicle involved in striking a pedestrian.

Both fibers and cloth fragments should be packaged in a pillbox or in folded paper that is taped shut. Only on rare occasions will it be possible to obtain a cast of a cloth impression. This effort, however, should invariably be preceded by the taking of several photographs; at least one of these photos should show a scale to allow for comparisons at some future date.

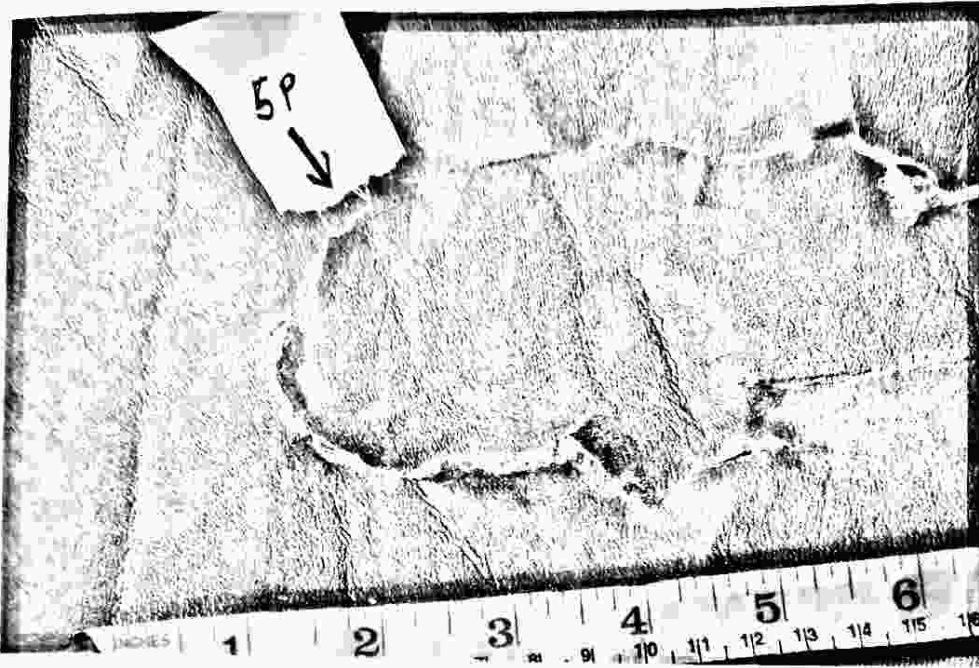
STRING, CORD, ROPE, AND TAPE

String, cord, rope, and tape evidence is usually found in robbery, murder, rape, and kidnapping cases. It is also associated with accidental hangings by children and accidental

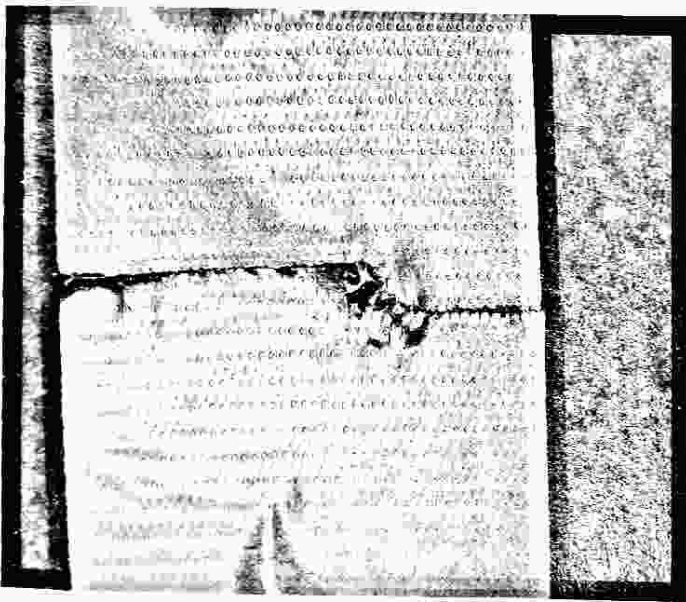
in which all glass originally existed, marking the sides of the frame to show which way is inside and outside, along with marking it "top," "bottom," "left," and "right." Broken pieces should be carefully packaged in separate containers to avoid breakage in transit. Depending on the sizes involved, it may be necessary to place the glass between sturdy pieces of cardboard or plywood.³³

FIBERS, CLOTH FRAGMENTS, AND IMPRESSIONS

Fibers are of value as evidence because they incorporate such variables as material type, number of fibers per strand, number of strands, thickness of fibers and strands, amount and direction of twists, dye content, type of weave, and the possible presence of foreign matter embedded in them. When something composed of fibers, such as clothing, comes into contact with other clothing or objects, there is the opportunity for the exchange or transfer of fibers. Fibers may also be located on the body of the victim or the suspect, serving to connect one to the other (Figure 4-12).



◀ **FIGURE 4-13 Fabric match**
Physical matching (sometimes called *physical fit* or *jigsaw fit*) is powerful and incontrovertible evidence. Shown here is a fragment from a victim's clothing found in the grille of the suspect's vehicle involved in a hit-and-run case. The fabric fragment fitted the victim's raincoat and conclusively established the contact between the suspect's vehicle and the victim. (© The McGraw-Hill Companies, photographer Keith Eng)



◀ **FIGURE 4-14 Tape match**

In a particularly violent rape, the suspect used gray duct tape to tie the victim's hands and cover her mouth. The victim was left for dead, but she managed to crawl out an open window and seek help. The top portion of the photograph is the filament tape recovered from the victim's face covering her mouth. The bottom part of the photograph is the end of the tape roll found in the suspect's pocket. By showing that these two ends of the duct tape match, a physical match is established. (Courtesy Portland, Oregon Police Bureau)

sexual asphyxiations. String, cord and rope have essentially the same characteristics and share some characteristics of fibers. Known samples of these types of evidence can be compared to crime scene evidence on the basis of composition, diameter, color, and construction; if a tracer is present, it is possible to identify the manufacturer. There is some preliminary evidence if string, cord, and rope is made from plant material, and contains cells from the plant of origin, then DNA analysis techniques can exclude or include as a source remnants found in a suspect's possession as compared to a length used to bind a victim.³⁴

In instances where the victim was tied, it may be possible to match the ends of the string, cord, rope, and tape with the rest of the roll in the suspect's possession (Figure 4-14). When rope evidence is removed from a victim or from anyplace, knots should never be severed. Instead, a place away from the knot should be cut and a piece of

twine used to loop the two ends together. A tag should be attached to indicate that the investigator has cut the rope. Evidence about knot tier handedness and use of habitual knots has been scarce and conflicting. A 2010 study of 562 subjects did reveal differences in patterns of knot tying between left and right handers.³⁵ Ordinarily, because of its resilient nature, the packaging of this type of evidence poses no particular problem when standard procedures are followed.

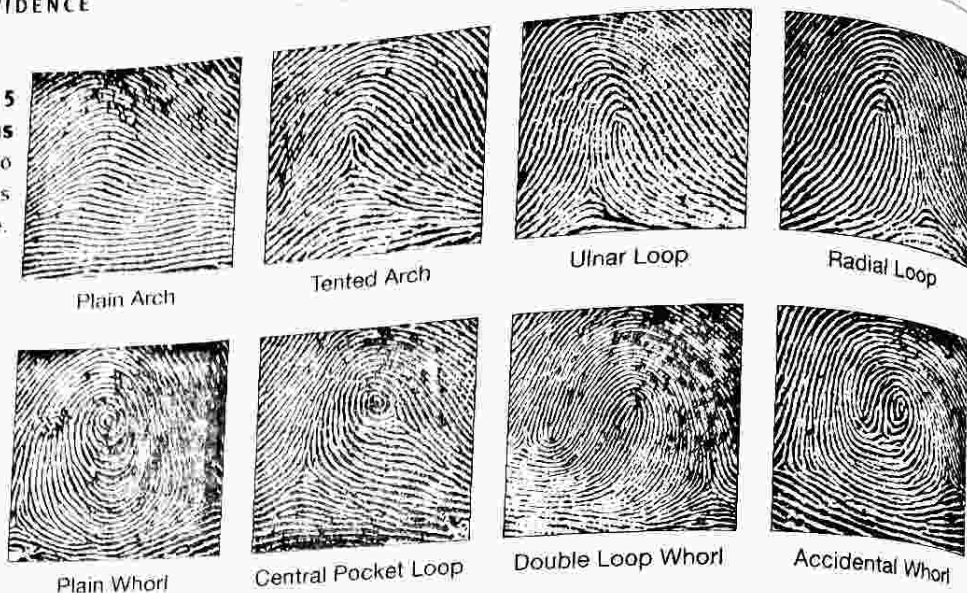
FINGERPRINTS

Several different parts of the body—such as palms, fingers, toes, and the soles of the feet—have friction ridges that can form a “fingerprint.” All such prints are collected, preserved, and identified using similar methods. But it may not be immediately apparent which part of a body made the print; as used here, “fingerprint” includes all prints made by friction ridges. Basically, a **fingerprint** is a replica of the friction ridges that touched the surface on which the print was found. These ridge characteristics are also called **minutiae**.

► FIGURE 4-15

Fingerprint patterns

Fingerprints are initially classified into one of the major classifications shown here.



With just a few exceptions—persons with birth defects or amputations—everyone has fingerprints. This universal characteristic is a prime factor in establishing a standard of identification. Since a print of one finger has never been known to duplicate exactly another fingerprint—even of the same person or an identical twin³⁶—it is possible to identify an individual with just one impression. The relative ease with which a set of inked fingerprints can be taken as a means of identification is a further reason for using this standard. Despite such factors as aging and environmental influences, a person's fingerprints do not change. This unaltering pattern is a permanent record of the individual throughout life.

BASIS FOR FINGERPRINT IDENTIFICATION

The ridge detail of fingerprints—including ends of ridges, their separations, and their relationship to one another—constitutes the basis for identification of fingerprints. There are as many as 150 ridge characteristics in an averaged-sized fingerprint.³⁷ The major **fingerprint patterns** are shown in Figure 4-15. About 65% of the population have loops, roughly 30% have whorls, and the remaining 5% have arches.³⁸ Points are identical characteristics that are found in fingerprints from known and questioned sources. Positive identification cannot be made when an unexplained difference appears, regardless of the points of similarity.

There is no reliable method for judging the age of latent fingerprints, although the context in which they are found may provide some information. However, both here and in England over the past decade, research has been conducted on how the chemical composition of latent fingerprints varies from the time they are deposited; there is also interesting work suggesting that the chemical composition of latent fingerprints may at some point allow us to make some statements about the

approximate age of the donor.³⁹ The more immediate application of the research on the chemical composition of latent fingerprints will be improvements in the methods of developing them.

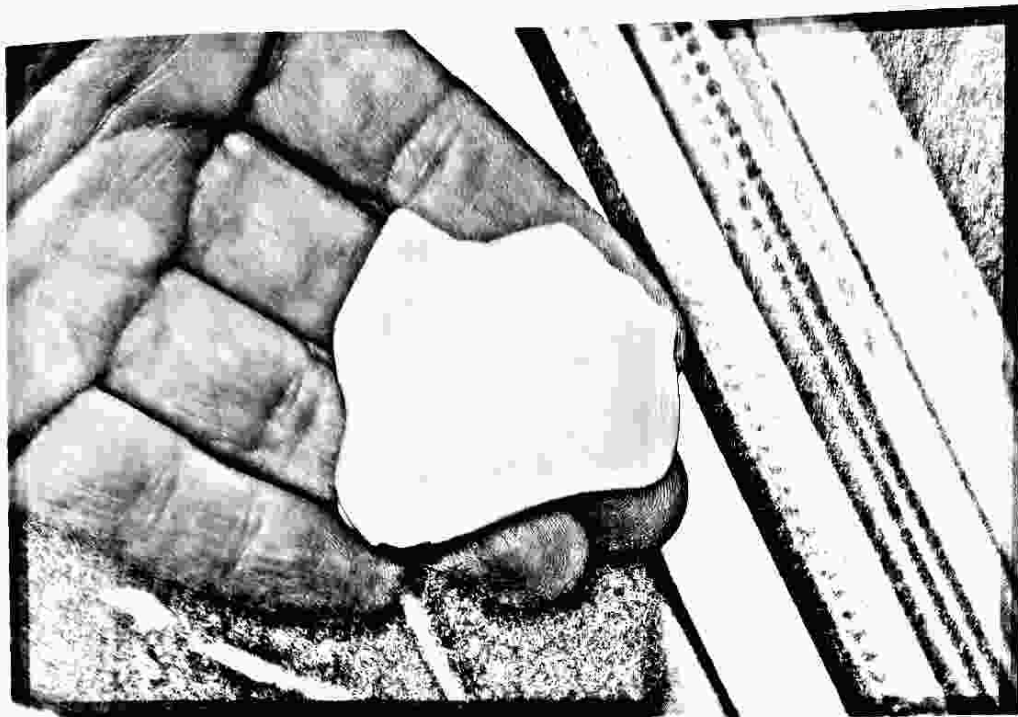
There is no standard requirement of print size for positive identification. It is necessary only that the partial print be large enough to contain the necessary points of individuality. This number may be found in an area as small as the flat end of a pencil. Thus, the rule whenever an investigator develops a partial latent print that appears to have only a few ridges is that it should be submitted to the laboratory.

Some persons erroneously believe that the points used for identification of the fingerprint occur only in the pattern area of the finger. In fact, all the different types occur outside the pattern area on the finger as well as on the first and second joints of the finger and the entire palm of the hand. They are also present on the toes and the entire sole of the foot; they may be found in any area where friction ridges occur.

LATENT FINGERPRINTS

Latent prints can be used in two different ways: (1) to refer to all three categories of prints identified below, in the sense that they have been found at the scene of the crime or on items of investigative interest—for example, a murder weapon recovered from a lake far from the primary crime scene—and (2) to refer specifically to latent/invisible prints. Ordinarily, the context in which the term is used helps in understanding which meaning is intended.

1. **Plastic prints** are three-dimensional; they are molded, indented, or impressed into some pliable surface (Figure 4-16). They are created when fingers touch material such as a painted surface that is still "tacky," oil films, explosives, edible fats, putty, dust, caulking, and similar surfaces.



◀ **Figure 4-16 Plastic print**
 A suspect left this print in a child's "silly putty" while keeping his victims at bay during a home invasion robbery. (© The McGraw-Hill Companies, Inc./Jill Braaten)

2. **Patent/contaminated/visible prints** result after fingers, contaminated with foreign matter such as soot, oils, face powder, ink, and some types of safe insulation, touch a clean surface. The most common type of contaminated print results when a finger is pressed into a thin layer of dust before touching a smooth surface. Fingerprints that result from blood contamination are sometimes less distinct than those that result from other types of contamination. Patent prints are readily visible to the eye.
3. **Latent/invisible prints** are unseen or hidden. When a crime scene is processed for latent fingerprints, they are made visible by "developing" them, a process described later in this chapter. Latent prints are associated with the small amounts of body perspiration and oil that are normally found on the friction ridges. A latent fingerprint is created when the friction ridges deposit these materials on a surface.

CONDITIONS AFFECTING THE QUALITY OF LATENT FINGERPRINTS

The quality of latent fingerprints is affected by a number of conditions, including these:

1. *The surface on which the print is deposited:* The type of surface on which latent prints are left affects their durability and the type of process used to develop them. There are three broad categories of surfaces:⁴⁰
 - a. **nonporous surfaces**, which are not absorbent. These surfaces often appear polished and repel moisture. Examples include mirrors, glass, smooth ceramics, plastic, and painted wood. Prints on these types of surfaces are more susceptible to

damage, because they are on the outermost surface. Undisturbed, they might last for years.

- b. **porous surfaces**, which are absorbent, such as documents and cardboard. Prints on documents, for example, may be durable and fairly stable over a period of years or they can quickly fade or deteriorate beyond the point of being useful if they are subject to high humidity or if they become wet.
- c. **semiporous surfaces**, which don't fit easily into the previous two categories, because they both resist and absorb fingerprints, which may or may not soak into the surface. Semiporous examples include glossy cardboard, magazine covers, and some types of cellophane. The durability of prints on these surfaces is variable.

Textured surfaces, such as the "pebbled" effect of some computer monitors are both nonporous and porous, because the pebbled effect creates an inconsistent contact between the friction ridge skin and the surface, producing a discontinuous appearance when developed and a lack of fine detail.

2. *The nature of the material contaminating the fingerprint:* patent fingerprints resulting from contamination by soot, safe insulation, and face powder are quickly destroyed; those made with blood, ink, or oil can last longer periods of time under favorable conditions.⁴¹
3. *Any physical or occupational defects of the person making the print.*
4. *How the object on which the prints appear was handled:* The distance between friction ridges is very small, and if the finger moves even slightly, that ridge detail can be lost.

5. *The amount of the contamination:* When the finger leaving the print is very contaminated, both the ridge surfaces and their "valleys" get filled up, resulting in a smeared appearance with little value as evidence.

LOCATING LATENT FINGERPRINTS

Proper latent print processing begins with wearing latex, nitrile, or other suitable gloves.⁴² Latent prints are such valuable evidence that extraordinary efforts should be made to recover them. The investigator must adopt a positive attitude about this, regardless of apparent problems or past failures.

It is imperative that the investigator thoroughly search all surface areas in and around the crime scene that might retain prints. Shining a flashlight at an oblique angle to the surface being examined is often helpful in this search. The fact that an individual may have worn gloves in no way lessens the need for a complete search. On occasion, gloves themselves leave impressions as individualized as fingerprints. Moreover, although unusual, it may be possible to develop a latent fingerprint on the inside of a glove recovered at a crime scene.⁴³ Particular attention should be paid to less obvious places, such as the undersides of toilet seats, toilet handles, tabletops, and dresser drawers; the surfaces of dinner plates and filing cabinets; the backs of rearview mirrors; and the trunk lids of automobiles. Frequently handled objects, such as doorknobs and telephones, ordinarily do not yield good prints. But because they are likely to have been touched, they should always be processed.

Never assume that the offender took precautions against leaving prints or destroyed those left. The commission of a criminal offense involves stress, and the offender may have made a mistake. If gloves were worn, for example, the suspect may have removed them for some operation.

It helps to attempt to view the scene as the criminal did. Such conditions as time of day, weather, and physical layout may suggest that certain surfaces should be more closely examined. In conducting the examination for latent prints in a burglary case, for example, the investigators should begin at the point of entry. For other crimes, such as the issuance of worthless checks, the point of entry often takes on less importance. Ordinarily, however, whatever the crime and its attending circumstances, reconstruction by the investigator gives direction to the search.

A person who is familiar with the environment, such as the owner of the building or the occupant of an apartment, may give valuable aid in obtaining latent prints. The person should be allowed to observe the scene so that he or she can indicate any items out of place or brought to the scene by the suspect.

When neither the ambient lighting nor the use of a bright flashlight reveals latent prints, other methods of

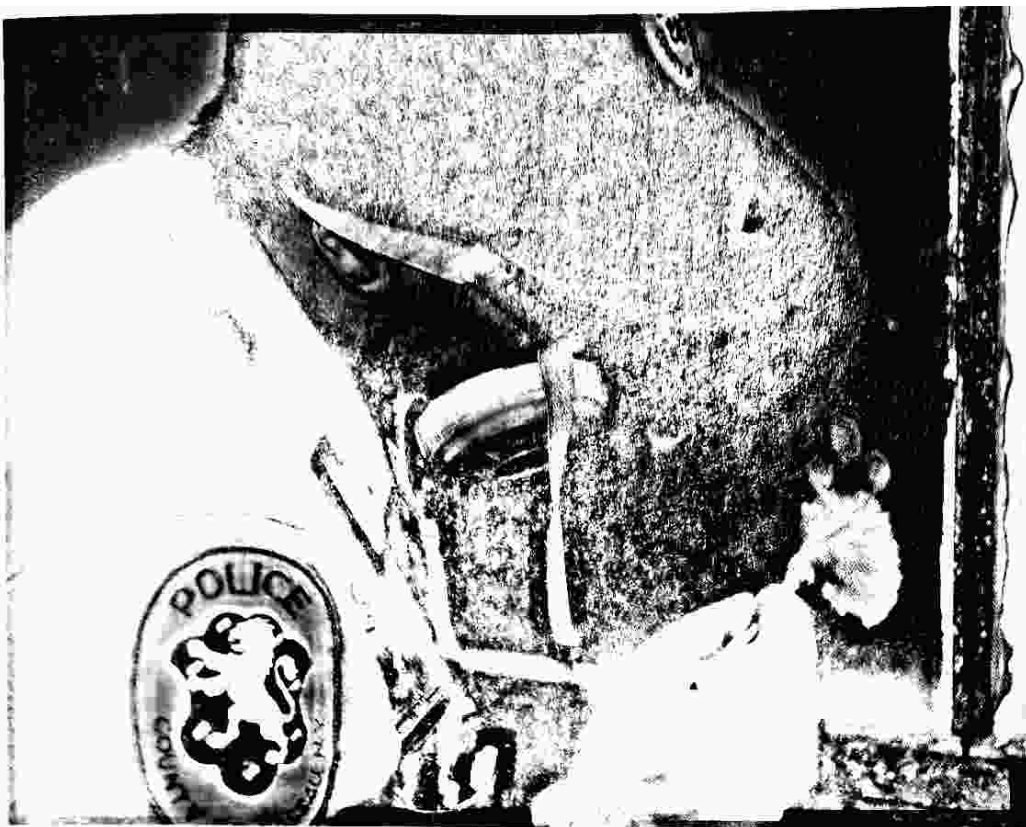
searching for them—a forensic light or laser unit—may provide results. A **forensic light source (FLS)** is a powerful light source that has one or more specialized light capabilities, such as infrared (IR) or ultraviolet (UV) light capabilities. UV lights, in addition to causing naturally fluorescent/glowing prints to be visible, are useful in locating small amounts of body fluids, hairs, fibers, and other evidence too small to be visible to the naked eye. Historically, lasers had superior illumination capabilities, but their size and cost precluded their use in most law-enforcement agencies. With the recent arrival of less costly, handheld third-generation laser systems, which are green-light-based, laser systems are becoming more widely used in the field. Appropriate safety precautions prescribed by FLS and laser system manufacturers, for example, wearing approved goggles, should be followed.

METHODS OF DEVELOPING LATENT FINGERPRINTS

Plastic and contaminated prints require little or no development. However, there are numerous ways to develop latent prints. Four methods that investigators should be familiar with are (1) use of traditional powders, (2) use of fluorescent powders, (3) application of chemicals, and (4) cyanoacrylate or superglue fuming. The most common method of developing latent/invisible prints is through the use of traditional powders (Figure 4-17). Because it may be possible to obtain a DNA sample from a print, the method selected for development should not eliminate this possibility.

Traditional Powders

Commercially prepared **traditional powders** come in a number of colors, including black, white, silver, red, and gray. To provide a good contrast between the print and the background on which it has been made, darker powders are used to locate latent/invisible prints on lighter-colored surfaces, and lighter ones are used on darker backgrounds (Figure 4-17). There are also dual-use powders, which appear black when dusted on a light-colored surface and silver when applied to a dark one. The tip of the brush is gently placed into the wide-mouthed powder container and then lightly tapped to allow excess powder to drop away. Caution must be used when applying the powder to a latent print. Too much powder creates a print in which the details are difficult to identify. This is why powder is never sprinkled directly on the surface to be dusted. The entire area to be dusted should be covered with smooth, light brush strokes until the ridge detail begins to show. Then, the brush strokes should follow the contours of the ridges until the latent/invisible print is fully visible. Even if the first attempt to develop a print is not successful, a second one may be. The choices of brushes include tips made of fiberglass, feathers, and camel hair. Most latent print development is done with traditional powders



◀ **FIGURE 4-17 Locating prints**

A crime scene technician uses protective equipment while dusting for fingerprints. Several developed prints can be seen in the area the technician is dusting. (Courtesy Nassau County, New York Police Department)

Magnetic applicators may be used in lieu of a brush. A magnetic applicator has a magnet in its head and when placed close to a magnetic powder container, it attracts the powder, forming a virtual brush. Magnetic powders commonly come in black, gray, and white. There are also dual-use magnetic powders. Magnetic powders are only used on nonmetallic surfaces.

Fluorescent Powders

As mentioned earlier, low concentrations of some naturally occurring substances will cause a latent print to fluoresce, or glow, under FLS or laser illumination. To compensate for the typically low level of naturally occurring fluorescence, investigators can dust the area to be examined with a special **fluorescent powder**, which chemically enhances the print when viewed under FLS or laser illumination (Figure 4-18). Fluorescent powders are also available in several colors for use with a magnetic applicator.

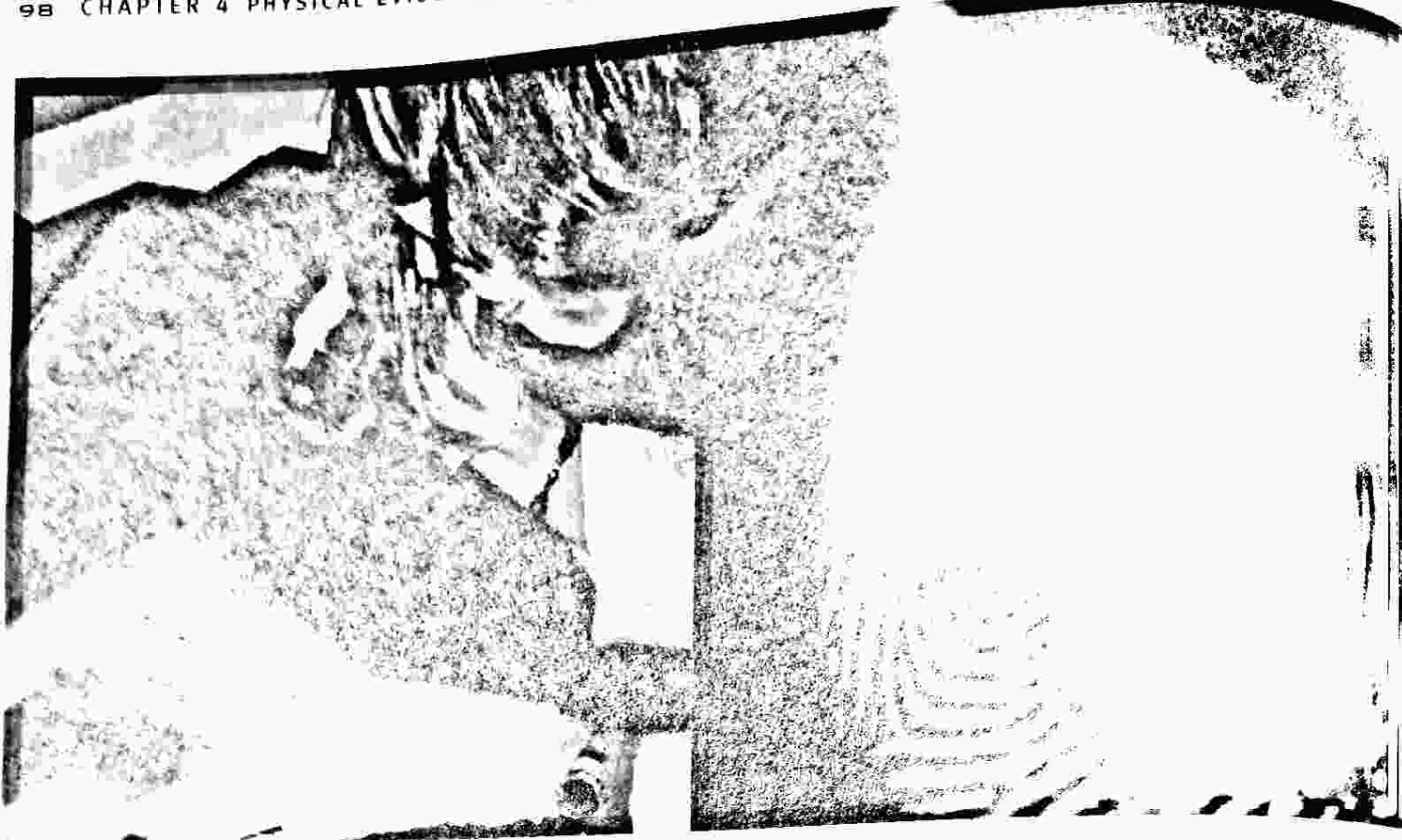
CHEMICALS

A variety of chemicals are used to develop and enhance latent prints. These chemicals are applied by spraying or brushing the surface being examined, by fuming, or by dipping the object on which there may be prints in a solution.⁴⁴ Among chemicals in use are the following:

- Amido black is a dye sensitive to properties in blood and may be used with contaminated/visible prints involving blood. It has the capability to turn blood proteins to a blue-black color. It should not

be used as a presumptive test for blood, because it also reacts to other things.

- Gentian violet is a dye used to develop purplish latent prints on the adhesive side of almost any kind of tape.
- Ninhydrin was formulated in 1910 and proposed for use in developing fingerprints in 1954; this chemical is used to develop latent prints on paper and cardboard, producing purplish prints (Figure 4-19).
- DFO (1, 8-diazafluoren-9-one) functions similarly to ninhydrin but is about three times more sensitive in developing latent prints on paper. The developed red-colored prints are immediately visible but paler than those produced by ninhydrin. DFO prints fluoresce under FLS and laser illumination. Both DFO and ninhydrin may be used on paper, but DFO must be used first to get any fluorescence.
- Small-Particle Reagent (SPR) is used for developing latent prints that have been immersed in water, such as when a perpetrator has attempted to dispose of a firearm used in a crime by throwing it into a river or lake. It is also used to develop prints on dew- or rain-soaked cars; on surfaces covered with a residue, such as salt from being on or near the ocean; and on waxed materials, plastics, tile, and glass. Developed prints appear dark gray on a light surface and light gray on a dark surface. Although SPR can be sprayed on an object, immersion of the object for about 30 seconds in an SPR solution produces better results.



▲ **FIGURE 4-18** Reflected ultraviolet imaging system

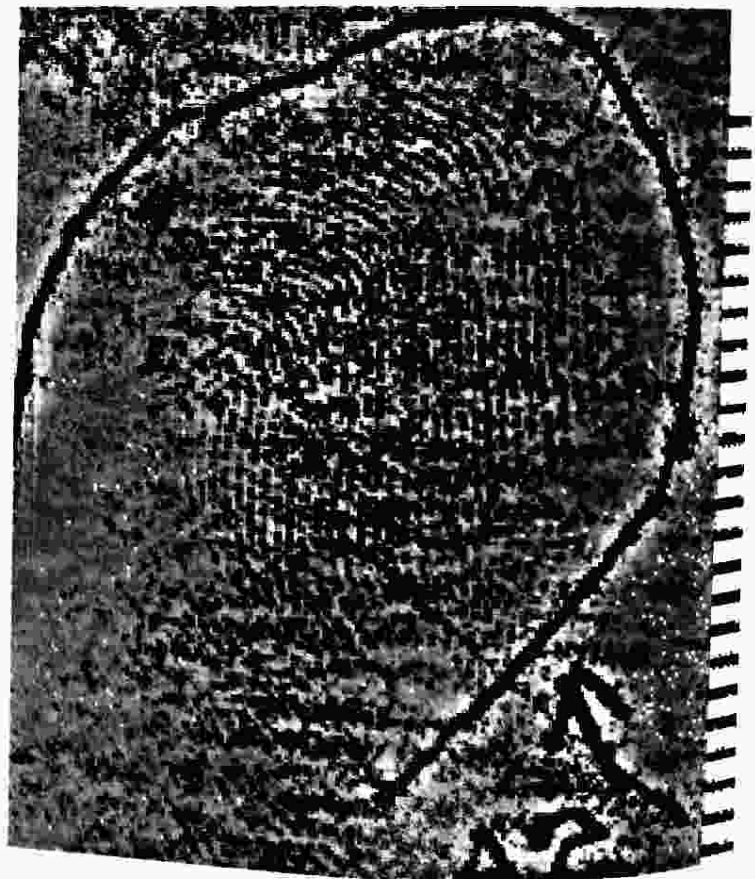
The technician is holding a RUVIS SceneScope in her right hand, which is shaped a like a fat flashlight. The RUVIS operates on ultraviolet (UV) light and can locate objects that are naturally fluorescent. In this case, a .45 Colt semi-automatic pistol was dusted with fluorescent powder. This RUVIS has an attached camera, which photographed the fluorescing fingerprint on the pistol.

(Left: Courtesy HORIBA Jobin Yvon S.A.S., North Carolina Bureau of Investigation, State Crime Lab, Latent Evidence Section, right: Courtesy State of Utah Crime Lab)

- Rhodamine 6G is an excellent fluorescent chemical dye to use on metal, glass, leather, plastic, wood, and many other types of nonabsorbent surfaces. Rhodamine 6G may enhance latent prints already developed and also reveal others.
- After Super Glue fuming, Basic Yellow 40 can be effectively used on nonporous surfaces. It fluoresces well under alternative lighting. Ardrex and Basic Red 28 are also used following Super Glue fuming.

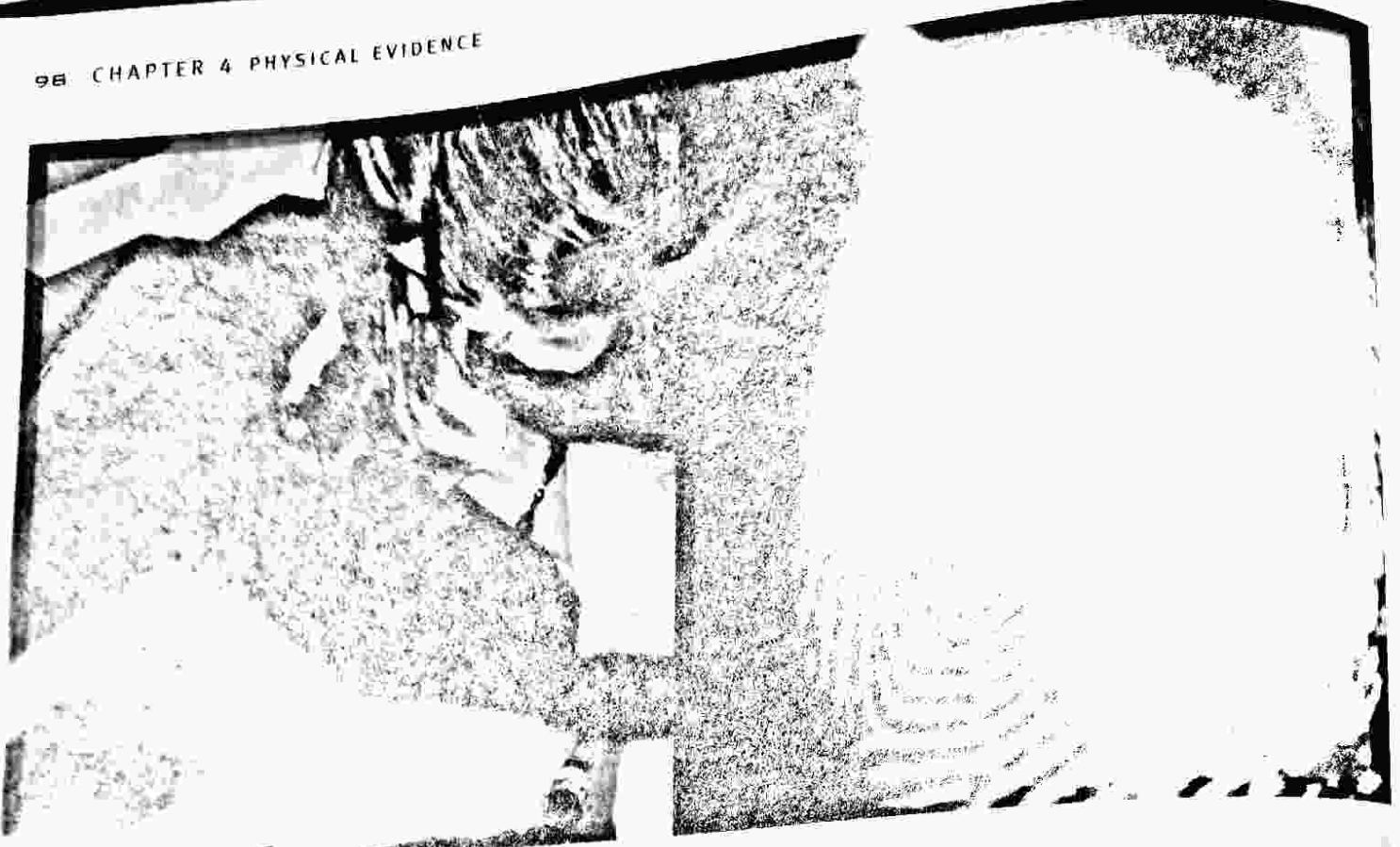
Cyanoacrylate (CA) or Super Glue Fuming

Super Glue fuming was developed in 1978 in Japan. The three factors associated with its rapid acceptance were ease of use, remarkable results, and low cost. The mechanics of



► **FIGURE 4-19** Ninhydrin developed print

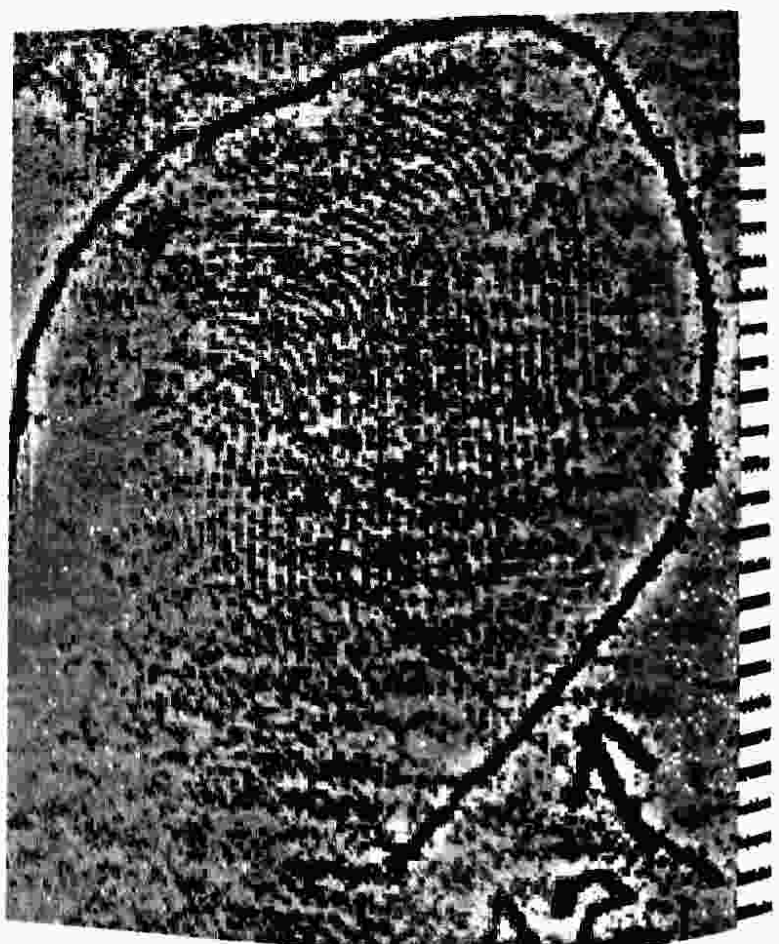
Using ninhydrin is an excellent technique to develop latent prints on paper. In this case, a thumb print is raised on an envelope containing an extortion note. (Courtesy Wisconsin Department of Justice, Law Enforcement Services Division)



▲ **FIGURE 4-18 Reflected ultraviolet imaging system**
 The technician is holding a RUVIS SceneScope in her right hand, which is shaped a like a fat flashlight. The RUVIS operates on ultraviolet (UV) light and can locate objects that are naturally fluorescent. In this case, a .45 Colt semi-automatic pistol was dusted with fluorescent powder. This RUVIS has an attached camera, which photographed the fluorescing fingerprint on the pistol.
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► **FIGURE 4-19 Ninhydrin developed print**
 Using ninhydrin is an excellent technique to develop latent prints on paper. In this case, a thumb print is raised on an envelope containing an extortion note. (Courtesy Wisconsin Department of Justice, Law Enforcement Services Division)



▲ **Figure 4-20 Portable Super Glue fuming chamber**
 This portable Super Glue unit is being used to process a weapon and liquor bottles at the scene of a murder-robbery in New York City. Note that the chamber can be used in the field or in the laboratory. (© Seth Gottfried)

Super Glue fuming are fairly straightforward. Cyanoacrylate (CA) is heated in a high-humidity chamber. As the fumes condense, they develop white-colored latent prints in 5 to 15 minutes. The developed prints may be further enhanced with powders or soaked in chemicals that fluoresce under FLSs.

Super Glue fuming may be done by small Super Glue fuming wands, in small portable chambers (Figure 4-20) and in various sized chambers in the laboratory. On a larger scale, entire rooms and automobiles are processed using this method.

DEVELOPING LATENT FINGERPRINTS ON BODIES

The development of identifiable latent fingerprints on living victims and corpses has been accomplished using a variety of methods, including tradition, magnetic, and

fluorescent powders and Super Glue fuming. Success has also been reported using combinations of these methods—for example, fuming followed by the use of fluorescent powders. There is no consensus method. Because of potential health threats to living victims, investigators need to be well-informed about the products they use. As bodies decompose, the likelihood of developing latent fingerprints on them is reduced.

Some authorities recommend after the medical examiner has released a body at the scene, it should be glue fumed to preserve any latent prints while the body is transported to the morgue. The body should not be refrigerated until after further latent print development efforts are completed. At the scene, there may be some indication of specific handling of a body by the suspect—for instance, placed in a pose or the victim's statement. Key target areas for finding latent prints on the victim are ankles, armpits, wrists, inner thighs, and neck. On living victims areas of redness are a key indicator of handling. Humidity and temperature levels can affect development efforts and charts are available to determine the optimum conditions for processing.⁴⁵

COLLECTING AND PRESERVING LATENT PRINTS

Occasionally items such as beer cans or glasses that have condensation on them need to be processed for prints. Heat lamps or any other source of artificial heat should not be used to dry the object quickly. Such objects should be allowed to air-dry naturally. Similarly, articles that have been frozen and need to be processed for prints must be allowed to thaw and dry naturally. Whenever reasonable to do so, the actual item on which the print is located should be submitted for developing in the laboratory.

Once a print is found it should be photographed immediately with a rigid scale in view. The ruler allows a one-to-one, or actual-size, picture of the print to be made. This provides a permanent record of the print in the event that it is accidentally altered or destroyed while attempting to collect or transporting it.

Most latent prints are lifted with a clear strip of tape, 1½ inches to 2 inches wide, or with clear flap lifter after they have been developed with powders. One end of the clear tape is placed on the surface just before the latent print appears. Pressure is then applied to progressively lay the tape over the print, taking care not to leave air bubbles. If air bubbles are accidentally created, the tape should be carefully smoothed over to eliminate them. The tape may be left on the object if the object is to be submitted to the laboratory.

Alternatively, the pattern of the print is lifted by pulling up the tape, starting at one end and moving progressively to the other end. Now the powder that shows the print pattern is stuck to the sticky side of the tape. This tape is then laid back down on an appropriately colored

backing card. For example, assume that a latent print on a glass window is developed with dark powder.

MARKING AND IDENTIFYING PRINT LIFTS

When a latent print has been developed, lifted, and placed on a card, the card must be properly identified. Information recorded on the card should include the date, type of case, case number, address of the crime scene, name of the officer who made the lift, exact place of the lift, and type of object from which the print was lifted. Regardless of how well the latent print was developed and lifted, if the card is not properly marked with all the data required or if the fingerprint specialist is not furnished with the information required, the entire process may be wasted effort. In describing the exact place that the lift was made, it is sometimes helpful to draw a simple sketch of the object. The sketch should be made on the fingerprint card that is sent to the laboratory. The inclusion of corresponding numbers on both the lift and the sketch establishes the location of the latent print.

FORENSIC ODONTOLOGY

Forensic odontology has been defined as the intersection of dentistry and criminal law; it is a medical specialty relating dental evidence to investigation. The most common cases involve missing and unidentified persons (MUPs) cases, where unidentified human remains are found at a crime or death investigation scene.⁴⁶ In second place is the recognition, documentation, preservation, evaluation, interpretation, and comparison of bite mark evidence.

A forensic dentist may be able to make significant contributions to the following types of cases:

1. a head is found or there is an otherwise unidentifiable body;
2. a decomposing, burned, or skeletonized body is found;
3. sexual assault, child/elder abuse, domestic violence, and homicide cases involving aggressive and/or defensive bite marks. More rarely, bite marks may be self-inflicted as part of a staged crime.⁴⁷ Although bite marks are most frequently found on skin and in human tissue, they may also be located on pencils, styrofoam cups, food (Figure 4-21), and other objects.
4. identifying mass casualties of attacks and natural and industrial disasters—such as 9/11, the Indian Ocean tsunami (2004) that may have killed as many as 250,000 people, Hurricane Katrina (2005), and the Interstate 35 bridge collapse in Minneapolis (2007) (Figure 4-22). In Thailand, 75% of the 2004 tsunami victims were identified by forensic odontology;⁴⁸
5. verifying a presumptive, or reasonably believed, identity—for example, Hitler, Eva Braun, and Mussolini during World War II and more recently al-Qaeda terrorists Abu Musab al-Zarqawi and Mohammed Atef.

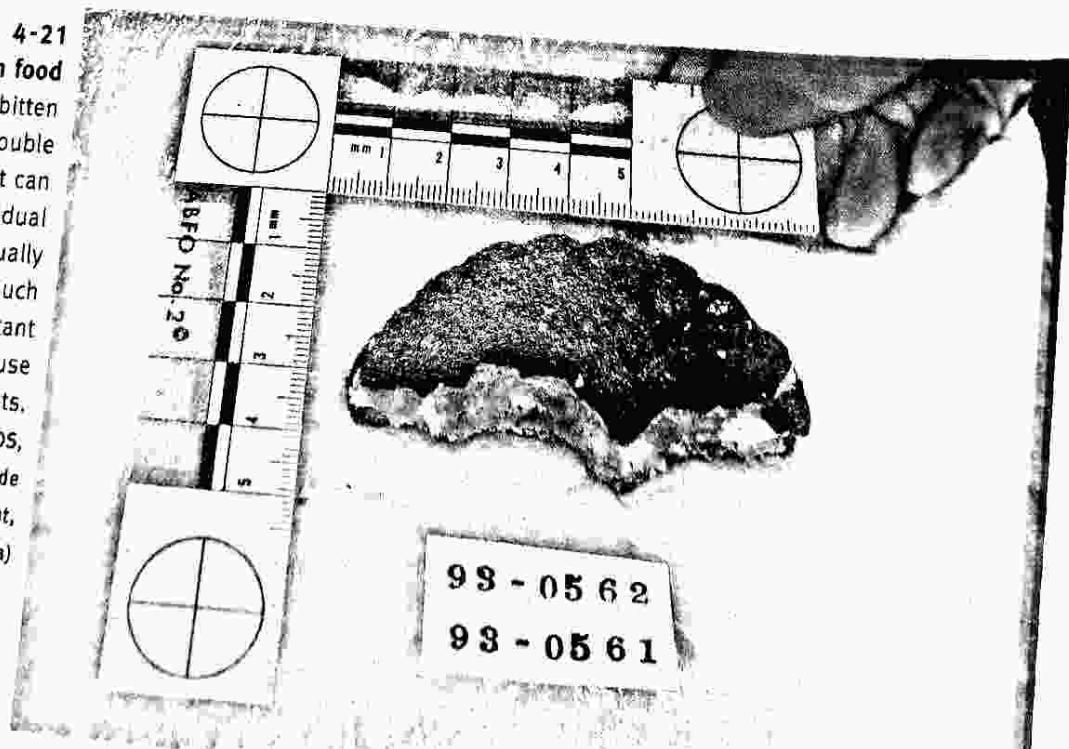
IDENTIFICATION

Forensic odontology's normal approach to identifying MUPs is the comparison of postmortem or after-death dental remains with antemortem or predeath records, including written notes, radiographs/X rays, casts, bridges,

► FIGURE 4-21

Bite mark in food

A partially eaten "Moon Pie" bitten by one of the suspects in a double homicide. From the bite marks it can be determined that the individual making them had two non-equally protruding upper front teeth. Such information can play an important role in determining probable cause for arrest and/or search warrants. (Courtesy Dr. Richard R. Souvion, DDS, ABFO, Chief Forensic Odontologist, Dade County Medical Examiner Department, Miami, Florida)



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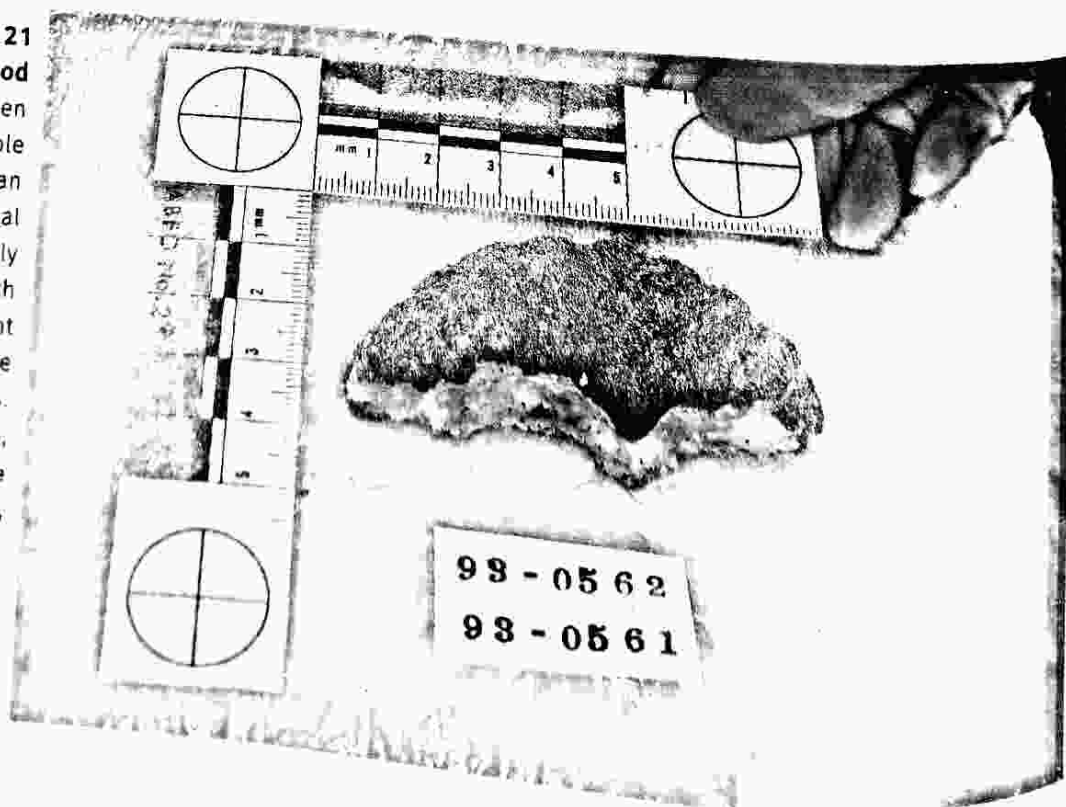
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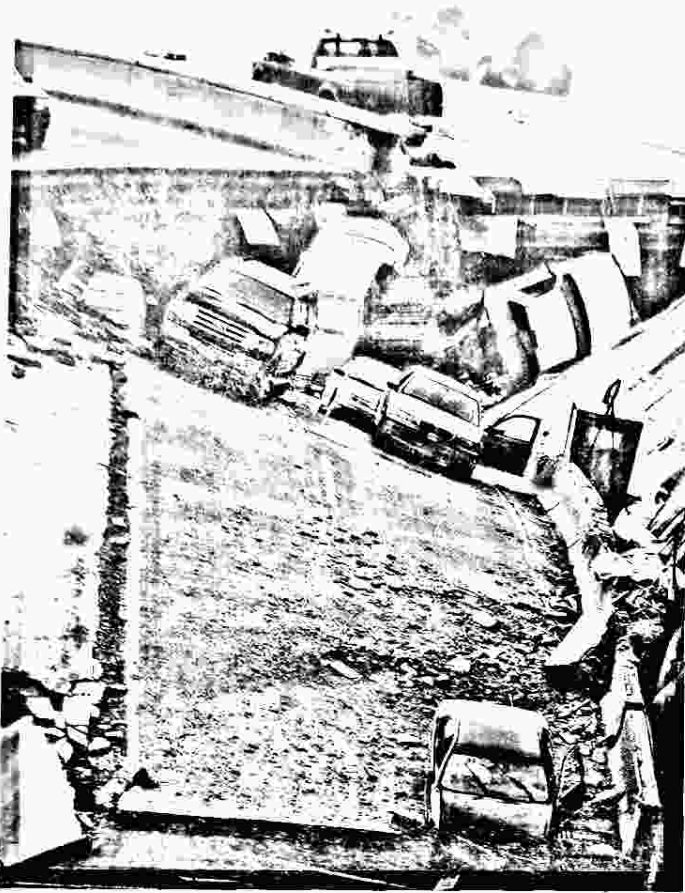
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► **FIGURE 4-21**
Bite mark in food

A partially eaten "Moon Pie" bitten by one of the suspects in a double homicide. From the bite marks it can be determined that the individual making them had two non-equally protruding upper front teeth. Such information can play an important role in determining probable cause for arrest and/or search warrants. (Courtesy Dr. Richard R. Souvion, DDS, ABFO, Chief Forensic Odontologist, Dade County Medical Examiner Department, Miami, Florida)





▲ **FIGURE 4-22 Identification of victims at disasters**
Cars and trucks lie in the wreckage of the I-35W bridge that spanned the Mississippi River in Minneapolis, Minnesota (August 1, 2007). Forensic odontology has been an invaluable tool in identifying the victims of disasters. (© AP Photo/The Minnesota Daily, Stacy Bengs)

fillings, and caps.⁴⁹ Morphological (shape and form) peculiarities of teeth can also help establish identity of MUPs.

Additionally, forensic dentists have established individual identity on the basis of "smiling photographs" (Figure 4-23). Some dentures are marked and can be traced to a particular owner, although the possibility that they were discarded at the scene must be eliminated. There is no set number of points required to establish a positive match; one unique feature may be sufficient.

The FBI maintains the National Dental Image/Information Repository (NDIR) on missing persons and unidentified remains and is adding dental information to the wanted persons file. Other sources of dental records include the military, health insurance carriers, local dentists, and community health clinics for indigent and low income persons and families. In some cases, it is useful to have a forensic artist prepare a likeness of the deceased, as he/she may have appeared in life, which can be done from as little as a skull. This image is placed in the news-

paper with a public appeal for assistance in making an identity. Any suggestions as to identity may be checkable against dental records.

Searches for dental records may not be productive, because (1) some number of individuals under the age of 30 have no dental decay, and (2) individuals with decayed or missing teeth may never have sought treatment. In either case, there are no records of antemortem dental restorations that can be compared with the postmortem dental features of a victim.

When human remains are discovered in remote areas, clandestine graves, abandoned buildings, or under similar circumstances, the bodies may be in very "rough" shape, and animal predation may require treating a larger area as a crime scene. However, teeth are the most durable part of the body, and dental evidence may play a key role in these types of investigations. The longer bodies have been left unattended, the greater the probability that teeth have fallen out or otherwise been dislodged from their normal place. Violence to the victim may have accomplished the same thing. "Rough" body scenes are unpleasant, and investigators should be sure that every precaution is taken to recover loose teeth and other evidence associated with the scene. The addition of a forensic anthropologist, skilled in methodically processing human remains sites, to the investigative team should be considered, especially at burial sites and when the victim's body is skeletonized.

DENTAL PROFILING

When there is an unidentifiable victim and there are no antemortem or predeath dental records, the forensic dentist can help narrow the population pool to which the deceased belongs by **postmortem (after-death) dental profiling** by providing a variety of useful observations:⁵⁰

1. Some teeth give us an idea of racial characteristics—for example, Native Americans and Asians have deep grooves in the inner aspects of their upper front teeth, called shovel-shaped incisors.
2. Age at time of death estimate—through 13 years old an approximation of age accurate to within six months is possible; from 14 to 25 years old a one year plus or minus window is possible; after age 25, scientific testing is usually required to establish an approximate age.
3. Gender—the morphology of teeth does not vary by gender, but analysis of dental pulp and the cranium can provide gender identification. There is also research on using the geometric relationships of teeth to establish gender; this method has achieved accuracy rates of 84% in controlled testing.
4. Suggestion of social class by the presence or absence of various types of dental care.
5. Opinions about habits, such as pipe smoking and nail biting.

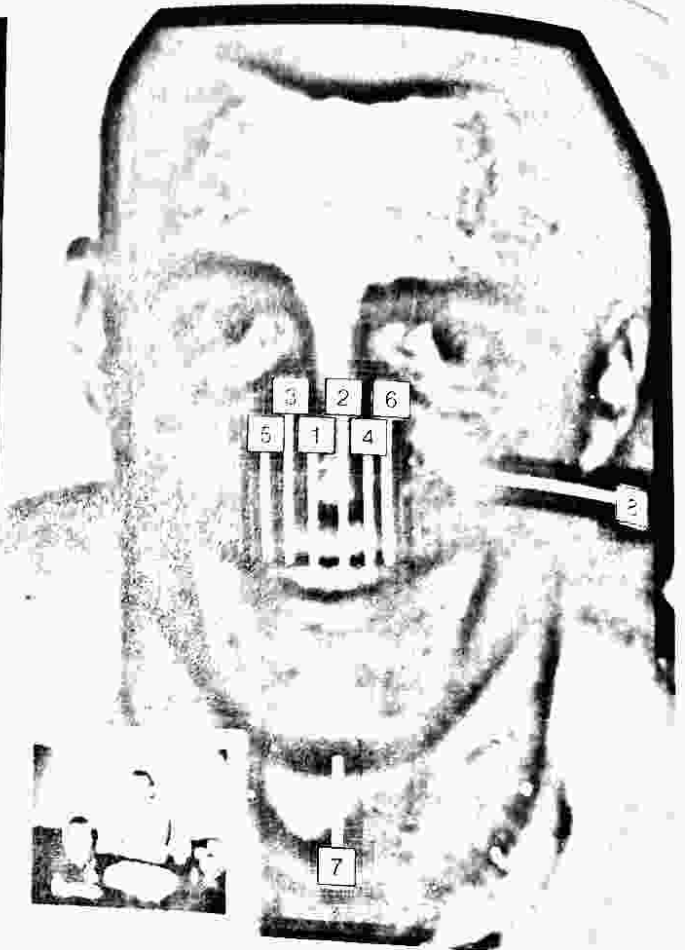


FIGURE 4-23 Dental comparison

The left photo shows upper and lower jaws of an unknown white male. Some bone loss (pyorrhea) and tobacco staining are evident. There were no fillings, decay, or missing teeth and no evidence of any dental treatment. The right photo is an enhancement and enlargement of a photo of the victim at his son's birthday party. His kidnappers/killers were sentenced to life terms. (Courtesy Dr. Richard R. Souviron, D.D.S., ABFO, Chief Forensic Odontologist, Dade County Medical Examiner's Department, Miami, Florida)

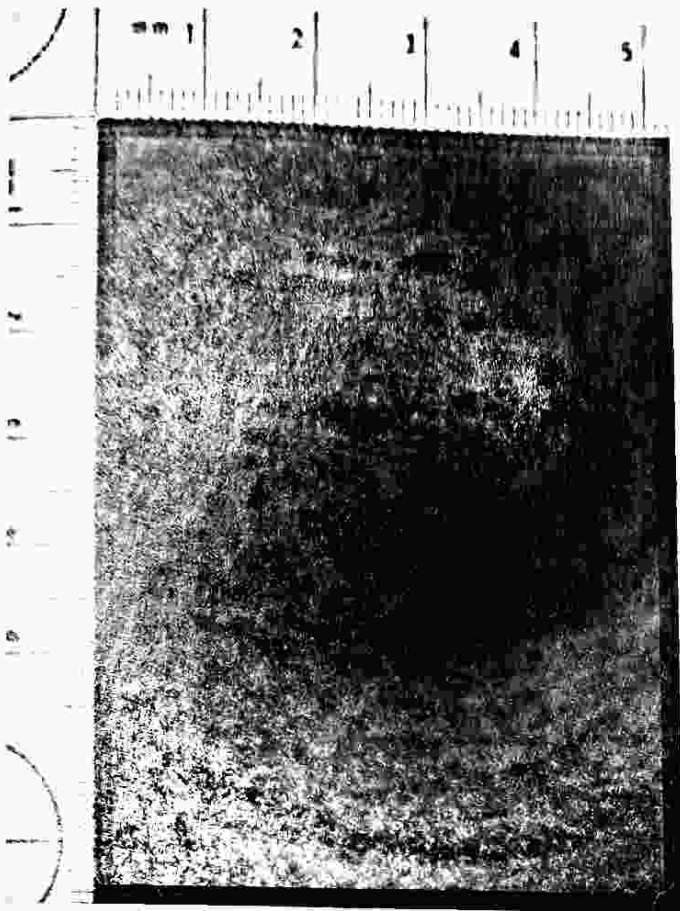
BITE MARKS

Investigators must be particularly alert to the possibility that bite-mark evidence exists, particularly when they are working sexual assault, child/elder abuse, and homicide cases. Female victims are most often bitten on the breast, buttocks, and legs during a sexual assault, whereas male victims are more likely to be bitten on the arms and shoulders. Bite marks on the arms and hands are usually defensive wounds caused when a person holds up his/her arms to ward off an attacker.⁵¹ Facial hair associated with bite marks may be transferred between attackers and victims; it should be collected consistent with the guidelines in the next major section, "Hair." In 99% of all violent rapes, victims are bitten at least once by their attacker (Figure 4-24).⁵² The collection of bite mark evidence, when reasonably possible, should be left to a forensic dentist.

Bite marks may be mistaken for bruises, abrasions, indentions, or lacerations (Figure 4-25); most have an overall ovoid appearance. One or both arches of teeth may be present and there may be multiple, overlapping

bites at the same location. Bite marks on skin should be processed quickly because they may be degraded by skin elasticity, the post mortem position of the body, and skin dehydration. Collecting bite mark evidence includes the following steps:

1. Document the bites using color photography; the shots should include general views establishing where the bites are on the victim, a medium-range photograph, and close-ups without and then with an American Board of Forensic Odontology (ABFO) #2 scale. Some labs request that the scales used be submitted with the evidence; in the absence of an AFBO #2, place two scales at right angles as close to the bite mark as possible without disturbing it. When possible, infrared and ultraviolet photos should also be taken.
2. Swab the center of each bite mark *twice* with a different sterile cotton applicator moistened with distilled water. Each swab should be allowed to air dry and packaged in a paper envelop, sealed, and marked. Even if the prospects for collecting saliva seem



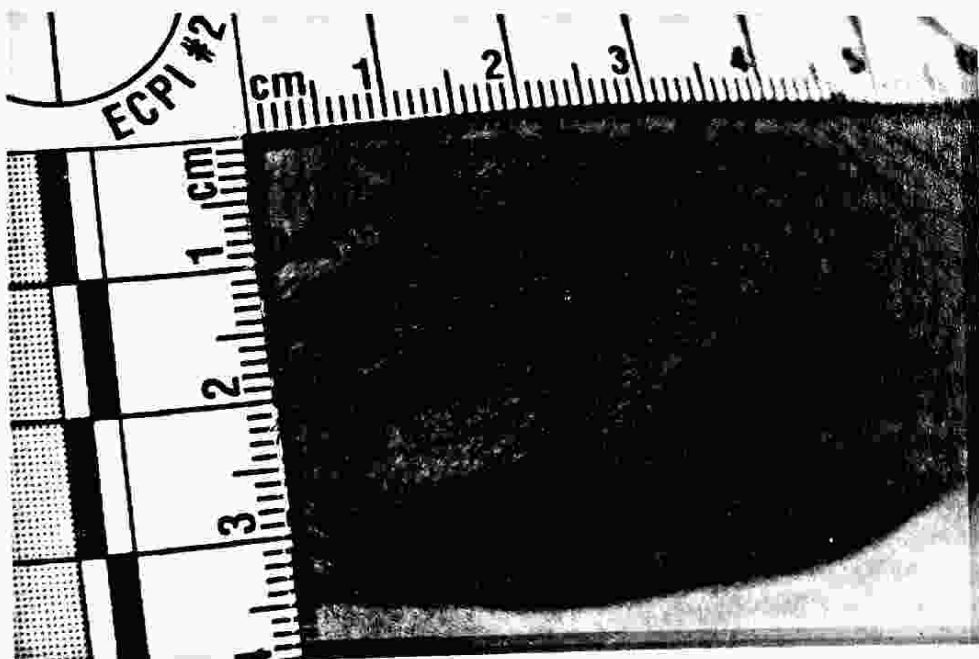
◀ **FIGURE 4-24 Bite mark on breast and nipple**

Bite marks are often found on victims of sexual abuse, rape, and violence. It is not uncommon that the suspect bites the victim as part of the sexual sadist ritual. Here, a bite mark is reflected on the breast and nipple of a sexual assault victim. First swab the area for traces of the suspect's saliva, which may yield DNA evidence. Photograph the bite mark and follow other guidelines set forth by the ABFO relating to bite mark evidence collection and preservation. (Courtesy Forensic Dentistry Online)

3. When the bite area is within reach of the victim's dentition, a cast of his/her teeth should be taken.
4. Impressions of the bite area can be made using dental grade silicon impression material.
5. If the victim is deceased, the medical examiner's office may remove the block of tissue containing the bite mark and preserve it in formalin. To maintain the size and contour of the bite mark, it is attached to a custom-made ring prior to the tissue being removed.⁵⁴

Although bruises and bite marks change color as time passes, this process is not linear and unvarying. Statements about bruise color and age of the injury should be regarded warily because they are opinions unsupported by science. A 2010 study of the ability of forensic experts to date the age of bruises showed them to be unreliable; however, they were better in placing sequential photographs of bruises from the same subject in the correct chronological order. These photographs were taken from the time they appeared until they disappeared.⁵⁵

remote, the procedure should be followed; in a rare case saliva was recovered from the skin of a victim submerged in a slow-running river for 5.5 hours.⁵³ If the bite mark is made *through* clothing, the clothing is also a potential source of saliva to be processed.



◀ **FIGURE 4-25 Hand laceration by teeth**

Laceration at base of suspect's thumb area caused by victim's defensive bite. Suspect grabbed victim from behind, trying to gag her with his hand. (Courtesy Los Angeles Police Department)

Before collecting evidence from a suspect, the legal authority to do so must be established; normally this is done by search warrant, court order, or consent. A request for consent and sometimes a court order will alert suspects and/or their attorneys to a pending examination and may provide sufficient time for suspects to alter their dentition—for example, have all teeth pulled. Two search warrants should be obtained to (1) seize the suspect's dental records and (2) collect evidence from the suspect. The application for the search warrant should specify what evidence will be collected using what methods, including saliva swabbing for DNA if appropriate to the fact situation.

Collection of evidence from the suspect is the responsibility of forensic dentists or technicians working under their supervision, who should describe the protocols that will be used to the suspect. Elements of evidence collection include:

1. The suspect's dental records subsequent to, or in closest proximity to the date of the bite mark.
2. A complete set of photographs.
3. A clinical examination, to include identification of misaligned, broken, or missing teeth; a determination of how long teeth have been broken or missing; restorative dental work; evidence of trauma and surgery; maximum mouth opening; periodontal condition and any loose teeth. A dental chart is usually prepared.
4. Two impressions of the upper and lower arches of the suspect's teeth.
5. Sample bite marks in a wax—for example, aluwax, Styrofoam, or other ABFO-approved material; suspects should not be physically forced into providing a standard/reference sample.⁵⁶

The process of comparing bite marks with a suspect's dentition includes analysis and measurement of size, shape and position of the individual teeth.⁵⁷ From the impressions, a life-sized study model of the suspect's dentition is produced. At the broadest level of comparison, if the arch and shape characteristics do not match, the suspect can immediately be excluded. Most comparison methods rely on the use of overlays. The use of laser imaging in bite mark comparisons is very promising, producing a high level of three-dimensional details.⁵⁸

HAIR

Hair evidence is often found because both victims and suspects can transfer it to each other or the scene; hair is easy to locate and recover, and durable.⁵⁹ It may be found on ski masks abandoned by armed robbers, in the head and pubic hairs of assailants and victims, clutched in the hands of victims, on clothing, and numerous other places. Hair evidence is primarily associated with violent crimes.

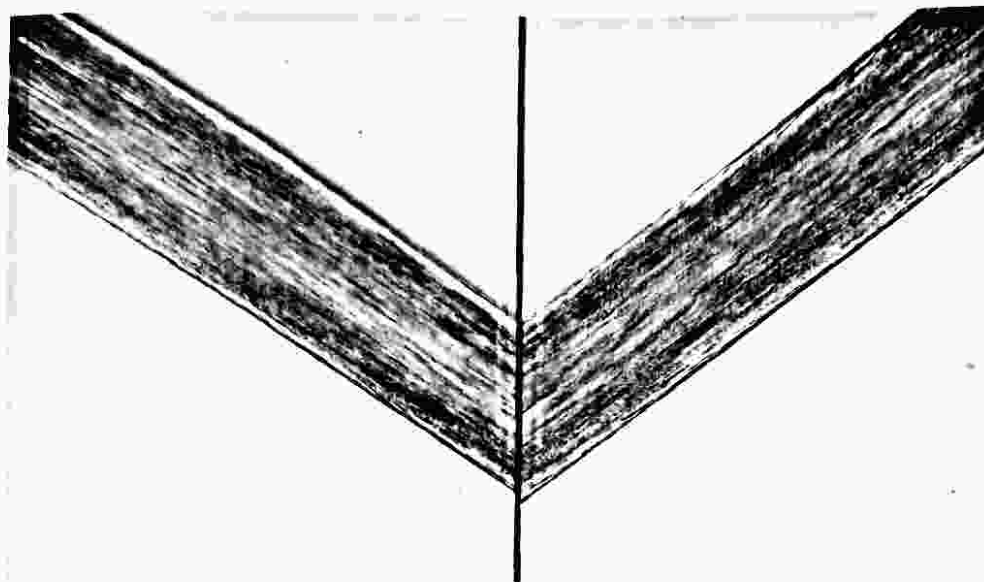
Microscopic examination of hairs can determine whether the origin is a fiber wig, animal, or human. A number of useful conclusions are possible from the microscopic examination of human hair, such as the:

1. racial characteristics of the donor—that is, European, Asian, or African;
2. somatic or body area origin of the hair—for example, eyelashes, pubic, scalp, and beard;
3. manner in which it was removed—for instance, if hair has an anagen/active growth root it suggests forcible removal;
4. damage to the hair—for example, by putrefaction, blunt force trauma, or burned;
5. types of drugs ingested and how recently;
6. presence of hair contaminants, including blood, semen, soil, pet hair, and soil; contaminants may suggest an occupation—for instance, automotive spray paint particles might indicate working in a body shop;⁶⁰
7. hair treatment, including bleaching, shampoo residues, and dyes;⁶¹
8. determination of whether known and questioned hair samples could have a common origin (Figure 4-26).

Most often, when a reference to DNA and investigation is made, it is in the context that individual identification can be established. This is true with nuclear DNA (nDNA), which is passed from both parents to their offspring. Thus, if a hair has its root, or other tissue attached, then establishing individual identity is possible from nDNA. However, when investigators have recovered only a hair shaft, it contains a different type of DNA, mitochondrial or mtDNA, which is inherited only from the maternal line. It is not possible to establish individual identity with mtDNA, because other people along the same maternal lines share it. There is also the possibility of a random match. In contrast, some mtDNA is so rare that it is seen only once even in very large DNA databases. MtDNA can be used to exclude suspects, establish that the victim is not from a particular lineage (or that he/she is), all of which helps to focus investigative effort.⁶²

When collecting hair standards, at least 50 should be cut at the skin from various portions of the head to assure that all shades of texture and color have been properly sampled; this number should be doubled for deceased individuals, and they should be pulled.⁶³ At least 20 standard pubic hair samples should be cut at the skin surface from various regions on a live person; double that number and pull them from deceased. Standard hair samples can be placed in a clean envelope, which is sealed and labeled.⁶⁴ Pill boxes, glass vials, and other tightly sealed containers are also acceptable in many labs.

The collection of questioned hair samples requires a clean piece of paper to be placed under the area to be combed. All areas of the pubic or other area should be thoroughly combed to dislodge foreign hairs and other materials.⁶⁵ When the process is completed, place the



◀ **FIGURE 4-26 Hair analysis**
 Photomicrograph of hair found inside a rape suspect's vehicle (*left*) is matched with a sample of hair from the victim (*right*). Note the darker shading of brown near the outside of each strand as a result of color added to the victim's hair. These types of peculiarities provide matches between the characteristics of hairs but not to the exclusion of a donor other than the victim. (Courtesy Texas Department of Public Safety)

comb on the paper, carefully fold it, and place the paper in an envelope. If samples are collected from several portions of the body, the comb should be changed between areas and each area packaged separately. Known and questioned samples should be packaged separately when submitted to the laboratory. The investigator should be present when qualified medical personnel collect samples. Before the process begins, the investigator should verify that the medical person understands the proper collection and packaging of samples.

Hair collection at the crime scene requires a different set of considerations regarding known and questioned samples:

1. Document by photos, the evidence log, and by diagram where the hairs were recovered.
2. Do not submit wet hairs to the lab; they should be allowed to air dry.
3. If they are firmly attached to an object, leave the hairs intact and submit the object.
4. When visible hairs are not firmly attached to an object or the object is too large to submit to the lab, carefully remove them with clean tweezers.
5. If hairs were possibly transferred to the victim's and/or suspect's clothing, keep their clothes apart. Package each article of clothing separately and submit to the laboratory separately.⁶⁶
6. Do not overlook the potential probative value of animal hair; if a victim's pets were present at the time of the offense, samples should be pulled from them and handled in the usual manner.

BLOOD

Blood was class-characteristic evidence until the introduction of DNA analysis in the early 1980s. However, an initial study published in 2010 hints at the possibility

that blood may have other important contributions to make. Blood samples from 195 people, from a few weeks to 80 years old were analyzed. The research reports the ability to identify age from blood, plus or minus 8.9 years.⁶⁷ However, even if confirmed, this capability may be five or more years away from common use. The identification of eye and hair color, skin pigmentation, height, and weight from blood analysis are also being explored.⁶⁸

On average, an adult's body contains about 5 to 6 quarts of blood, and even small cuts can produce a lot of blood. At crime scenes, blood may be encountered in amounts ranging from small drops to large pools, in states ranging from fresh to dried, and in almost any place, including on floors, walls, ceilings, clothes, weapons, the suspect's and victim's bodies, and the exterior and interior of vehicles.

Because of the frequency with which blood is encountered and the fact that DNA analysis can provide individual identification (Table 4-1), officers need to be alert to locating and protecting this type of evidence. Moreover, they should wear appropriate PPE and take the other kinds of protective measures discussed in Chapter 3, "Investigators, the Investigative Process, and the Crime Scene."

THE APPEARANCE OF BLOODSTAINS

If blood at the crime scene is fresh and relatively uncontaminated, identifying it as blood is not difficult. If it is in some other condition, identifying blood merely by "eyeballing it" becomes increasingly difficult. Blood may appear as a rust-colored stain or have gray, black, green, or blue tints. It may also be mixed with earth, grease, paint, or other substances, making it difficult to see.

Very fine drops of blood can be located by viewing the surfaces concerned at an oblique angle close to the plane

Sources of DNA Evidence

EVIDENCE	POSSIBLE LOCATION OF DNA ON THE EVIDENCE	SOURCE OF DNA
Baseball bat or similar weapon	Handle, end	Sweat, skin, blood, tissue
Hat, bandanna, or mask	Inside	Sweat, hair, dandruff
Eyeglasses	Nose or ear pieces, lens	Sweat, skin
Facial tissue or cotton swab	Surface area	Mucus, blood, sweat, semen, earwax
Dirty laundry	Surface area	Blood, sweat, semen, vomit
Toothpick	Tips	Saliva
Used cigarette	Cigarette butt	Saliva
Stamp or envelope	Licked area	Saliva
Tape or ligature	Inside or outside surface	Skin, sweat
Bottle, can, or glass	Sides, mouthpiece	Saliva, sweat
Used condom	Inside or outside surface	Semen, vaginal or rectal cells
Blanket, pillow, or sheet	Surface area	Sweat, hair, semen, urine, saliva, dandruff
"Through and through" bullet	Outside surface	Blood, tissue
Bite mark	Person's skin or clothing	Saliva
Fingernail or partial fingernail	Scrapings	Blood, sweat, tissue

Source: www.dba.Gov/Basics/Evidence_Collection/Identifying, January 5, 2011.

of the surfaces. If the light is not strong or if the scene is dark, viewing the surfaces will be enhanced by shining a flashlight beam at the same oblique angle. Blood is naturally fluorescing and may be detected by the use of a FLS.

The drying time of blood depends on a number of factors, including whether it is on a porous or nonporous surface, its size and thickness, and the presence or absence of a fan or breeze. Higher temperatures hasten the drying time of blood, whereas increased humidity decreases it. Drying first appears at the edges of a bloodstain and works toward its center. A dried bloodstain will begin to pucker and crack from the edges inward after further drying. Thus, it is difficult to accurately estimate the age of bloodstains. Research has been carried out on dating the age of blood using changes in its chemical composition.⁶⁹

USING BLOODSTAINS TO RECONSTRUCT THE CRIME

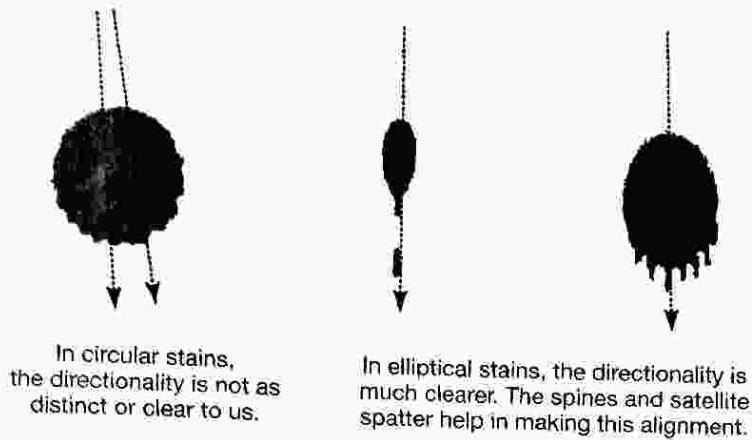
Bloodstains (known as blood spatter) may take many forms at a crime scene. These forms are not random but are produced by such factors as the type, location, and number of wounds inflicted; the type of weapon involved; movements by the victim while trying to escape, defend himself/herself, or attack the offender; changes in the location of the victim's body owing to being moved by the offender or someone; and continuing postmortem violence to the body by the offender,

suggesting that the killer was in a state of rage and possibly knew the victim.

By studying bloodstain and spatter evidence, the investigator can learn significant facts that facilitate reconstruction of the crime. These facts include:

1. Direction in which blood droplets were traveling when they were deposited on the surface (Figure 4-27).
2. Distance from the source of the blood to the surface on which the droplets were found (Figure 4-28). An important fact to note concerning blood spatter is that blood droplets cannot exceed 4 feet in horizontal travel from a stationary point (for example, blood spatter from a direct gunshot wound); thus, the blood droplets in Figure 4-28 reflect vertical fall.⁷⁰
3. Angle at which the droplets impacted (see Figure 4-29).
4. Direction and relative speed of blood trails.
5. Nature of the object used as a weapon.
6. Number of blows struck.
7. Relative locations of other persons, surfaces, and objects having droplets on them.
8. Sequence of events, if multiple events are involved.
9. Interpretation of blood-contact or blood-transfer patterns.
10. Estimation of the elapsed time for the event and the volume of bloodshed.⁷¹

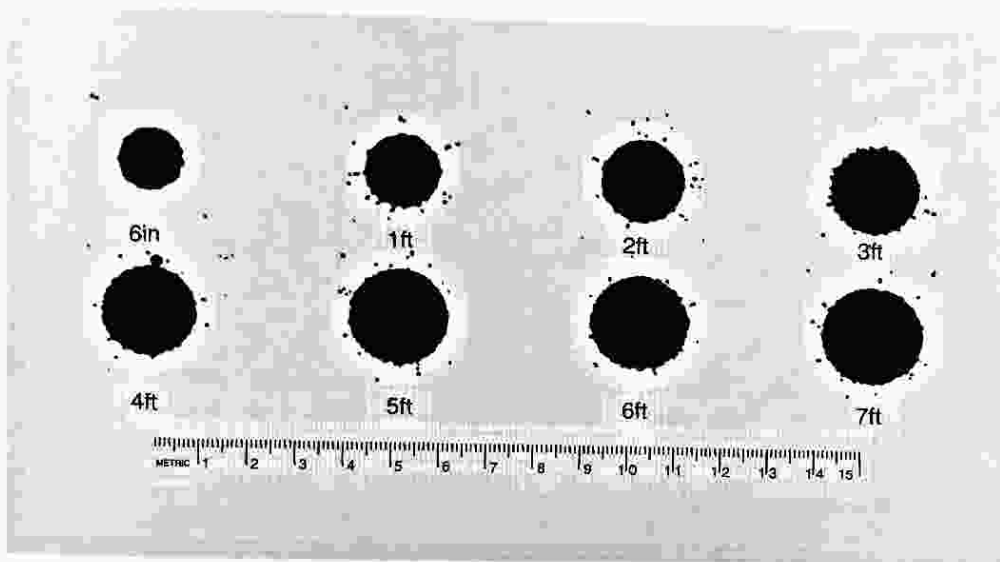
When presented with a stain, the analyst simply visualizes a line through the center of the stain, which is aligned with the spines or satellite stain.



◀ FIGURE 4-27

Directionality of blood droplet

To visualize or demonstrate directionality in a droplet, the analyst simply draws a line down the long axis of the stain, splitting it into two equal parts. This line is oriented to the scallops, spines, or satellite stains. (Source: Tom Bevel and Ross M. Gardner, *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction*, 2nd ed. [Boca Raton, FL: CRC Press, 2002], p. 146. Used by permission.)



◀ FIGURE 4-28

Distance between bloodstain and source

Increasing diameter of bloodstains as a function of increasing distance fallen by single drops of blood from fingertips onto smooth cardboard (Source: Stuart H. James and William G. Eckert, *Interpretation of Bloodstain Evidence at Crime Scenes*, 2nd ed. [Boca Raton, FL: CRC Press, 1998], p. 21. Used by permission.)

LOCATING BLOOD EVIDENCE

The places at which the investigator will find bloodstains are virtually unlimited. For example, if a criminal homicide occurred indoors, blood might be found not only on the floor but perhaps also on the walls or even the ceiling. Ordinarily when perpetrators of violent crimes get blood on their bodies or clothing, they will attempt to rid themselves of it immediately. In some instances, they may be so repelled by the sight of blood on their hands that they will impulsively wipe it on a piece of furniture, such as a stuffed chair; if the fabric is multicolored or sufficiently dark, the stain may escape detection by the unobservant investigator. They may also attempt to clean bloodied hands before leaving the scene by using such surfaces as the reverse side of a small throw rug or the undersides of cushions on a couch.

At bloody scenes it is not uncommon for the suspect to have left a shoeprint on some hard, smooth surface. In turn,

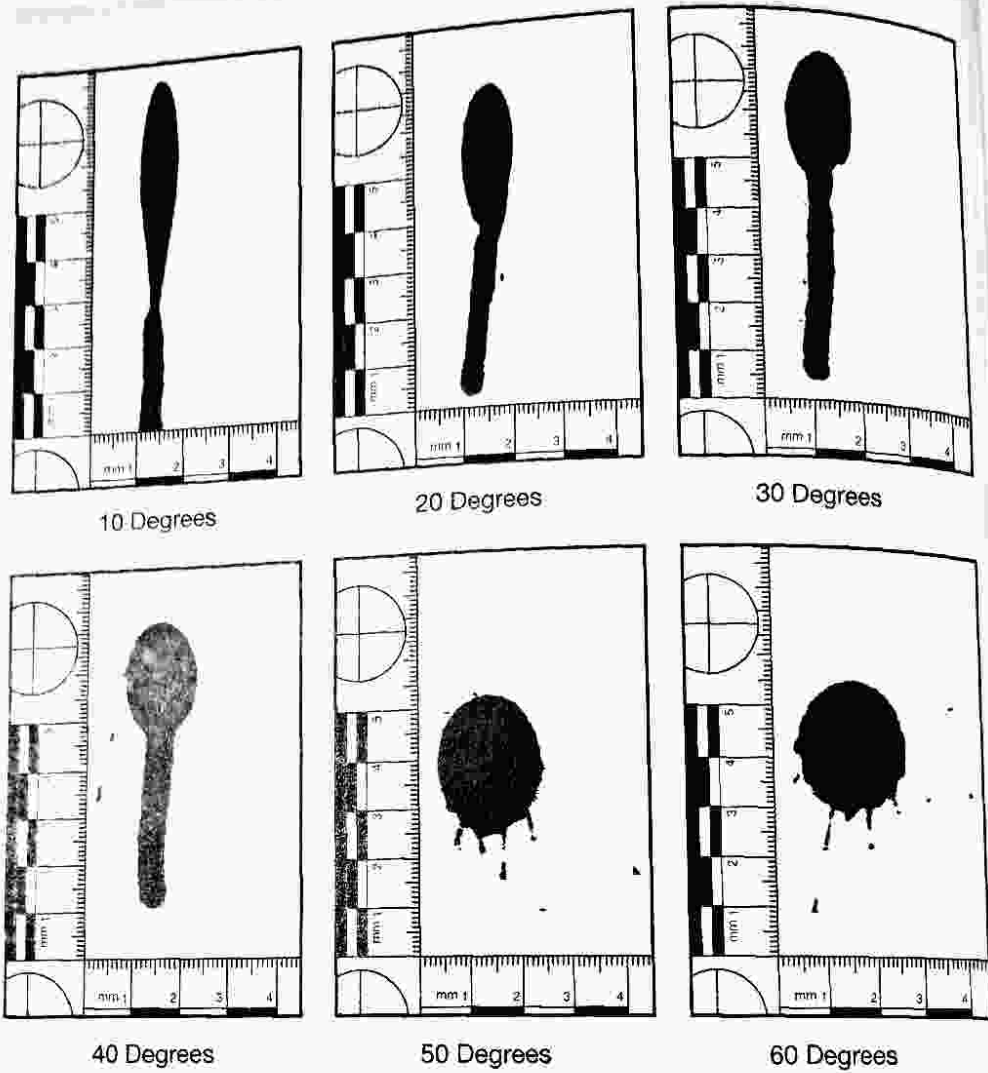
it is likely that some of the blood may be found in the cracks and crevices of the suspect's shoe soles. This is important evidence, because it can tie the suspect to the scene with great certainty, particularly if DNA evidence from the blood can positively link the suspect to the scene.

Another way of locating blood evidence is use of a presumptive or preliminary field test (Figure 4-30). **Luminol**, a water-based spray, locates trace amounts of blood within 30 seconds, creating a blue glow after the lights are turned out. Luminol's disadvantages are that the glow is short lasting; it doesn't differentiate between human and animal blood, and it reacts to copper, some alloys, and certain bleaches. **Hemident** also does not distinguish between human and animal blood. In the presence of blood, it produces a dark blue/green appearance within seconds. **Hexagon OBTI** (Figure 4-31) distinguishes between animal and human blood in two to three minutes; however, it also displays sensitivity to the blood of higher primates. To have legal significance, all three of these presumptive tests

FIGURE 4-29

Impact angle and stain shape

The range of droplet shapes that result from the varying impact angles. The more elliptical the stain, the more acute the angle of impact. Round stains indicate that the impact angle was closer to 90 degrees. (Source: Tom Bevel and Ross M. Gardner, *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction*, 2nd ed. [Boca Raton, FL: CRC Press, 2002], Color Figure 2. Used by permission.)

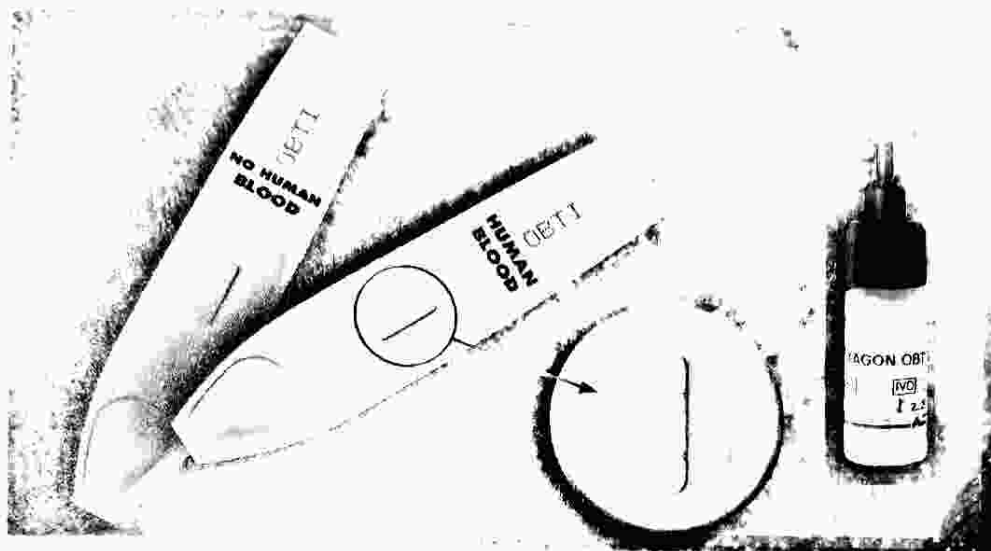


▲ FIGURE 4-30 Use of BlueStar forensic
Mop used by assailant in an effort to clean up blood from scene of an attack. The BlueStar reagent was sprayed on the mop, revealing presence of blood invisible to naked eye. (Courtesy BlueStar Forensics)

must be confirmed by more elaborate testing procedures in the laboratory. Some presumptive tests for blood may interfere with DNA analysis, and so investigators need to determine whether the one they are contemplating using does so.⁷² If yes, the collection of blood samples from the scene should precede presumptive testing. Alternatively, a small blood sample can be collected and tested.

Occasionally, in an indoor homicide, the perpetrator will remove the body to an outdoor area to avoid discovery and then will return to the scene and attempt to eliminate all traces of the crime. Typically, this involves washing hands and scrubbing or mopping the floor on which the body had lain:

An aggravated assault occurred between two friends who mutually agreed to misrepresent it as an accident. When the victim appeared at the local hospital for



◀ **FIGURE 4-31 Hexagon OBTI**
Blood is placed in the white collection tube, followed by the addition of the reagent in the red-capped bottle at right. If the test is functioning properly, but there is no human blood detected, a single blue line appears in the window. Two single blue lines denote the presence of human blood. (Courtesy BlueStar Forensics)

treatment, the police were summoned owing to the nature of the wounds and their locations, which suggested to the doctor that they were not accidentally inflicted. Investigators went to the scene and were told the accident happened outside while barbecuing. Granted permission to look inside the house, they found fresh blood underneath the faucets at the kitchen sink. Trace amounts of blood were found on the recently mopped floor between the back door and the kitchen sink. The location of the blood evidence was particularly pertinent, because the people involved alleged that the "accident" had happened in the backyard while they were barbecuing and that they had gone directly to the hospital. Although a solid investigation was conducted, no prosecution resulted due to a lack of cooperation from the victim and witnesses.

Before handling any blood evidence, investigators must document its location and physical state (for example, fresh) by some combination of notes, diagrams, video recording, and photographs. Other details may be pertinent to record as well, such as the temperature, humidity, or existence of multiple severe wounds but little blood. The last condition suggests that the person was killed somewhere else or that an attempt was made to clean the victim and/or scene, an action possibly indicating that the perpetrator had an attachment to the victim.

Blood Samples from a Known Source

Only qualified medical personnel should collect blood samples from a person. The following guidelines apply:

1. Draw two 5-milliliter samples of blood in purple-stoppered tubes, the insides of which are coated with EDTA, a preservative used to prevent coagulation.

2. If drug or alcohol testing is to be done, collect a 10-milliliter sample in a gray-stoppered tube, which contains a sodium fluoride (NaF) preservative.
3. Identify each tube with the date, time, collector's name, case number, subject's name, location at which drawn, and evidence number.
4. Do not freeze blood samples; the tubes may break. Refrigerate them, and use cold packs, not dry ice, to pack them for shipment to the laboratory.
5. Pack the blood tubes in special bubble packs, or wrap them in the same type of material.
6. After sealing the outer container or box, label it "Keep in a Cool Dry Place," "Refrigerate on Arrival," and "Biohazard."
7. Submit the samples to the laboratory as soon as possible.⁷³

Fresh or Dried Blood on a Person

If there is fresh blood, absorb it on a clean cotton cloth or swab. If the blood is clotting or has dried, use distilled water to moisten a cotton cloth or swab and then absorb the blood with the moist surface. Leave a portion of the cloth or swab unstained as a control or blank sample. Let the cloth or swab air dry naturally. Do not place it in direct sunlight or next to a heat source, and do not use a hair dryer on it. These actions could cause the evidence to begin decomposing, thus reducing or eliminating its evidentiary value. Wrap the evidence in clean, dry paper, or place it in an envelope with sealed corners; plastic or airtight containers should not be used.

Fresh Blood on Surfaces or in Snow or Water

The procedure for collecting fresh blood from most surfaces is the same as that previously described for blood on a person. However, when blood is in a filled bathtub or some other body of water or when it is on snow, a different approach is required. For blood in water, recover

the sample from the thickest concentrations of blood and clots whenever possible. When gathering blood from snow, eliminate as much snow as possible from the sample. Freeze it in a clean, airtight container, and submit the sample to the laboratory as rapidly as possible.⁷⁴

Fresh or Dried Bloodstains on Garments and Objects

Allow fresh bloodstains on garments to air dry naturally; then fold the clothing with the crusts intact. Do not fold clothing in a way that creases bloodstains, since the creases may cause them to become dislodged. As you fold the clothing, place clean paper between each layer. Usually, bloodstained garments are found at the crime scene or retrieved from a hospital's emergency room.

Fresh bloodstains on a small movable item, such as a weapon, lamp, or door, should also be allowed to air dry naturally. The item is then submitted to the laboratory for processing; pack the item in clean paper in such a way that the paper does not rub against the bloodstains, since rubbing could alter or eradicate the bloodstain pattern.

When bloodstains are on a large immovable object, they can be collected, if fresh, by using the cotton cloth or swab technique or by cutting a large sample from a dried stain. If there are multiple stains on the object, use a new cloth or swab each time you switch from one stain to another; likewise, thoroughly clean the scalpel, razor blade, or knife you are using to cut dried samples when you switch from one collection area to another. In some cases, it may be necessary to cut a section out of the immovable object and transport it to the laboratory; do not forget the need for a control or blank sample.

Other Considerations in Handling Blood Evidence

During warm weather, especially during daylight hours, blood evidence should not be locked in car interiors or trunks, because heat could rapidly degrade the evidence. If dried-blood evidence is not submitted to the laboratory immediately, the garments, objects, and/or samples taken should be refrigerated.

LABORATORY DETERMINATIONS

Under ordinary conditions, laboratory examination of blood evidence can determine the following characteristics about the source of the blood:

1. species (human, dog, horse, and so on);
2. gender;
3. blood type and DNA profile;
4. use of drugs or alcohol by the blood source;
5. presence of certain types of illnesses (for example, venereal disease);
6. presence of carbon monoxide;
7. whether the source was a smoker.

The importance of such determinations was highlighted when labor leader Jimmy Hoffa disappeared in 1975. He had told people he was meeting that night with organized crime figures. It was thought that someone close to Hoffa betrayed him because of bloodstains found in that person's car. However, laboratory examination confirmed the person's statement that the bloodstains were from fish he was taking home. Hoffa was declared dead in 1982; his body was never found.

LIP COSMETICS, DNA, AND LIP PRINTS

Laboratories can differentiate between many types of lip cosmetics, and this information can destroy a suspect's alibi that the lipstick on his shirt was deposited there by his girlfriend when it is consistent with the victim's and inconsistent with the girlfriend's.⁷⁵ An unidentified victim's lip cosmetics will supply enough material for a DNA profile of him/her about 80% of the time.⁷⁶ Lip print comparisons presently lack scientific validity.

FIREARMS

Firearm evidence is commonly encountered and includes single- and double-action revolvers, semi-automatic handguns, rifles, scopes, shotguns, rim- and center-fire ammunition, bullets, shot pellets and slugs, shell cases, gunshot residues, clips and magazines, firing-pin impressions, and extractor and ejector marks. Moreover, there may be blood, tissue, and/or fingerprints on firearm evidence, making it even more important to a case. Investigators must acquire a broad, working knowledge of firearm evidence for three primary reasons: (1) the frequency with which they will encounter it; (2) the value of such knowledge in a combat situation;

A metropolitan police department had just completed transition to the .40 caliber, semiautomatic, 16-shot (15 magazine, plus 1 chambered) Glock Model 22. Two revolver-wielding gunmen robbed a bar and ran out the back door, where they were confronted by a patrol officer walking the alley. Several quick shots were fired as all three men scrambled to get behind some type of cover. After several more shots were exchanged, the officer had fired six shots. One of the gunmen yelled "He's out of ammo, Let's get him!" They left their cover and rushed the officer, who dropped both of them.

and (3) your personal safety and that of others—never assume that a firearm is unloaded, no matter who brings

or hands it to you; that assumption could get you or someone else killed:

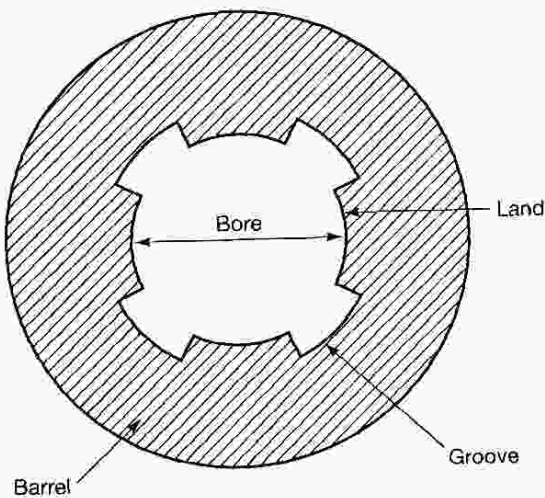
It was late on the evening watch in a detective division and three investigators were sitting around talking. Two other investigators brought a man in who was not handcuffed and told him to sit down in front of a desk. One of them laid a revolver on the desk and said, "We're charging this guy with murder; watch him 'til we get back." A few minutes later, the suspect stood up, picked up the revolver, and killed himself in front of the three investigators.

LABORATORY DETERMINATIONS

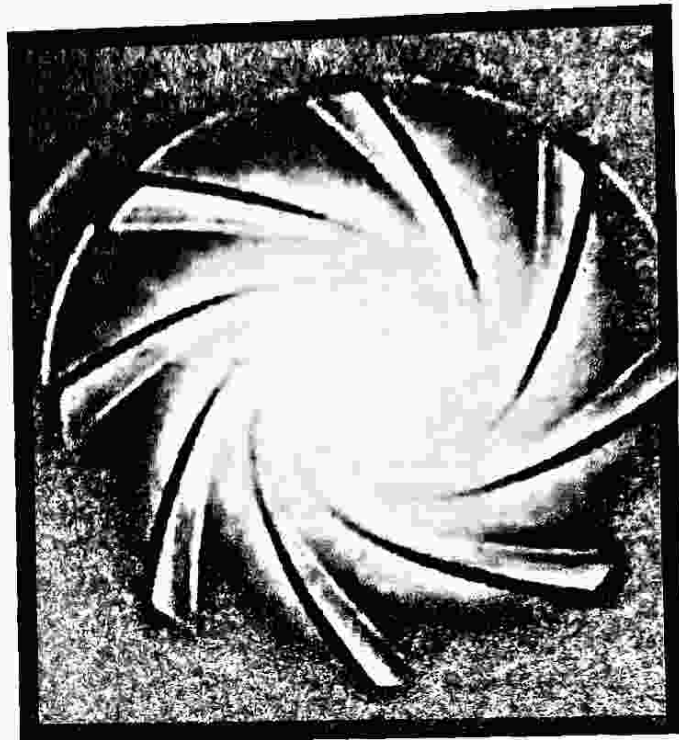
The laboratory examination of firearm evidence may be able to provide answers to a number of important investigative questions.

1. Was This Bullet Fired from This Weapon?

Shotguns are smooth-bore weapons, but pistols and rifles have **rifling**. The **caliber** is the diameter of a bullet, whereas the **bore** (Figure 4-32) is the diameter of the barrel's interior between its opposing high sides, or **lands**. The low sides of the barrel's interior are called **grooves**. When a cartridge is fired, its bullet portion separates from it and passes through the barrel. Because the bullet's caliber is



▲ FIGURE 4-32 Rifled barrel
Important features of a rifled firearm's barrel



▲ FIGURE 4-33 Barrel rifling

Cross-section photograph of the barrel of a 9-mm pistol with traditional rifling. Note how the lands and grooves "twist" to the right, spinning the bullet as it is propelled through the barrel of the weapon. Rifling allows the bullet to be much more aerodynamic, improving the accuracy and stability of the bullet in flight. (Courtesy Forensic Training and Consulting, LLC)

somewhat larger than the bore, the rifling grips the bullet, causing it to rotate, usually in a right-hand direction. The rotation increases the range and accuracy of the bullet (Figure 4-33.)

This rotation also creates striations on the bullet. Marks are also left on fired bullets from manufacturer defects and the use of a firearm. The combination of these distinctive scratches creates a "signature" on a bullet as it passes down a rifled barrel. A bullet recovered from a body can be compared to one fired from a suspect's firearm in a laboratory (Figure 4-34). Identification, however, is affected by the condition of the gun and that of the bullet or fragments. Although it is ideal to have the firearm, bullets themselves can yield important data. By matching striations on bullets recovered at different crime scenes, investigators can tie together information from several cases; the combined data may produce new leads and result in the clearance of the case.

In some cases, the striations on a bullet recovered from a decomposed body can be negatively affected by the interaction between the bullet material and the body tissue.⁷⁷ Conversely, an older revolver whose cylinders do not properly align may shear off a portion of the bullet when fired, creating distinctive markings. Other aspects

► FIGURE 4-34

Bullet comparison

A drug user murdered his supplier in order to "cancel" his debt and obtain additional drugs. This is a photomicrograph of the bullet recovered from the body (left) compared to a bullet fired from the murder gun (right) after the revolver was recovered from a river by police divers. (courtesy Royal Canadian Mounted Police)



of how individual-class firearm evidence is produced are discussed later in this section.

2. What Else Can Be Learned from the Bullet?

A fired bullet yields evidence of the class characteristics of the weapon that fired it with respect to the number of lands and grooves as well as their height, depth, and width. The class characteristics of a firearm are the design specifications to which it was manufactured; weapons of a given make and model will have the same class characteristics. The individual characteristics of the bore are found in the striae along the fired bullet. Examination of a fired bullet will suggest the type of weapon from which it was fired, whether the bullet is a hard-nose or soft-nose projectile, and the pitch and direction of twist within the barrel. Additionally, if the fired bullet is recovered in sufficient size, it may be possible, through weighing and measurement, to determine its caliber. Since bullets are often recovered as fragments, the caliber may only be implied; for instance, the weight may rule out smaller calibers. Although it is possible to determine the caliber of the bullet, some caution must be taken with respect to determining the bore of the weapon from which it was fired, since a smaller-caliber bullet can be fired through a larger-bore weapon.

Fired bullets are ordinarily damaged on impact. In some cases, you can see fabric impressions on the bullet's nose that were made as the bullet passed through the victim's outer garment. Additionally, there may be minute traces of blood, tissue, bone, fabric, or other such materials (Figure 4-35). Great care must be taken by the investigator not to destroy or in any way alter such evidence. When the fired bullet is to be recovered from the victim, the investigator should alert the attending medical personnel, if there is any doubt about their familiarity with proper handling procedure, as to the

irreparable damage that can be wrought by the careless application of forceps or other such instruments in removing the bullet.

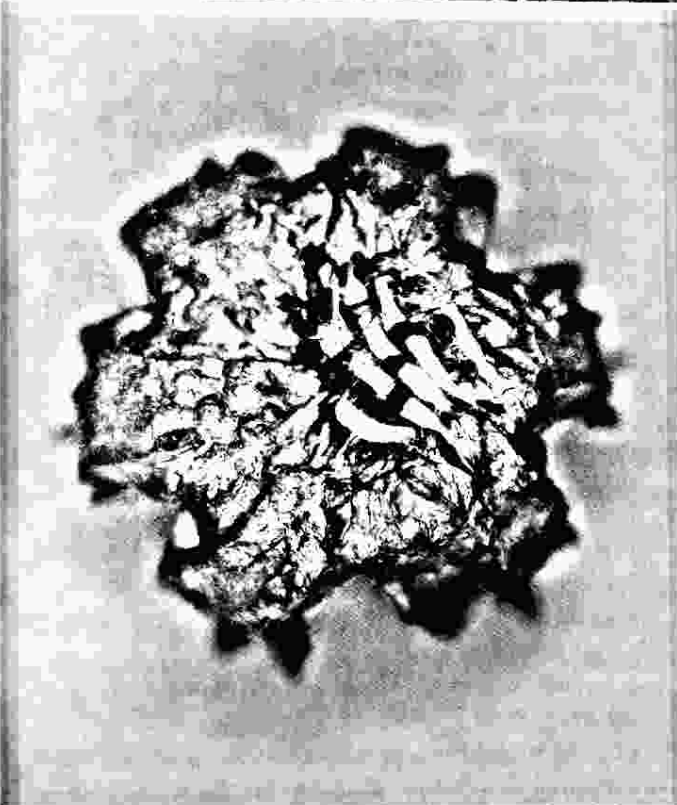
Note that it is ordinarily not possible to make a positive identification as to whether pellets were fired from a particular shotgun. However, in extraordinarily rare circumstances involving smooth-bore firearms, it may be possible to make an individual identification on the basis of gross defects in the barrel.⁷⁸

3. What Determinations Can Be Made from Cartridge Cases?

In contrast to a bullet, which is typically acted on only by the barrel, a cartridge case is subject to a number of different forces that make marks on it, any of which can produce individual-class evidence. Such marks include:

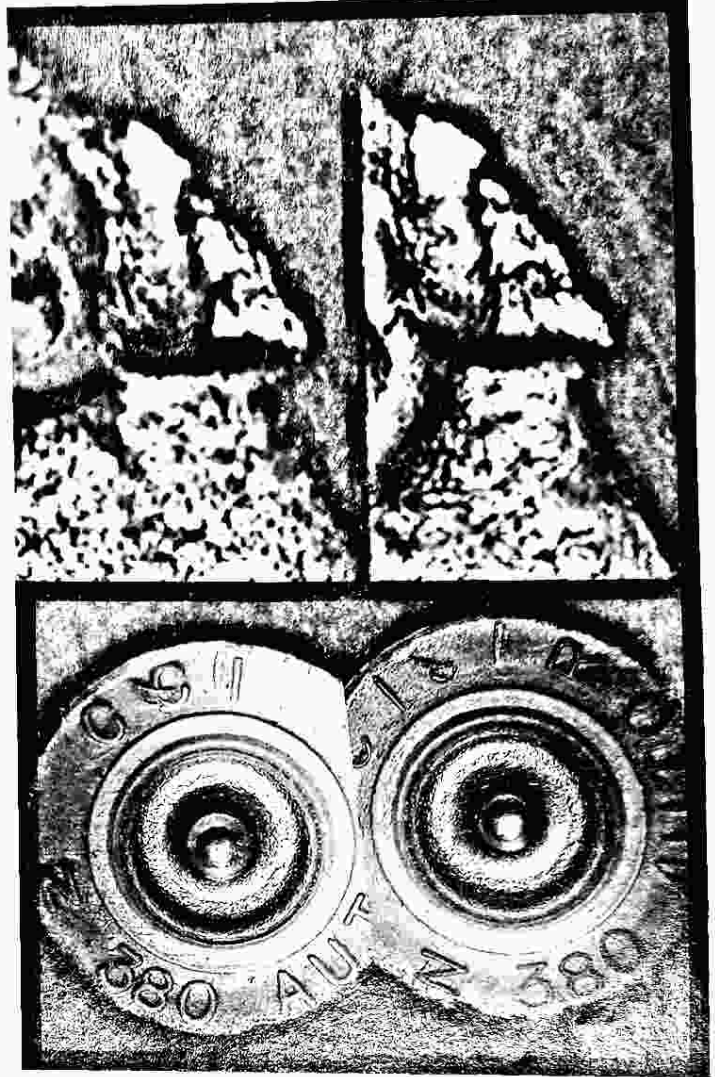
1. Striations made on the outside of cartridge case as it is loaded into the chamber in preparation for firing; these striations may be caused by the action of the magazine or by the slide action of the firearm.
2. A firing-pin impression made on the base of the cartridge case, which is created when the weapon is fired (Figure 4-36).
3. Marks are left on the cartridge case as the exploding gases that propel the bullet forward force the casing outward against the chamber wall and backward against the breach face of the weapon (Figure 4-37). The breach face is the mechanism that holds the bullet in the chamber.
4. Extractor marks made when the case is pulled out of the chamber and ejector marks made when the case is "kicked out," both of which are associated with semiautomatic and automatic weapons.

Markings made on cartridges by self-loading pistols can vary somewhat over a series of discharges. In laboratory



▲ FIGURE 4-35 Fabric traces in spent bullet

In some cases, the fabric of the garment being worn by the victim can be found attached to the bullet. In this unique homicide, the fibers from the sweater of the victim (*top*) are found inside the flattened "mushroom" of the bullet (*bottom*) recovered from the body. (Courtesy Forensic Training and Consulting, LLC)



▲ FIGURE 4-36 Firing pin impressions

(*Top*) Photomicrograph showing comparison of questioned and known firing-pin impressions of .22-caliber rim-fire cartridge cases. (*Bottom*) Photomicrograph showing comparison of questioned and known firing-pin impressions on .380-caliber center-fire cartridge cases. Note the significant differences between a rim-fire and a center-fire cartridge: on the center-fire cartridge, the pin must strike the center of the primer to ignite the powder; however, on the rim-fire cartridge, contact may be anywhere around the face of the cartridge. (Courtesy Forensic Training and Consulting, LLC)

tests, the first and 250th cartridges fired by the same auto-loader were identifiable as being made by the same weapon, but some differences in individual characteristics were observed.⁷⁹ Visualization of fingerprints deposited on cartridge cases before the gun was fired can be problematic owing to discharge heat and friction, but prints may be recoverable.⁸⁰



▲ FIGURE 4-37 Breach-face markings

Photomicrograph of the breach-face markings on two Speer 9-mm cartridge cases that were recovered at different locations at the scene of a murder. The victim was scheduled to testify in the trial of a drug dealer the next day. The murder is unsolved and under active investigation. (Courtesy Tennessee Bureau of Investigation)

What Miscellaneous Determinations Can Be Made by Examination of Firearms Evidence?

If a firearm is received at a crime laboratory several determinations beyond those mentioned may be possible. Does the weapon function properly, including safety features? Has it been modified to discharge in a manner other than designed, for example, for automatic fire? What was the shot trajectory? If the trigger pull on a weapon is of the "hair" nature, requiring only the slightest pressure to pull it, this would indicate that an accidental shooting was possible. Laboratory examination might reveal that a firearm is constructed—or malfunctioning—in such a way that it could discharge if dropped on its hammer, thereby giving more credibility to a claim that a shooting was accidental. Furthermore, even though invisible to the naked eye, obliterated serial numbers can sometimes be restored

by the laboratory, thus providing an additional investigative lead.

COLLECTING FIREARM EVIDENCE

A cardinal rule in handling weapons at the scene of a crime is that they should never be picked up or moved until they have been photographed and measurements have been made for the crime scene sketch. As in the case of many rules for criminal investigations and as discussed in an earlier chapter, there are several exceptions: (1) if rapidly deteriorating weather conditions, for instance, a driving rain/sleet/snow storm or quickly rising water, threaten the potential to recover fingerprint or DNA evidence from a firearm located outside, move it to a sheltered area; (2) at the scenes of aggravated assaults and murders, feelings run high, and there is a danger that an emotionally charged person may suddenly attempt to pick up a weapon and shoot another party; or (3) there may be some compelling safety need, such as un-cocking a weapon that is in potential danger of falling and discharging.

Following documentation, the process of collecting firearms evidence includes:

1. noting the position of the hammer and the slide, and safety, if applicable;
2. recording the description of rounds and empty chambers in a revolver (Figure 4-37);
3. removing cartridges from a revolver and packaging them individually;
4. noting for semi-automatic/automatic weapons whether there is a misfeed/jam, a chambered cartridge, an inserted magazine, and the number and description of each round in the magazine in their exact sequence;
5. removing any chambered round in a semi-automatic or automatic weapon and releasing the magazine—do not remove any cartridges from the magazine;
6. recording the serial number, not to be confused with patent or model numbers—to avoid manual transcription errors, some law-enforcement agencies and laboratories recommend dusting and lifting the serial number;
7. allowing any fresh blood on a weapon to naturally air dry;
8. placing metal objects recovered from water into a container filled with water from the same source.

In no case should a pencil or similar object be placed into the barrel of the gun to pick it up; this can dislodge evidence that may be in the barrel, such as tissue, blood, hair, or other trace evidence, and it can contaminate the barrel, thereby confusing the laboratory examiner.

To enhance the recovery of blood, tissue, and fingerprints, firearms evidence should be handled as little as possible consistent with the need to process it and "safe" the firearm. A victim is often the donor of blood and tissue

on a firearm. Although a victim may grab a gun barrel and leave fingerprints, the more usual case is any fingerprints developed on a weapon or other firearms evidence are from the shooter, unless the victim's own gun has been used against him/her.

"Touch DNA" is a relatively new iteration in DNA analysis that involves skin cells rather than body fluids. When an assailant touches a weapon or rips the clothing from a rape victim, he/she may deposit some of his/her own outermost skin cells, which can establish individual identity. Requests for touch DNA examinations became so routine that some laboratories adopted a policy to conduct them only after all significant leads have been exhausted. Whether done in the field or the laboratory, the systematic swabbing of firearms evidence may produce blood, tissue, or touch DNA. Among the areas to which particular attention should be directed are serrated triggers, hammers, pistol grips, magazines, and safety mechanisms.

In rare situations it may not be possible to "safe" a firearm because of mechanical failure or damage, and in this case the laboratory should be contacted for guidance. The lab may recommend transporting the malfunctioning/damaged gun loaded, which is otherwise not done. Lacking such guidance, one can check with other resources, such as the local ATF office or a military installation.

MARKING AND PACKAGING FIREARM EVIDENCE

The FBI and many state crime laboratories do not recommend marking directly on firearms evidence. A gun should be tagged and placed in an approved firearms box. To secure the gun, place a strap over the barrel and another at the base of the hammer. Straps should never be placed inside the trigger guard. Magazines are another type of firearms evidence that is tagged. Smaller items—for example, cartridges and bullet fragments—should be placed separately in paper envelopes, sealed, and then put into a rigid container. Plastic wrapping or bags are not used with firearms evidence. If there is dried blood on any firearms evidence, a "Biological Hazard" sticker should be placed on the outside of the container.

TOOL MARKS

Tool mark evidence is commonly, but not exclusively, seen in burglaries at the point where a suspect attempted or achieved a forced entry. Figure 4-38 shows a case in which a pry bar was used as a murder weapon. In a rare case, a clod of soil at a gravesite had substantial details left by the digging tool. Later, when a suspect was identified, a mattock was found in the trunk of his car that

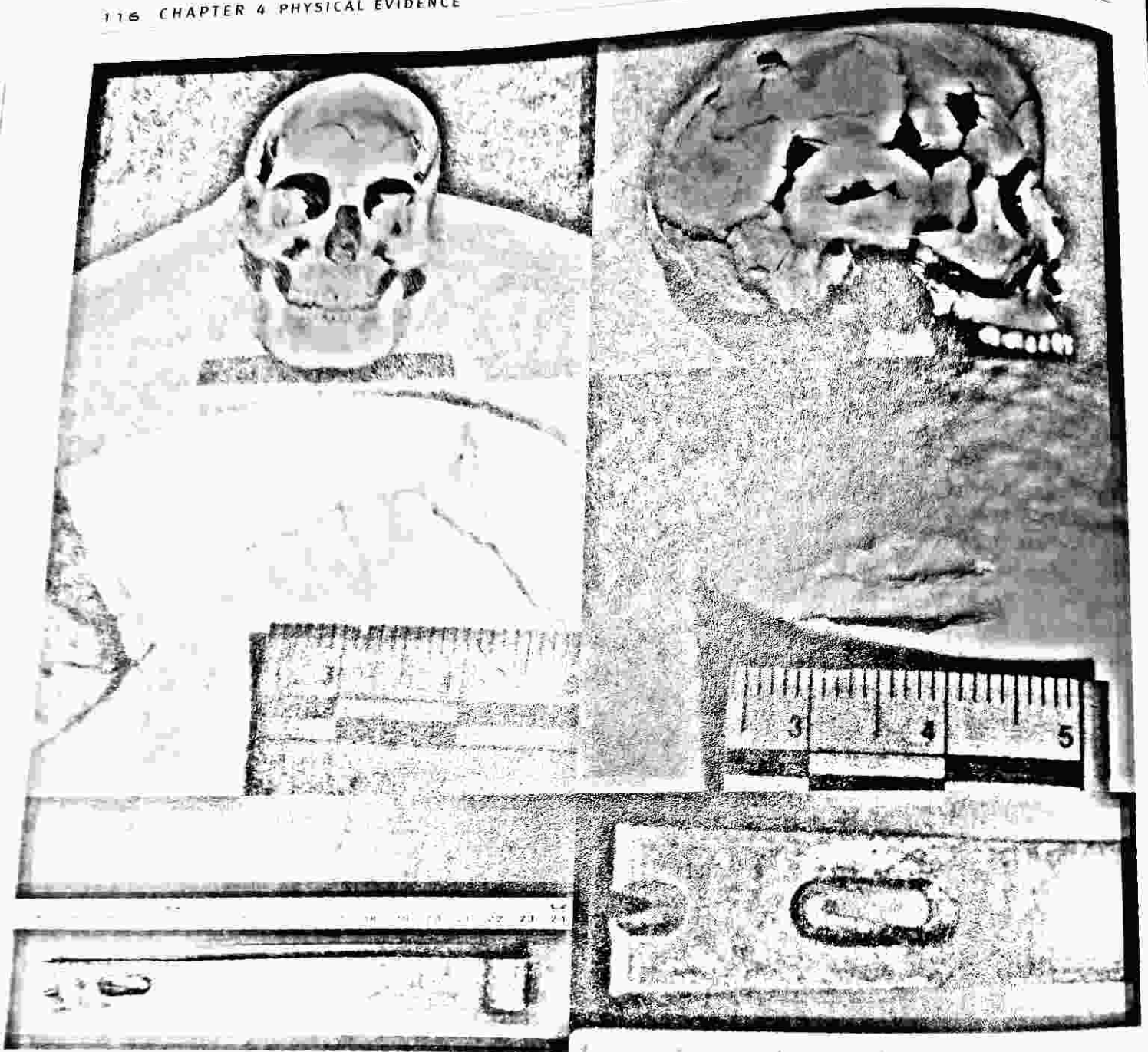
examiners concluded was used to dig the grave.⁸¹ A mattock has a wooden handle of roughly 36–42 inches and a metal head, one end of which is a pointed "spike" and the other end looks like a hoe.

A **tool mark** is any impression, cut, gouge, or abrasion made when a tool comes into contact with another object.⁸² When a tool and a softer surface come into contact with each other, the softer surface yields (Figure 4-39). The tool may create an impression in the softer surface, produce striations on it, holes through it, or cut/shear the item. Tools often leave microscopic markings that can be class or individual class characteristic evidence⁸³ (Figure 4-40). Additionally, contaminants on the tool and/or the surface affected may be transferred. Tools may simply require "elbow grease" to use or have a designed action, such as scissors or a bolt cutter. Tool mark examination includes locks and keys, for example, in an attempt made to open a lock with an unauthorized implement.

Tool mark examinations are conducted to:

1. identify the type of tool that made the mark or impression;
2. establish the action used to operate the tool;
3. specify the size and other characteristics of the tool;
4. identify unusual features—for example, a broken tip on a screwdriver;
5. establish whether two portions of a tool were ever commonly joined (Figure 4-41);
6. establish whether the evidence is suitable for comparison purposes;
7. determine whether "this" tool could have made "that" impression or mark. Alternatively, the examiner might report that the evidence is inconclusive or exclude the tool as a source for making an impression or mark.

In collecting evidence of tool marks, make every effort to obtain and submit the actual area for direct comparison. When this is not possible, a cast should be made. There are several good choices for casting tool marks, including Mikrosil. Tool marks should be photographed to establish their locations; however, the images have no forensic identification value. In no event should the investigator place a tool against a tool mark for size evaluation; doing so could lead to accidental cross contamination or result in the accidental destruction of evidence. When a tool is to be submitted to the crime laboratory for examination, the actual tool should be submitted; the making of test impressions or cuts is a function of qualified technicians in the laboratory. The importance of this last point is illustrated by the fact that under test conditions in the laboratory examiners found that when there was more than a 15-degree difference between the vertical angle at which a screwdriver was actually used and the comparison mark made in the laboratory, an improper finding of no identity from the same tool could result.⁸⁴



▲ FIGURE 4-38 Tool marks on human skull

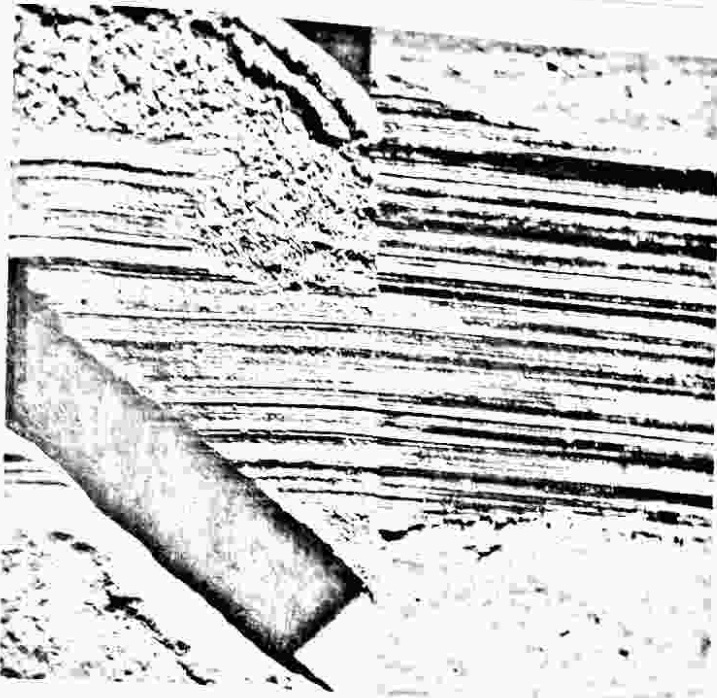
A murder case in Arizona represents a unique tool match with wounds to the skull of the victim. The severely fractured skull and body of a young female victim were found in a freezer, presumably left there by the killer some two years before. Several tools investigators determined that a pry bar was the murder weapon. Confirming the tool mark comparison and match were microscopic pieces of bone found on the prongs of the bar. (Courtesy Forensic Training and Consulting, LLC)

QUESTIONED DOCUMENTS

loosely defined, a **document** is anything on which a mark, symbol, or writing is made for the purpose of transmitting a meaning. The mark, symbol, or writing may or may not be visible to the naked eye and may appear on surfaces other than paper. A disputed or **questioned document**

is one whose origin or authenticity is in doubt.⁸⁵ The typical questioned document submission involves the comparison of a questioned document with a known sample⁸⁶—for example, was this suicide note written by the deceased?

White-collar crimes generate most requests for handwriting examinations.⁸⁷ These tests typically involve checks,



▲ **FIGURE 4-39** Screwdriver marks

The photomicrograph on the left depicts microscopic striations on the head of a woodscrew left by a burglar attacking a door. The right side is a known or test impression made by the laboratory examiner using the screwdriver seized in the suspect's custody. Note that black-and-white photography is often used to highlight the striations.

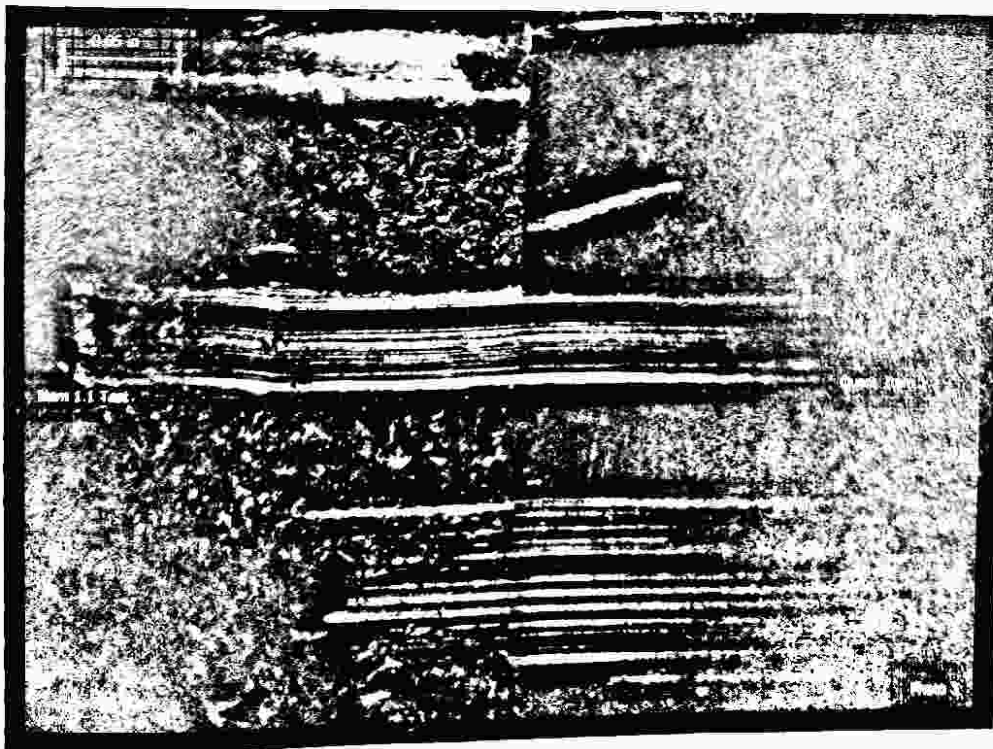
credit cards, and other financial and legal documents (Figure 4-42). Although in a lesser volume, handwritten documents, such as schedules, plans, checklists, and bank robbery and ransom notes, may be part of the execution of violent crimes.

Document examiners analyze non-handwritten evidence as well, including writing instruments, inks, paper, and rubber stamps. Mechanical means of printing and the writings they produce are also within the purview of document examiners—for example, check writers, scanners, facsimile machines, photocopiers, computer printers, and, less frequently, typewriters.⁸⁸ Some mechanical means of printing are central to counterfeiting items such as receipts, driver's licenses, ski lift and sporting event tickets, academic transcripts and degrees, social security cards, and passports.

HANDWRITING SAMPLES AND EXAMINATIONS

Handwriting samples may be requested or nonrequested. Some state/regional laboratories provide booklets for collecting requested samples of signatures and extended writings. If such a tool is not available, there are some basic guidelines:

1. For requested samples, if only a signature is being sought, 15 to 20 should be collected from an individual, one to a page. If there is an extended questioned sample, for example, an extortion demand or death threat, the investigator should dictate the contents, obtaining at least five repetitions. No instructions as to format or other aspects of writing should be given—for instance, assistance with spelling words or punctuation—except if the questioned sample is printed or handwritten, the known sample should also be. The questioned samples are never shown to the person providing the known samples. As each page is completed, have the subject initial it; separate from those initials the investigator should



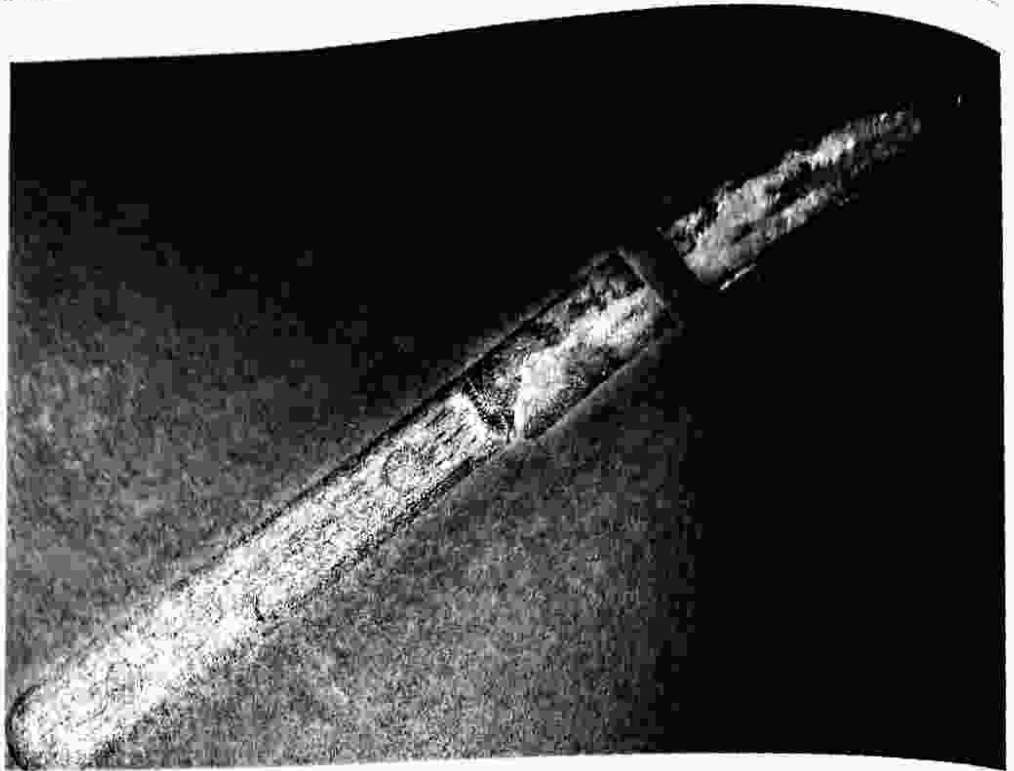
◀ **FIGURE 4-40**
Comparison of plier marks

After breaking in, a suspect used pliers to dismantle copper tubing to sell for scrap metal. This image compares marks found on the copper tubing at the scene with test marks made in the laboratory with pliers found in the suspect's possession.

(Courtesy Wyoming State Crime Laboratory)

► FIGURE 4-41
Fracture-match tool

While trying to pry open a window during an attempted burglary-rape, the suspect broke the kitchen knife he was using as a tool, leaving the end of the knife embedded in the window sill. The suspect was later found walking in a nearby park with the broken knife and handle in his pocket. A fracture match of the knife tip was made with the remainder of the knife handle. (Courtesy Albuquerque Police Department)



► FIGURE 4-42
A counterfeit marriage license

Note the differences between the "M" in "Robert M. Webster" and the "M" in "May," "March," and "Minister." Also, note the differences between the "3" and "4" in Webster's age and the same numbers elsewhere in the document. The differences in the type fonts as well as the gaps in the lines under the changed letters, left by whitening out the original entry, indicate a counterfeit document. (Courtesy Immigration and Naturalization Service, Forensic Document Laboratory)

Certified Copy of Record of Marriage

License No. 93-471
Date issued May 23, 1993
Date filed May 13, 1993

I, CLARA HARTLEY WOODARD, County Clerk hereby certify that:

Mr. Robert M. Webster
of 110 Pine Street in the County of Dade
and State of Florida of the age of 34 years, and
Miss Elizabeth Thomas
of 201 Willow Lane in the County of Dade
and State of Florida of the age of 22 years
were united in Marriage
on the 3rd day of March A.D. 1993
in said County, at Dade County Baptist Church
by Stevenson Edwards a Minister

Witnessed
Sandra Williams
Louis Hobbs

I do hereby certify that the foregoing is a true and correct copy of the License and Certificate of Marriage as the same appear of record in my office.

IN TESTIMONY WHEREOF I have set my hand and official seal this 23rd day of May A.D. 93

Clara Hartley Woodard
COUNTY CLERK
By Marianne E. Pappas
Deputy

SCAL

- add his/her own initials, identifying number, and the date and time, and he/she should number the pages sequentially as they are completed.
2. Collect requested writings with the same class/type of writing instrument as was used in the questioned samples. If this is not known, use a black ballpoint pen. If the questioned is on lined paper, paper of the same size should be used to collect the known. As each signature or extended

- writing is completed it should be removed from the person's sight.
3. Nonrequested samples should be collected from existing documents created/signed closest to the time the questioned document was executed, because handwriting evolves over time. Among the sources for nonrequested samples are signatures on Miranda warnings; suspects' statement; notes to jailers; credit, employment, insurance, and mortgage

applications; messages written on greeting cards given to others; and workers' compensation claims.

Nonrequested writings were not executed with the thought they would be scrutinized and therefore ordinarily are not disguised in any way. Disguised handwriting is problematic for document examiners, and it attracts more misleading and inconclusive rates of authorship opinions; one study concluded that the error rate for examiners in labeling a writing genuine or disguised was 4.3%.⁸⁹ A difficulty with nonrequested samples is locating sufficient high-quality signatures and extended writing material from the same time frame as the questioned samples.

Document examination is partially automated, using software such as CedarFox. Its capabilities include comparison of samples and searching handwriting databases to find potential matches, both of which must be confirmed by the examiner.⁹⁰

LABORATORY DETERMINATIONS

In addition to the possibility of determining whether handwriting can be attributed to a particular person, laboratories *may* be able to:

1. Determine whether a document is authentic or counterfeit. In 1983, 62 volumes of diaries attributed to Adolph Hitler were purchased by a German publisher. Three handwriting experts concluded Hitler wrote them, although others disagreed. However, forensic analysis established the method used to produce the paper on which the diaries were written was not available until 1954, and the ink used was first manufactured in 1982.
2. Recover indented writing; if not visible to the eye, indented writings may be located by an electrostatic detection apparatus (ESDA).
3. Identify the class/type of the writing instrument, such as a ballpoint, felt-tip pen, or pencil.
4. Determine whether the inks of known and questioned samples have consistent characteristics—the Secret Service and the Internal Revenue Service maintain the International Ink Library with more than 9,500 samples.
5. Decipher charred, burned, or water-soaked documents.
6. Match the ends of cut/torn paper. A man handed a bank teller a note, "This is a robbery." He left

with money, but she retained the note. A week later, police executed a search warrant at the suspect's home, finding "This is a robbery" in indented writing on a pad. A portion of paper remaining in the pad also matched one end of the robbery note.⁹¹

7. Establish the source of paper through watermarks and other features.
8. Detect erasures, obliterations, and alterations to documents.
9. Determine whether one or more pages in a document were added subsequently to its original production.
10. Establish the relative age of a document.
11. Determine whether an office machine—for example, scanner, photocopier, typewriter, fax machine, or computer printer—is associated with a particular document. Often, the machine must have a defect or some unusual attribute to be distinguishable. However, there is substantial interest in developing "signatures" for scanners, printers, and digital cameras. One line of inquiry is looking at their intrinsic features to identify unique attributes; the alternative method is to embed microscopic codes, such as a serial number, on each page of output.

COLLECTING AND PACKAGING EVIDENCE

In many respects, all evidence collection is like the first rule of physicians: do no harm. Investigators should not attempt to reassemble torn or shredded documents; write on, trace, highlight, or underline portions of them; or make repairs to or fold them. Documents should be collected and processed using the following guidelines:

1. Wear gloves and use clean tweezers to handle documents.
2. Handle the documents as little as possible.
3. Use a transparent envelope if possible; otherwise, use a manila paper one.
4. Before placing the document in the envelope, fill out all required blocks of information on it and then slip it in the evidence and seal it.
5. Processing for latent prints and DNA is a laboratory responsibility.
6. Keep documents in a cool, low-humidity environment, out of the sunlight, until submitted to the lab.

bore
caliber
concentric fracture
class characteristics
CrimeShoe
cross contamination

dental stone
document
ejector mark
extractor mark
fingerprint
fingerprint patterns

fluorescent powder
forensic light source
forensic odontology
fracture match
grooves
Hemident