

Learning Objectives

After studying this chapter you should be able to:

- Define *physical evidence*
- Discuss the responsibilities of the first police officer who arrives at a crime scene
- Explain the steps to be taken to thoroughly record the crime scene
- Describe proper procedures for conducting a systematic search of a crime scene for physical evidence
- Describe proper techniques for packaging common types of physical evidence
- Define and understand the concept of chain of custody
- Understand the contributions the forensic pathologist, entomologist, and anthropologist can make to a homicide investigation

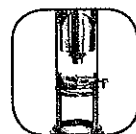
National Science Content Standards



Scientific Inquiry



Physical Science



History and Nature of Science

JonBenet Ramsey: Who Did It?

Patsy and John Ramsey were in the upper crust of Boulder, Colorado, society. In the span of five short years, John had built his computer company into a billion-dollar corporation. In addition to financial success, the Ramseys also had a beautiful 6-year-old daughter, JonBenet.

Just after five A.M. on December 26, 1996, Patsy Ramsey awoke and walked downstairs to her kitchen. At the foot of the staircase, she found a two-and-a-half-page note saying that JonBenet had been kidnapped. The note contained a ransom demand of \$118,000. When the police arrived to investigate, it was quite apparent to all that JonBenet was missing.

In retrospect, some serious mistakes were made in securing the crime scene—the Ramsey household. Initially, the police conducted a cursory search of the house, but failed to find JonBenet. The house was not sealed off; in fact, four friends along with the Ramsey pastor were let into the home and allowed to move about at will. John was permitted to leave the premises unattended for one and a half hours. One hour after his return, John and two of his friends searched the house again. This time John went down into the basement, where he discovered JonBenet's body. He removed a white blanket from JonBenet and carried her upstairs, placing the body on the living room floor.

The murder of JonBenet Ramsey remains as baffling a mystery today as it was on its first day. Ample physical evidence supports the theory that the crime was committed by an outsider, as well as the competing theory that JonBenet was murdered by someone who resided in the Ramsey household. Perhaps better care at securing and processing the crime scene could have resolved some of the crime's outstanding questions.

The Crime Scene

2



Key Terms

algor mortis

autopsy

buccal swab

chain of custody

finished sketch

livor mortis

physical evidence

rigor mortis

rough sketch

standard/reference sample

substrate control

Physical Evidence and the Crime Scene

physical evidence

Any object that can establish that a crime has or has not been committed or can link a crime and its victim or its perpetrator

As automobiles run on gasoline, crime laboratories “run” on **physical evidence**. Physical evidence encompasses any and all objects that can establish that a crime has or has not been committed or can link a crime and its victim or its perpetrator. But if physical evidence is to be used effectively to aid the investigator, its presence first must be recognized at the crime scene. If all the natural and commercial objects within a reasonable distance of a crime were gathered so that the scientist could uncover significant clues from them, the deluge of material would quickly immobilize the laboratory facility. Physical evidence achieves its optimum value in criminal investigations only when its collection is performed with a selectivity governed by the collector’s thorough knowledge of the crime laboratory’s techniques, capabilities, and limitations.

Forthcoming chapters discuss methods and techniques available to forensic scientists to evaluate physical evidence. Although current technology has given the crime laboratory capabilities far exceeding those of past decades, these advances are no excuse for complacency on the part of criminal investigators. Crime laboratories do not solve crimes; only a thorough and competent investigation conducted by professional police officers will enhance the chances for a successful criminal investigation. Forensic science is, and will continue to be, an important element of the total investigative process, but it is only one aspect of an endeavor that must be a team effort. The investigator who believes the crime laboratory to be a solution for carelessness or ineptness is in for a rude awakening.

Forensic science begins at the crime scene. If the investigator cannot recognize physical evidence or cannot properly preserve it for laboratory examination, no amount of sophisticated laboratory instrumentation or technical expertise can salvage the situation. The know-how for conducting a proper crime-scene search for physical evidence is within the grasp of any police department, regardless of its size. With proper training, police agencies can ensure competent performance at crime scenes. In many jurisdictions, police agencies have delegated this task to a specialized team of technicians. However, the techniques of crime-scene investigation are easy to master and certainly lie within the bounds of comprehension of the average police officer.

Not all crime scenes require retrieval of physical evidence, and limited resources and personnel have forced many police agencies to restrict their efforts in this area to crimes of a more serious nature. Once the commitment is made to process a crime site for physical evidence, however, certain fundamental practices must be followed.

Preserving and Recording the Crime Scene

In order to be useful to investigators, evidence at a crime scene must be preserved and recorded in its original condition as much as possible. Failure to protect a crime scene properly or record its details accurately may result in the destruction or altering of evidence, or hinder the search for the perpetrator by misleading investigators about the facts of the incident.

Securing and Isolating the Crime Scene

The first officer arriving on the scene of a crime must preserve and protect the area as much as possible. Of course, first priority should be given to obtaining medical assistance for individuals in need of it and to arresting the perpetrator. However, as soon as possible, extensive efforts must be made to exclude all unauthorized personnel from the scene. As additional officers arrive, measures are immediately initiated to isolate the area. (See [Figure 2-1](#).) Ropes or barricades along with strategic positioning of guards will prevent unauthorized access to the area.



FIGURE 2-1 The first investigators to arrive must secure the crime scene and establish the crime-scene perimeter. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com

Sometimes the exclusion of unauthorized personnel proves more difficult than expected. Violent crimes are especially susceptible to attention from higher-level police officials and members of the press, as well as by emotionally charged neighbors and curiosity seekers. Every individual who enters the scene has the potential to destroy physical evidence, even if by unintentional carelessness. To exercise proper control over the crime scene, the officer protecting it must have the authority to exclude everyone, including fellow police officers not directly involved in processing the site or in conducting the investigation. Seasoned criminal investigators are always prepared to relate horror stories about crime scenes where physical evidence was rendered totally valueless by hordes of people who trampled through the site. Securing and isolating the crime scene are critical steps in an investigation, the accomplishment of which is the mark of a trained and professional crime-scene investigative team.

Once the scene has been secured, a lead investigator starts evaluating the area. First, he or she determines the boundaries of the scene and then establishes the perpetrator's path of entry and exit. Logic dictates that obvious items of crime-scene evidence will first come to the attention of the crime-scene investigator. These items must be documented and photographed. The investigator then proceeds with an initial walk-through of the scene to gain an overview of the situation and develop a strategy for systematically examining and documenting the entire crime scene.

Record the Scene

Investigators have only a limited amount of time to work a crime site in its untouched state. The opportunity to permanently record the scene in its original state must not be lost. Such records not only will prove useful during the subsequent investigation, but also are required for presentation at a trial in order to document the condition of the crime site and to delineate the location of physical evidence. Photography, sketches, and notes are the three methods for crime-scene recording (see Figure 2-2). Ideally all three should be employed; however, personnel and monetary limitations often prohibit the use of photography at every crime site. Under these circumstances, departmental guidelines will establish priorities for deploying photographic resources. However, there is no reason not to make sketches and notes at the crime scene.

Photography The most important prerequisite for photographing a crime scene is for it to be unaltered. Unless injured people are involved, objects must not be moved until they have been photographed from all necessary angles. If objects are removed, positions changed, or items added, the photographs may not be admissible as evidence at a trial, and their intended value will be lost. If evidence has been removed or moved before photography, the fact should be noted in the report, but the evidence should not be reintroduced into the scene in order to take photographs.

Each crime scene should be photographed as completely as possible. This means that the crime scene should include the area in which the crime actually took place and all adjacent areas where important acts occurred immediately before or after the commission of the crime. Overview photographs of the entire

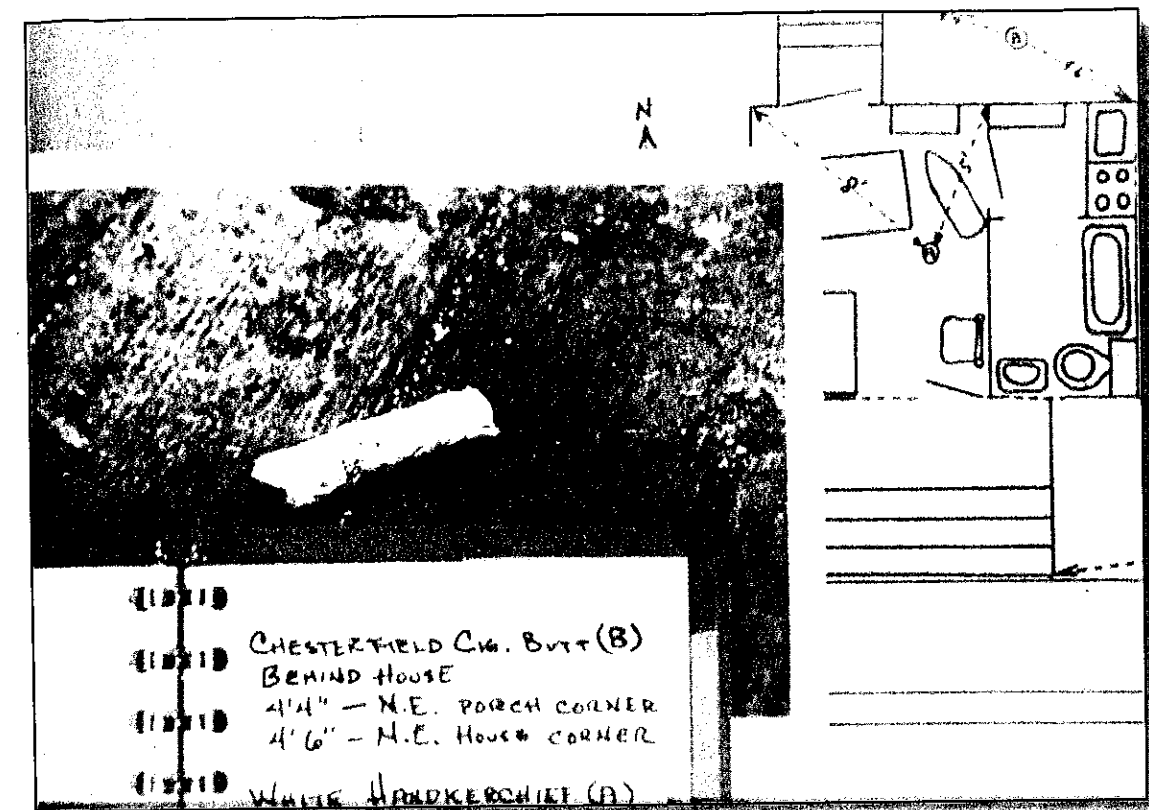


FIGURE 2-2 The finding of an evidential cigarette butt at the crime scene requires photographing it, making a sketch showing its relation to the crime scene, and recording the find in field notes. Courtesy Police Science Services, Niles, Ill.

scene and surrounding area, including points of exit and entry, must be taken from various angles. If the crime took place indoors, the entire room should be photographed to show each wall area. Rooms adjacent to the actual crime site must be similarly photographed. If the crime scene includes a body, photographs must be taken to show the body's position and location relative to the entire scene. Close-up photos depicting injuries and weapons lying near the body are also necessary. After the body is removed from the scene, the surface beneath the body should be photographed.

As items of physical evidence are discovered, they are photographed to show their position and location relative to the entire scene. After these overviews are taken, close-ups should be taken to record the details of the object itself. When the size of an item is significant, a ruler or other measuring scale may be inserted near the object and included in the photograph as a point of reference.

The digital revolution promises to bring enhanced photographic capabilities to the crime scene. For example, individual images of the crime scene captured with a digital camera can be stitched together electronically to reveal a near three-dimensional panoramic view of the crime scene (see Figure 2-3). With the aid of a computer, any area of the scene captured digitally can be enhanced and examined in fine detail.

The use of videotape or digital video at crime scenes is becoming increasingly popular because the cost of this equipment is decreasing. The same principles used in crime-scene photographs apply to videotaping or digital video. As with

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Scene
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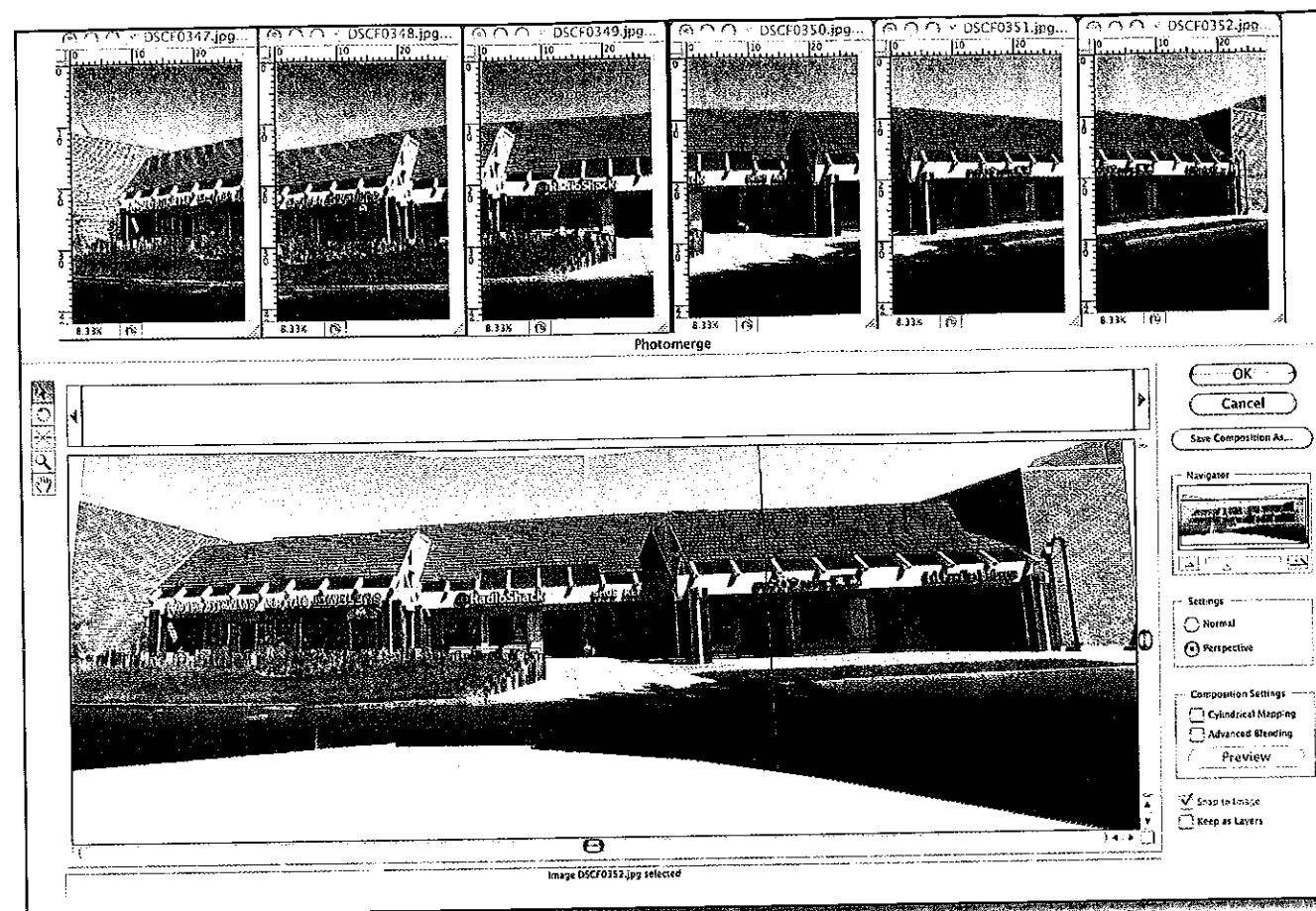


FIGURE 2-3 Individual images (top) are shown before being electronically stitched together into a single panoramic image (bottom). Individual photographs should be taken with about a 30 percent overlap. Courtesy Imaging Forensics, Fountain Valley, Calif., www.imagingforensics.com

conventional photography, videotaping or digital video should include the entire scene and the immediate surrounding area. Long shots as well as close-ups should be taken in a slow and systematic manner. Furthermore, it is desirable to have one crime-scene investigator narrate the events and scenes being recorded while another does the actual shooting.

Although videotaping or digital video can capture the sounds and scenes of the crime site with relative ease, the technique cannot at this time be used in place of still photography. The still photograph remains unsurpassed in the definition of detail it provides to the human eye.

Sketches Once photographs have been taken, the crime-scene investigator sketches the scene. The investigator may have neither the skill nor the time to make a polished sketch of the scene. However, this is not required during the early phase of the investigation. What is necessary is a **rough sketch** containing an accurate depiction of the dimensions of the scene and showing the location of all objects having a bearing on the case.

A rough sketch is illustrated in Figure 2-4. It shows all recovered items of physical evidence, as well as other important features of the crime scene. Objects are located in the sketch by distance measurements from two fixed points, such as the walls of a room. Distances shown on the sketch must be accurate and not

the result of a guess or estimate. For this reason, all measurements are made with a tape measure. The simplest way to designate an item in a sketch is to assign it a number or letter. A legend or list placed below the sketch then correlates the letter to the item's description. The sketch should also show a compass heading designating north.

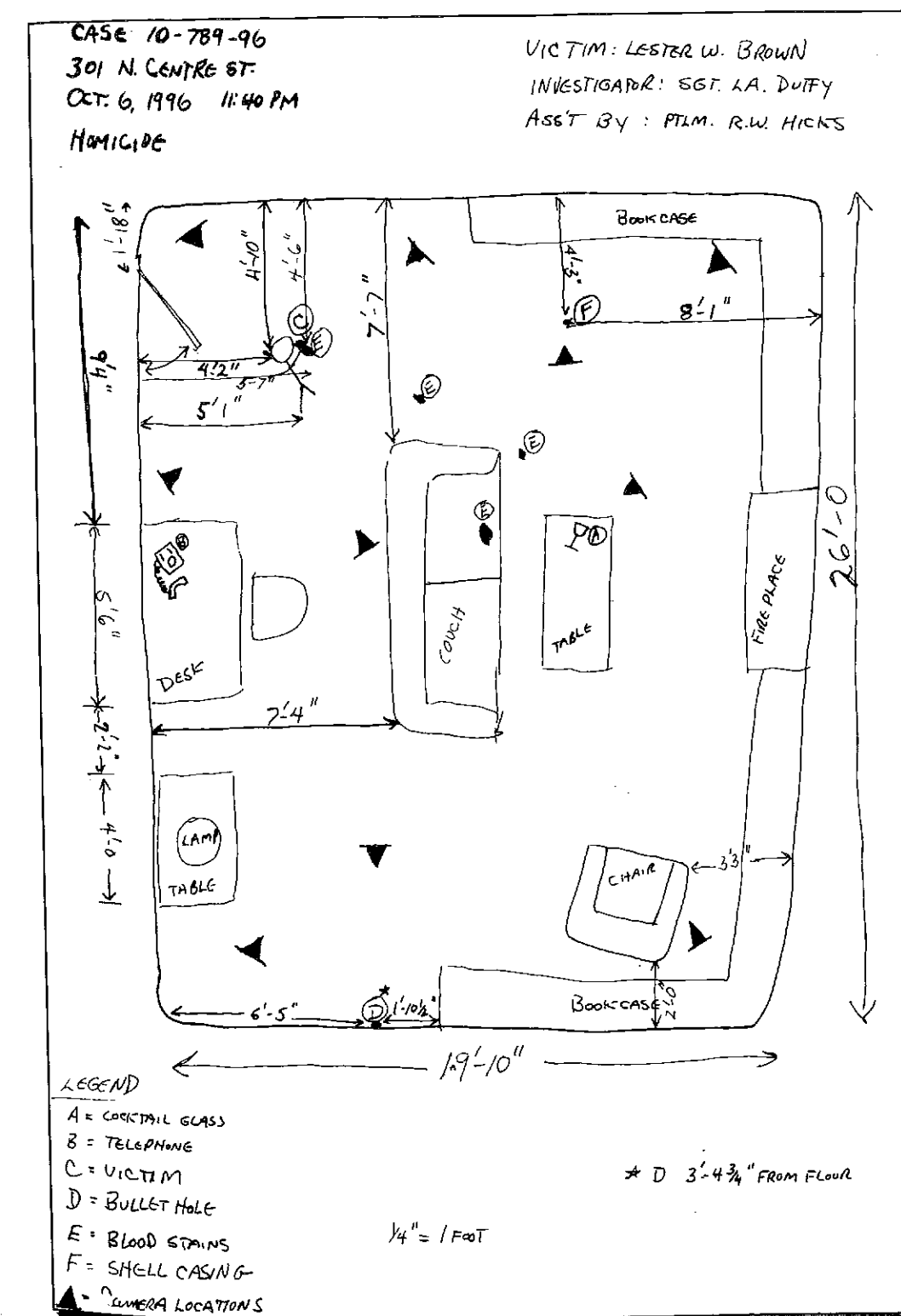


FIGURE 2-4 Rough-sketched diagram of a crime scene. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com

rough sketch

A sketch, drawn at the crime scene, that contains an accurate depiction of the dimensions of the scene and shows the location of all objects having a bearing on the case

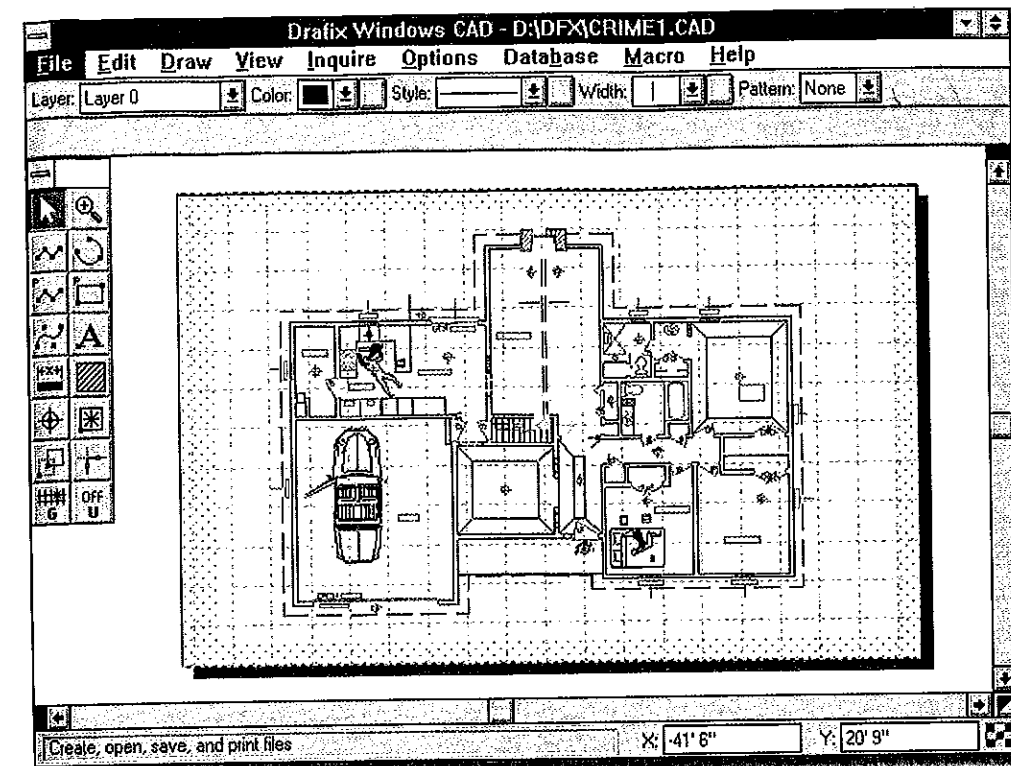
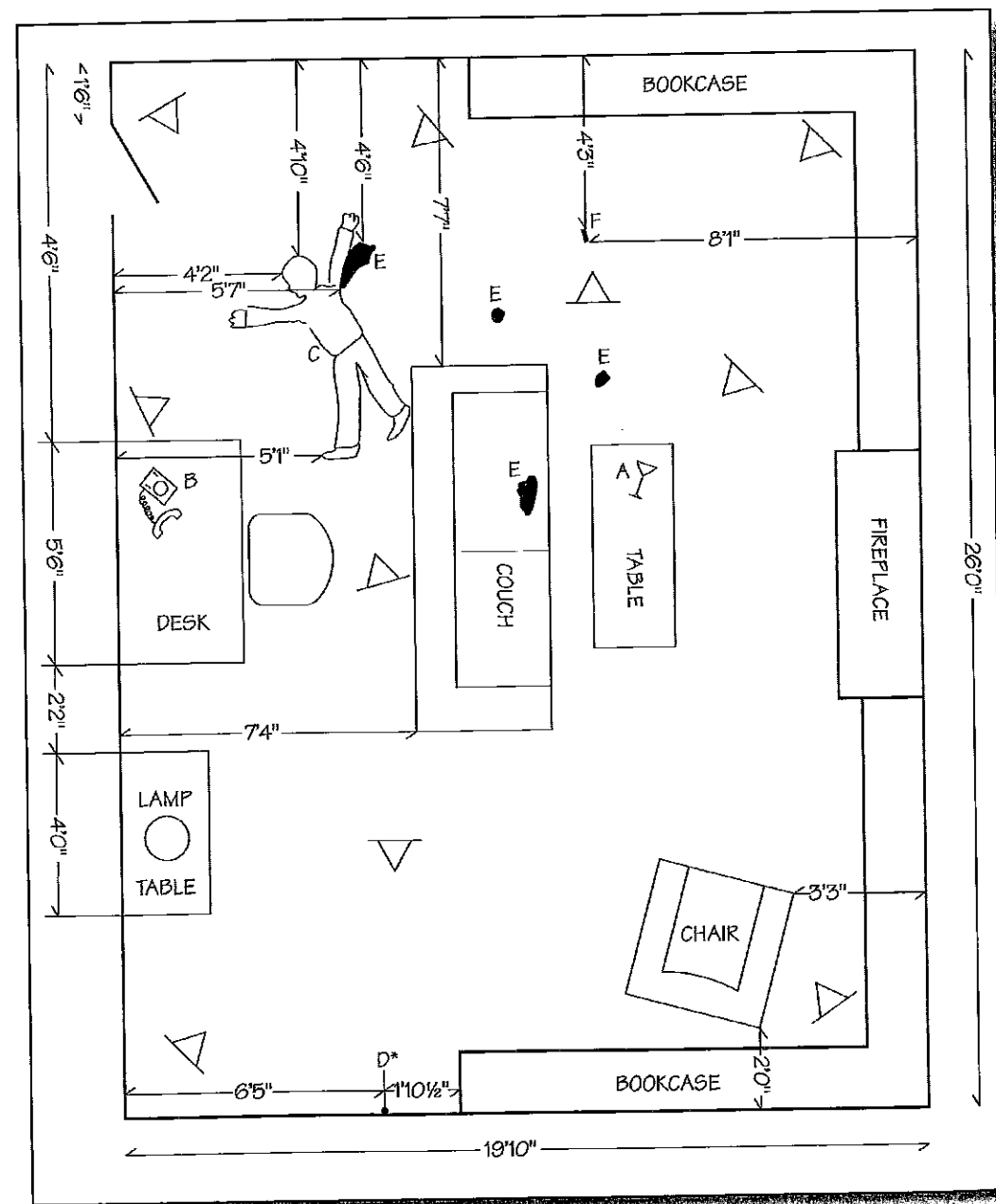
finished sketch

A precise rendering of the crime scene, usually drawn to scale

Unlike the rough sketch, the **finished sketch** in Figure 2-5 is constructed with care and concern for aesthetic appearance. When the finished sketch is completed, it must reflect information contained within the rough sketch in order to be admissible evidence in a courtroom. Computer-aided drafting (CAD) has become the standard method for reconstructing crime scenes from rough sketches. The software, ranging from simple, low-cost programs to complex, expensive ones, contains predrawn intersections, roadways, buildings, and rooms onto which information can be entered (see Figure 2-6). A generous symbol library provides a variety of images that can be used to add intricate details such as blood spatters to a crime-scene sketch. Equipped with a zoom function, computerized sketching can focus on a specific area for a more detailed picture. The CAD programs allow the user to select scale size so that the final product can be produced in a size suitable for courtroom presentation.

FIGURE 2-5

Finished sketch of a crime scene. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com

**FIGURE 2-6**

Construction of a crime-scene diagram with the aid of a computer-aided drafting program. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com

Notes Note taking must be a constant activity throughout the processing of the crime scene. These notes must include a detailed written description of the scene with the location of items of physical evidence recovered. They must also identify the time an item of physical evidence was discovered, by whom, how and by whom it was packaged and marked, and the disposition of the item after it was collected. The note taker must keep in mind that this written record may be the only source of information for refreshing one's memory months, perhaps years, after a crime has been processed. The notes must be sufficiently detailed to anticipate this need. Tape-recording notes at a scene can be advantageous—detailed notes can be taped much faster than they can be written. Another method of recording notes is to narrate a video recording of the crime scene. This has the advantage of combining note taking with photography. However, at some point the tape must be transcribed into a written document.

Quick Review

- Physical evidence includes any and all objects that can establish that a crime has been committed or can link the crime and its victim or its perpetrator.
- Forensic science begins at the crime scene, where investigators must recognize and properly preserve evidence for laboratory examination.
- The first officer to arrive must secure the crime scene.
- Investigators record the crime scene by using photographs, sketches, and notes and make a preliminary examination of the scene as the perpetrator left it.

Dealing with Physical Evidence

After the lead detective has conducted a preliminary walk-through, a more thorough search for physical evidence begins. Once found, physical evidence must be collected and stored in a way that preserves its integrity for forensic comparison and analysis. As a result, law enforcement officials have developed specific procedures for finding, collecting, and transporting physical evidence that preserve its evidentiary value.

Conduct a Systematic Search for Evidence

The search for physical evidence at a crime scene must be thorough and systematic. For a factual, unbiased reconstruction of the crime, the investigator, relying on his or her training and experience, must not overlook any pertinent evidence. Even when suspects are immediately seized and the motives and circumstances of the crime are readily apparent, a thorough search for physical evidence must be conducted at once. Failure in this, even though it may seem unnecessary, can lead to accusations of negligence or charges that the investigative agency knowingly "covered up" evidence that would be detrimental to its case.

The investigator in charge assigns the personnel responsible for searching a crime scene. Except in major crimes, or when the evidence is complex, a forensic scientist is usually not needed at the crime scene; his or her role appropriately begins when evidence is submitted to the crime laboratory. As has already been observed, some police agencies have trained field evidence technicians to search for physical evidence at the crime scene. They have the equipment and skill to photograph the scene and examine it for the presence of fingerprints, footprints, tool marks, or any other type of evidence that may be relevant to the crime.

Considerations in Searching the Crime Scene How one conducts a crime-scene search will depend on the locale and size of the area, as well as on the actions of the suspect(s) and victim(s) at the scene. When possible, one person should supervise and coordinate the collection of evidence. Without proper control, the search may be conducted in an atmosphere of confusion with needless duplication of effort. Evidence collectors may subdivide the scene into segments and search each segment individually, or the search may start at some outer point and gradually move toward the center of the scene in a circular fashion (see Figure 2-7). The areas searched must include all probable points of entry and exit used by the criminals.

What to search for will be determined by the particular circumstances of the crime. Obviously, the skill of crime-scene investigators at recognizing evidence and searching relevant locations is paramount to successful processing of the crime scene. Although training will impart general knowledge for conducting a proper crime-scene investigation, ultimately the investigator must rely on the experience gained from numerous investigations to formulate a successful strategy for recovering relevant physical evidence at crime scenes. For example, in

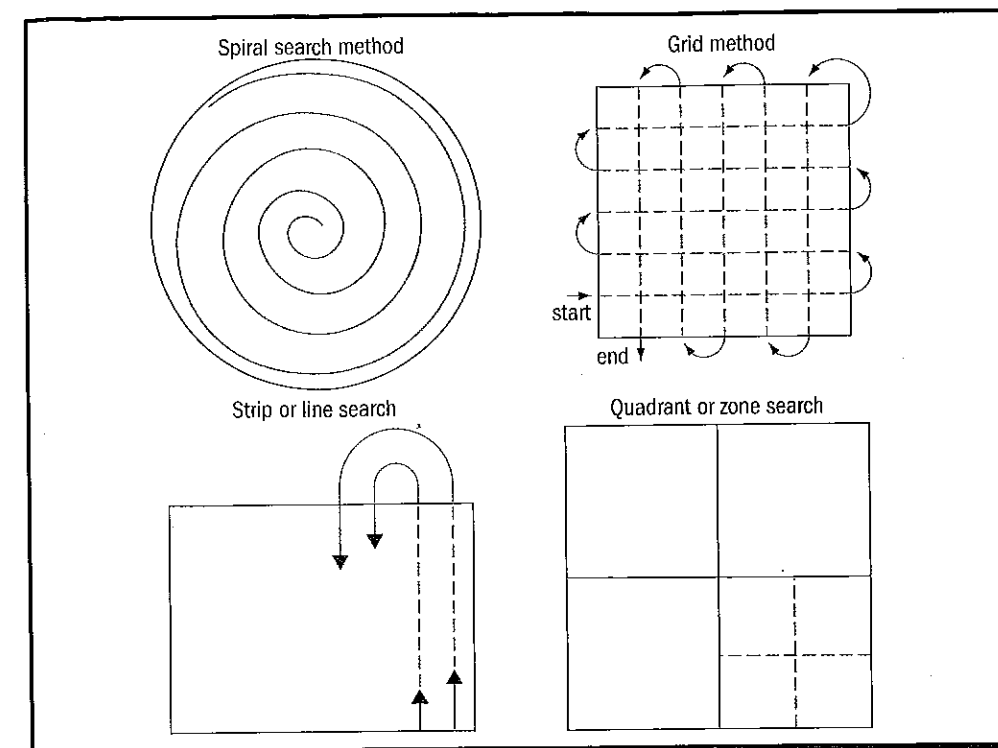


FIGURE 2-7 Several typical examples of crime-scene search patterns. The pattern selected normally depends on the size and locale of the scene and the number of collectors participating in the search.

a homicide case, the search will center on the weapon and any type of evidence left as a result of contact between the victim and the assailant. The cross-transfer of evidence, such as hairs, fibers, and blood, between individuals involved in the crime is particularly useful for linking suspects to the crime scene and for corroborating events that transpired during the commission of the crime. During the investigation of a burglary, efforts will be made to locate tool marks at the point of entry. In most crimes, a thorough and systematic search for latent fingerprints is required.

Vehicle searches must be carefully planned and systematically carried out. The nature of the case determines how detailed the search must be. In hit-and-run cases, the outside and undercarriage of the car must be examined with care. Particular attention is paid to looking for any evidence resulting from a cross-transfer of evidence between the car and the victim—including blood, tissue, hair, fibers, and fabric impressions. Traces of paint or broken glass may be located on the victim. In cases of homicide, burglary, kidnapping, and so on, all areas of the vehicle, inside and outside, are searched with equal care for physical evidence.

Collect Physical Evidence

Physical evidence can be anything from massive objects to microscopic traces. Often, many items of evidence are obvious in their presence, but others may be detected only through examination in the crime laboratory. For example, minute traces of blood may be discovered on garments only after a thorough search in the laboratory; the presence of hairs and fibers may be revealed in vacuum sweepings or on garments only after close laboratory scrutiny. For this reason, it is important

to collect possible carriers of trace evidence in addition to more discernible items. Hence, it may be necessary to take custody of all clothing worn by the participants in a crime. Each clothing item should be handled carefully and wrapped separately to avoid loss of trace materials.

Critical areas of the crime scene should be vacuumed and the sweepings submitted to the laboratory for analysis. The sweepings from different areas must be collected and packaged separately. A portable vacuum cleaner equipped with a special filter attachment is suitable for this purpose (see Figure 2-8). Additionally, fingernail scrapings from individuals who were in contact with other individuals may contain minute fragments of evidence capable of linking the assailant and victim. The undersurface of each nail is best scraped with a dull object such as a toothpick to avoid cutting the skin. These scrapings will be subjected to microscopic examination in the laboratory.

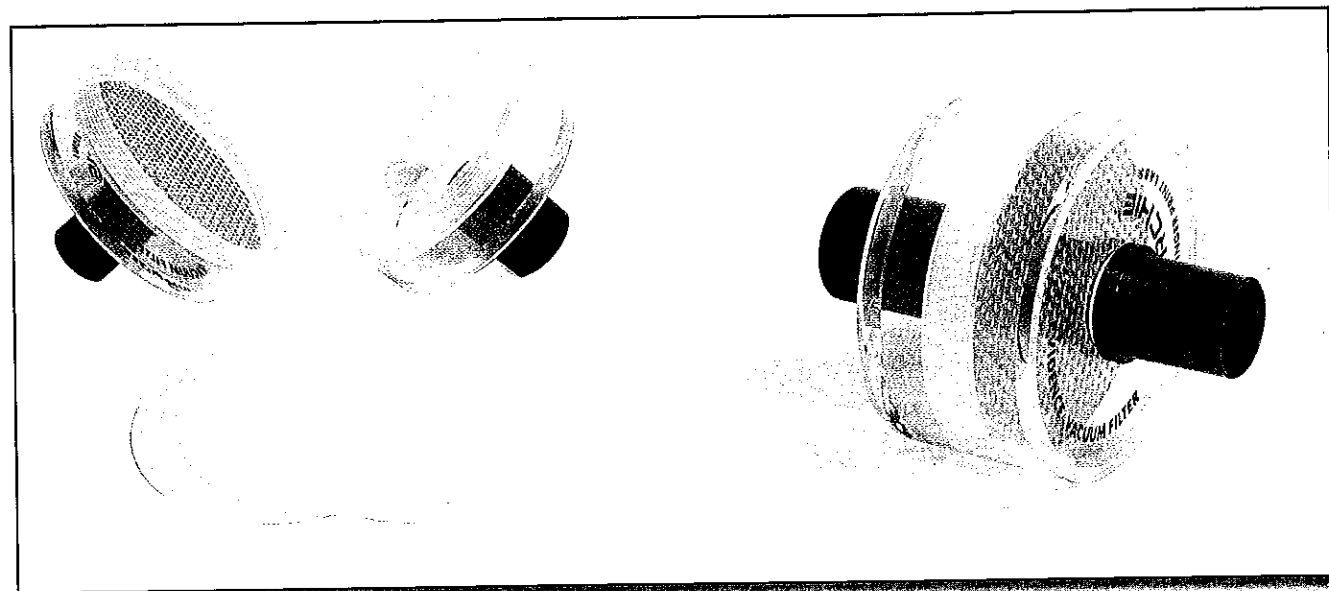


FIGURE 2-8 Vacuum sweeper attachment, constructed of clear plastic in two pieces that are joined by a threaded joint. A metal screen is mounted in one half to support a filter paper to collect debris. The unit attaches to the hose of the vacuum sweeper. After a designated area of the crime scene is vacuumed, the filter paper is removed and retained for laboratory examination. Courtesy Imaging Forensics, Fountain Valley, Calif., www.imagingforensics.com

The search for physical evidence must extend beyond the crime scene to the autopsy room of a deceased victim. Here, the medical examiner or coroner carefully examines the victim to establish a cause and manner of death. Tissues and organs are retained for pathological and toxicological examination. At the same time, arrangements must be made between the examiner and investigator to secure a variety of items that may be obtainable from the body for laboratory examination. The following are to be collected and sent to the forensic laboratory:

1. Victim's clothing
2. Fingernail scrapings
3. Head and pubic hairs
4. Blood (for DNA typing)

5. Vaginal, anal, and oral swabs (in sex-related crimes)

6. Recovered bullets from the body

7. Hand swabs from shooting victims (for gunshot residue analysis)

Once the body is buried, efforts at obtaining these items may prove difficult or futile. Furthermore, a lengthy delay in obtaining many of these items will diminish or destroy their forensic value.

Many police departments have recently purchased and equipped "mobile crime laboratories" (see Figure 2-9) for their evidence technicians. However, the term mobile crime laboratory is a misnomer. These vehicles carry the necessary supplies to protect the crime scene; photograph, collect, and package physical evidence; and develop latent prints. They are not designed to carry out the functions of a chemical laboratory. Crime-scene search vehicle would be a more appropriate but perhaps less dramatic name for such a vehicle.

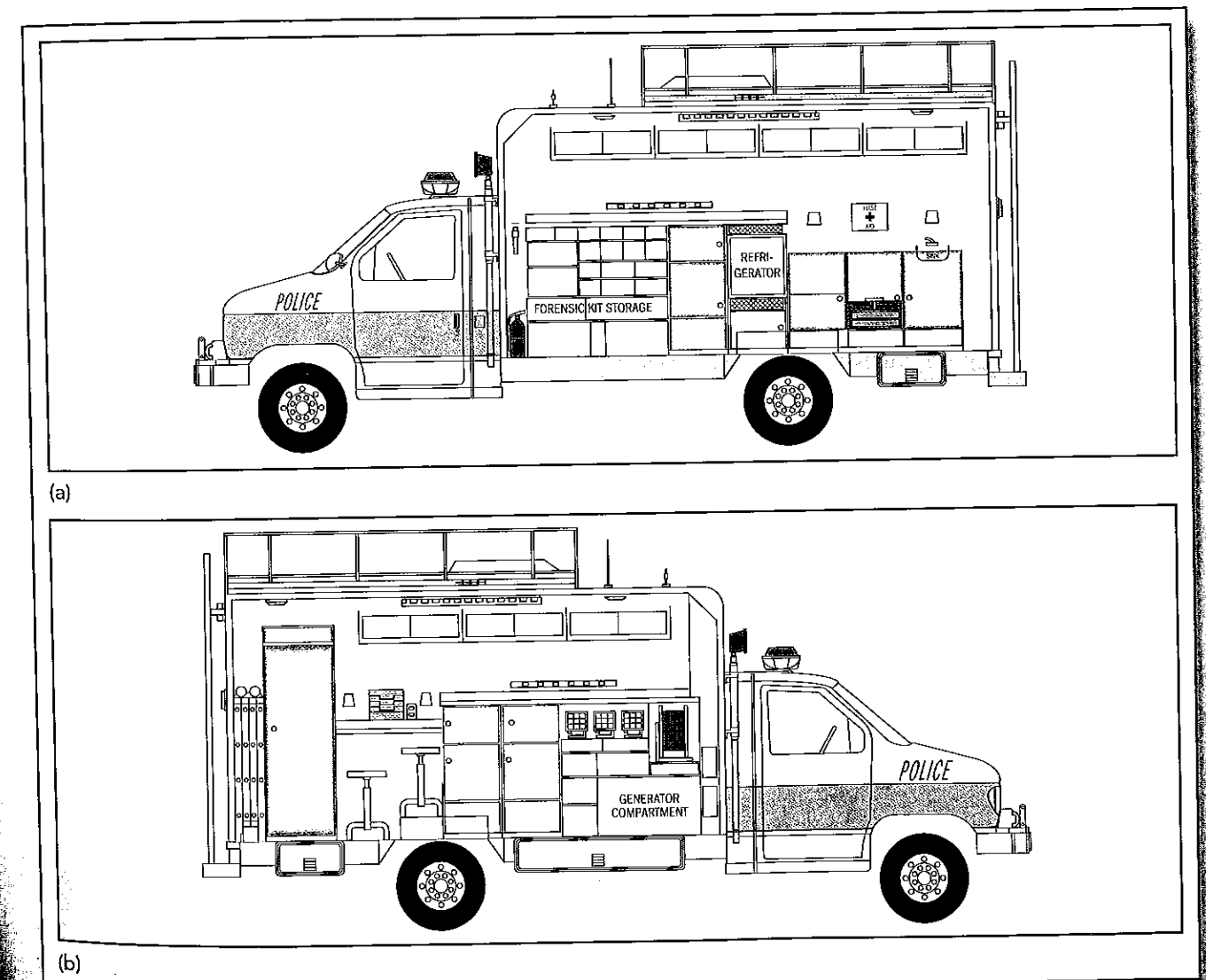


FIGURE 2-9 Inside view of a mobile crime-scene van: (a) driver's side and (b) passenger's side. Courtesy Imaging Forensics, Fountain Valley, Calif., www.imagingforensics.com

Procedures for Collecting and Packaging Physical Evidence Physical evidence must be handled and processed in a way that prevents any change from taking place between the time it is removed from the crime scene and the time it is received by the crime laboratory. Changes can arise through contamination, breakage, evaporation, accidental scratching or bending, or improper or careless packaging.

The integrity of evidence is best maintained when the item is kept in its original condition as found at the crime site. Whenever possible, evidence should be submitted to the laboratory intact. Blood, hairs, fibers, soil particles, and other types of trace evidence should not normally be removed from garments, weapons, or other articles that bear them. Instead, the entire object should be sent to the laboratory for processing.

Of course, if evidence is adhering to an object in a precarious manner, good judgment dictates removing and packaging the item. If evidence is found adhering to a large structure, such as a door, wall, or floor, common sense must be used; remove the specimen with a forceps or other appropriate tool. In the case of a bloodstain, one may either scrape the stain off the surface, transfer the stain to a moistened swab, or cut out the area of the object bearing the stain.

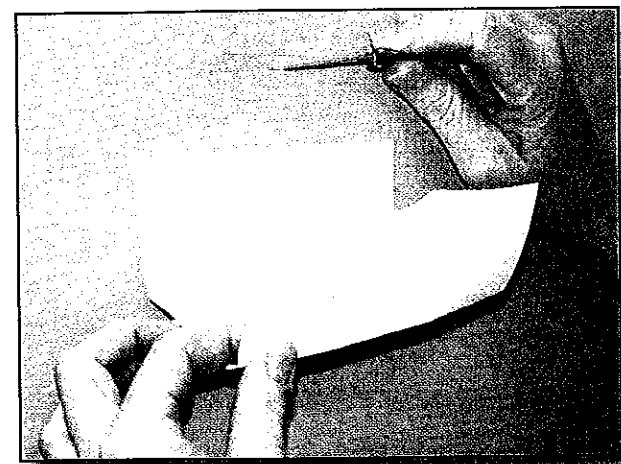
Each different item or similar items collected at different locations must be placed in separate containers. Packaging evidence separately prevents damage through contact and prevents cross-contamination.

Tools for Evidence Collection The well-prepared evidence collector arrives at a crime scene with a large assortment of packaging materials and tools, ready to encounter any type of situation. Forceps and similar tools may be used to pick up small items. Unbreakable plastic pill bottles with pressure lids are excellent containers for hairs, glass, fibers, and various other kinds of small or trace evidence. Alternatively, manila envelopes, screw-cap glass vials, or cardboard pillboxes are adequate containers for most trace evidence encountered at crime sites. Ordinary mailing envelopes should not be used as evidence containers because powders and fine particles will leak out of their corners.

Small amounts of trace evidence can also be conveniently packaged in a carefully folded paper, using what is known as a "druggist fold." This consists of folding one end of the paper over one-third, then folding the other end (one-third)

FIGURE 2-10

A druggist fold is used to package paint transfer evidence. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com



over that, and repeating the process from the other two sides. After the paper is folded in this manner, the outside two edges are tucked into each other to produce a closed container that keeps the specimen from falling out (see Figure 2-10).

Although manila envelopes, pillboxes, or sealable plastic bags (see Figure 2-11) are good universal containers for most trace evidence, two frequent finds at crime scenes warrant special attention. If bloodstained materials are stored in airtight containers, the accumulation of moisture may encourage the growth of mold, which can destroy the evidential value of blood. In these instances, wrapping paper, manila envelopes, or paper bags are recommended packaging materials (see Figure 2-12). All items of clothing must be air-dried and placed individually in separate paper bags to ensure constant circulation of air through them. This will prevent the formation of mold and mildew. On the other hand, charred debris recovered from the scene of a suspicious fire must be sealed in an airtight container to prevent the evaporation of volatile petroleum residues. New paint cans or tightly sealed jars are recommended in such situations (see Figure 2-13).

A detailed description of the proper collection and packaging of various types of physical evidence will be discussed in forthcoming chapters; additionally, most of this information is summarized in the evidence guide found in the Appendix.

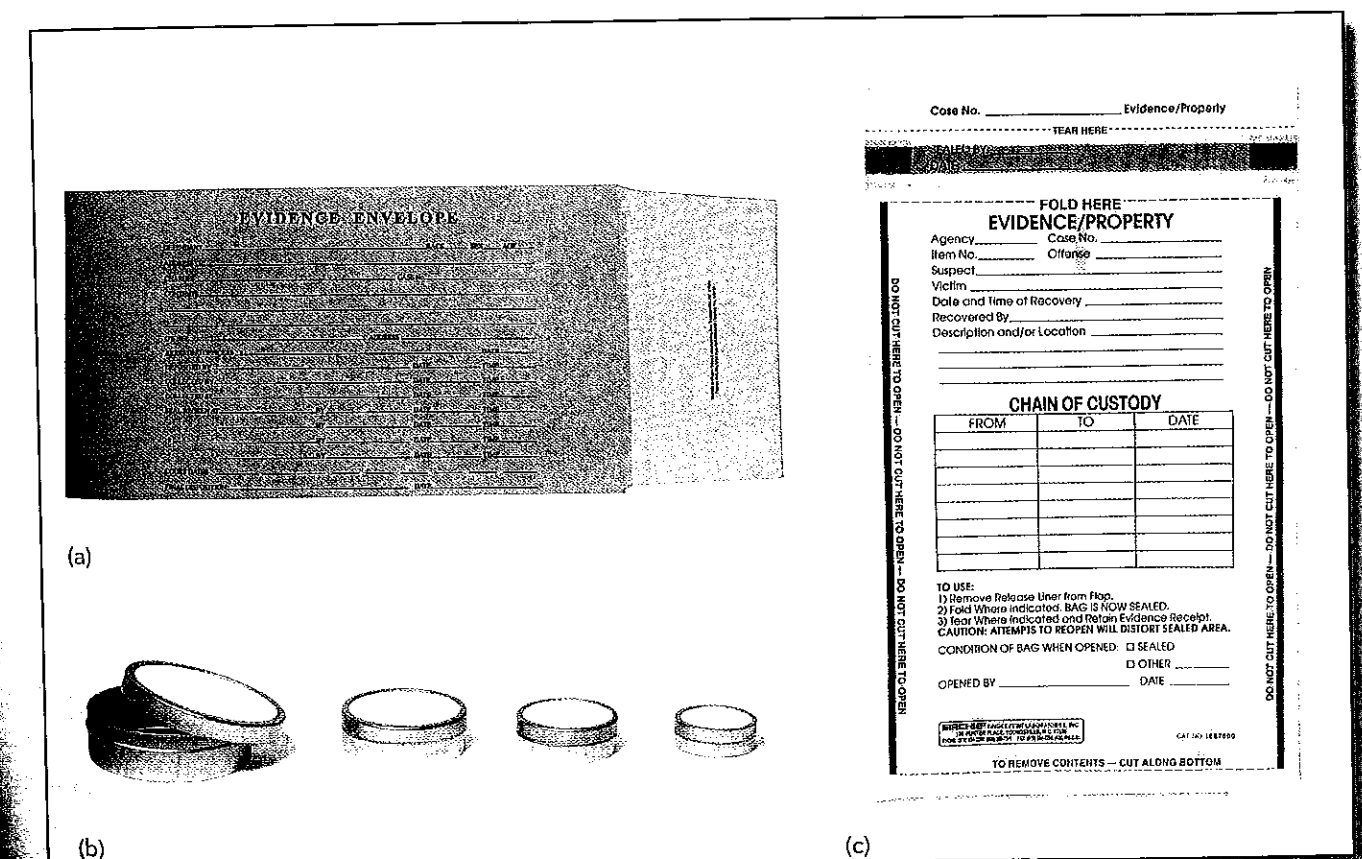


FIGURE 2-11 (a) Manila evidence envelope, (b) metal pillboxes, (c) sealable plastic evidence bag. Courtesy Imaging Forensics, Fountain Valley, Calif., www.imagingforensics.com

FIGURE 2-12

Paper bags are recommended evidence containers for objects suspected of containing blood and semen stains. Each object should be packaged in a separate bag. Courtesy Imaging Forensics, Fountain Valley, Calif., www.imagingforensics.com

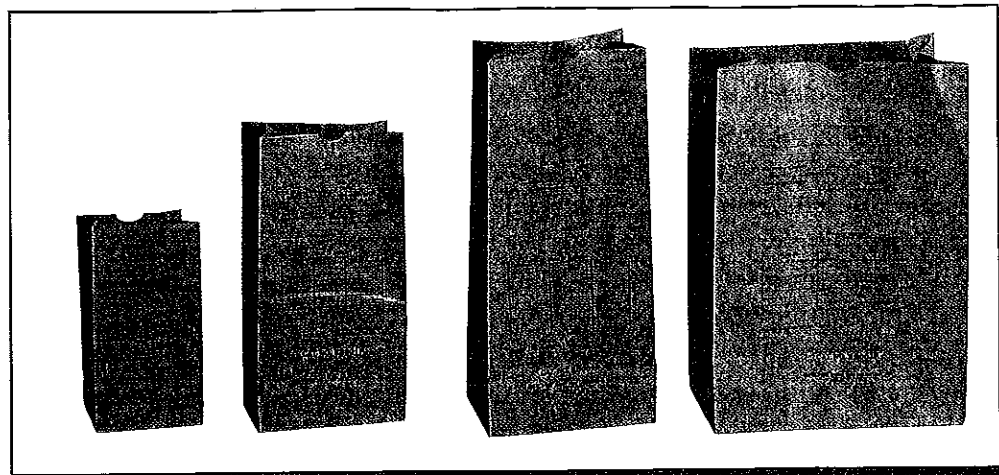


FIGURE 2-13

Air-tight metal cans used to package arson evidence. Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com



Maintain the Chain of Custody

chain of custody

A list of all people who came into possession of an item of evidence

Continuity of possession, or the **chain of custody**, must be established whenever evidence is presented in court as an exhibit. This means that every person who handled or examined the evidence must be accounted for. Failure to substantiate the evidence's chain of custody may lead to serious questions regarding the authenticity and integrity of the evidence and the examinations of it. Adhering to standard procedures in recording the location of evidence, marking it for identification, and properly completing evidence submission forms for laboratory analysis is the best guarantee that the evidence will withstand inquiries of what happened to it from the time of its finding to its presentation in court.

All items of physical evidence should be carefully packaged and marked upon their retrieval at crime sites. This should be done with the utmost care to avoid destroying their evidential value or restricting the number and kind of examina-

tions to which the criminalist may subject them. If possible, the evidence itself should be marked for identification. Normally, the collector's initials and the date of collection are inscribed directly on the article. However, if the evidence collector is unsure of the necessity of marking the item itself, or of where to mark it, it is best to omit this step. Where appropriate, the evidence is to be tagged for identification.

Once an evidence container is selected for the evidence, whether a box, bag, vial, or can, it also must be marked for identification. A minimum record would show the collector's initials, location of the evidence, and date of collection. If the evidence is turned over to another individual for care or delivery to the laboratory, this transfer must be recorded in notes and other appropriate forms. In fact, every individual who possesses the evidence must maintain a written record of its acquisition and disposition. Frequently, all of the individuals involved in the collection and transportation of the evidence may be requested to testify in court. Thus, to avoid confusion and to retain complete control of the evidence at all times, the chain of custody should be kept to a minimum.

Obtain Standard/Reference Samples

The examination of evidence, whether soil, blood, glass, hair, fibers, and so on, often requires comparison with a known **standard/reference sample**. Although most investigators have little difficulty recognizing and collecting relevant crime-scene evidence, few seem aware of the necessity and importance of providing the crime lab with a thorough sampling of standard/reference materials. Such materials may be obtained from the victim, a suspect, or other known sources. For instance, investigation of a hit-and-run incident may require the removal of standard/reference paint from a suspect vehicle. This will permit its comparison to paint recovered at the scene.

The presence of standard/reference samples greatly facilitates the work of the forensic scientist. For example, hair found at a crime scene will be of optimum value only when compared to standard/reference hairs removed from the suspect and victim. Likewise, bloodstained evidence must be accompanied by a whole-blood or **buccal swab** standard/reference sample obtained from all relevant crime-scene participants. The quality and quantity of standard/reference specimens often determine the evidential value of crime-scene evidence, and these standard/reference specimens must be treated with equal care.

Some types of evidence must also be accompanied by the collection of **substrate controls**. These are materials close to areas where physical evidence has been deposited. For example, substrate controls are normally collected at arson scenes. If an investigator suspects that a particular surface has been exposed to gasoline or some other accelerant, the investigator should also collect a piece of the same surface material that is believed not to have been exposed to the accelerant. At the laboratory, the substrate control is tested to ensure that the surface on which the accelerant was deposited does not interfere with testing procedures. Another common example of a substrate control is a material on which a bloodstain has been deposited. Unstained areas close to the stain may be sampled to determine whether this material can interfere with the interpretation of laboratory results. Thorough collection and proper packaging of standard/reference specimens and substrate controls are the mark of a skilled investigator.

standard/reference sample

Physical evidence whose origin is known, such as blood or hair from a suspect, that can be compared to crime-scene evidence

buccal swab

A swab of the inner portion of the cheek, performed to collect cells for use in determining the DNA profile of an individual

substrate control

Uncontaminated surface material close to an area where physical evidence has been deposited; used to ensure that the surface on which a sample has been deposited does not interfere with laboratory tests

(Submitted by New Jersey State Police)

Evidence is usually submitted to the laboratory either by personal delivery or by mail shipment. The method of transmittal is determined by the distance the submitting agency must travel to the laboratory and the urgency of the case. If the evidence is delivered personally, the deliverer should be familiar with the case, to facilitate any discussions between laboratory personnel and the deliverer concerning specific aspects of the case.

If desired, most evidence can be conveniently shipped by mail. However, postal regulations restrict the shipment of certain chemicals and live ammunition and prohibit the mailing of explosives. In such situations, the laboratory must be consulted to determine the disposition of these substances. Care must also be exercised in the packaging of evidence in order to prevent breakage or other accidental destruction while it is in transit to the laboratory.

Most laboratories require that an evidence submission form accompany all evidence submitted (see Figure 2-14). This form must be properly completed. Its information will enable the laboratory analyst to make an intelligent and complete examination of the evidence. Particular attention should be paid to providing the laboratory with a brief description of the case history. This information

FIGURE 2-14
An example of a properly completed evidence submission form. Courtesy New Jersey State Police

CRIME: Homicide; Aggravated Sexual Assault				COUNTY OF: Mercer					
VICTIM:		Age	Sex	Race	SUSPECT:		Age	Sex	Race
Jane Doe (v)		25	F	C	John Doe(s)		30	M	C
SUBMITTING AGENCY: (Address) Trenton P.D. Central Evidence 225 N. Clinton Avenue, Trenton, N.J. 08609									
FORWARD REPLY TO: (Name) Capt. John Smith, Chief of Detectives				Same as above				Telephone Number: 609 555-5555	
INVESTIGATED BY: Detective John Jones					DELIVERED BY: (Signature of Person Delivering Evidence)				
BRIEF HISTORY OF CASE: (Include Date and Location, if Applicable) On March 1st, 2001 the victim was found dead in her bedroom. Victim was partially clothed and autopsy revealed that victim was stabbed numerous times and medical examiner stated that there was evidence of sexual assault. Victim was last seen drinking with suspect at a local tavern. Suspect was arrested and item # 23, a folding knife, was found in his pocket. * Note* Suspect is HIV+									
EXAMINATION REQUESTED ON SPECIMENS LISTED BELOW: Examine items 2, 5, 8-11, 13-15, 18 and 19 for seminal material and compare to controls #'s 12 and 26. Examine #1, 2, 4, 7, 13, 14, 15, 18, 20, 21, 22 and 23 for trace evidence transfer. Examine #3 for saliva from suspect. Examine #6 for skin, blood and trace evidence. Examine #'s 20-23 for transfer blood evidence and compare to control #'s 12 and 26.									
Item #	* Code	LIST OF SPECIMENS *SOURCE OF EVIDENCE CODE (V-Victim, S-Suspect, SC-Scene)							
1	V	Debris collection							
2	V	Clothing, white panties							
3	V	Dried Secretions/bite marks							
4	V	Head Hair Combing							
5	V	Oral Specimens							
6	V	Fingernail Specimens							
7	V	Pubic Hair Combing							
8	V	External Genital Specimen							
9	V	Vaginal Specimens							
10	V	Cervical Specimens							
FOR ADDITIONAL INFORMATION USE FORM 631A AND ATTACH									
Page 1 of 2 pages									

will allow the examiner to analyze the specimens in a logical sequence and make the proper comparisons, and it will also facilitate the search for trace quantities of evidence.

The particular kind of examination requested for each type of evidence should be delineated. However, the analyst will not be bound to adhere strictly to the specific tests requested by the investigator. During the examination new evidence may be uncovered, and as a result the complexity of the case may change. Furthermore, the analyst may find the initial requests incomplete or not totally relevant to the case. Finally, a list of items submitted for examination must be included on the evidence submission form. Each item is to be packaged separately and assigned a number or letter, which should be listed in an orderly and logical sequence on the form.

Quick Review

- The search pattern selected at a crime scene depends on the size and locale of the scene and the number of collectors participating in the search.
- Many items of evidence may be detected only through examination at the crime laboratory. For this reason, it is important to collect possible carriers of trace evidence, such as clothing, vacuum sweepings, and fingernail scrapings, in addition to more discernible items.
- Each item of physical evidence collected at a crime scene must be placed in a separate appropriate container to prevent damage through contact or cross-contamination.
- Investigators must maintain the chain of custody, a record for denoting the location of the evidence.
- Proper standard/reference samples, such as hairs, blood, and fibers, must be collected at the crime scene and from appropriate subjects for comparison purposes in the laboratory.

The Murder Scene: Death and Autopsies

Unfortunately, the most important piece of evidence at many crime scenes is the dead body of a victim. When foul play is suspected, a victim's corpse is subjected to the same kind of intense physical analysis as any other piece of evidence. This task falls primarily to a forensic pathologist, often aided by the skills of specialists including forensic anthropologists and forensic entomologists. In its broadest sense, forensic pathology involves the study of medicine as it relates to the application of the law, particularly criminal law. In practice, this most often involves the investigation of sudden, unnatural, unexplained, or violent deaths.

autopsy

The medical dissection and examination of a body in order to determine the cause of death

Typically, forensic pathologists, in their role as medical examiners or coroners, must answer several basic questions: Who is the victim? What injuries are present? When did the injuries occur? Why and how were the injuries produced? The primary role of the medical examiner is to determine the cause of death. If a cause cannot be found through observation, an **autopsy** is normally performed to establish the cause of death. The manner in which death occurred is classified into five categories: natural, homicide, suicide, accident, or undetermined, based on the circumstances surrounding the incident.

Frequently, medical examiners must perform autopsies if a death is deemed suspicious or unexplained. The cause of death may not always be what it seems at first glance. For example, a decedent with a gunshot wound and a gun in his hand may appear to have committed suicide. However, an autopsy may reveal that the victim actually died of suffocation and the gunshot wound occurred after death to cover up the circumstances surrounding the commission of a crime.

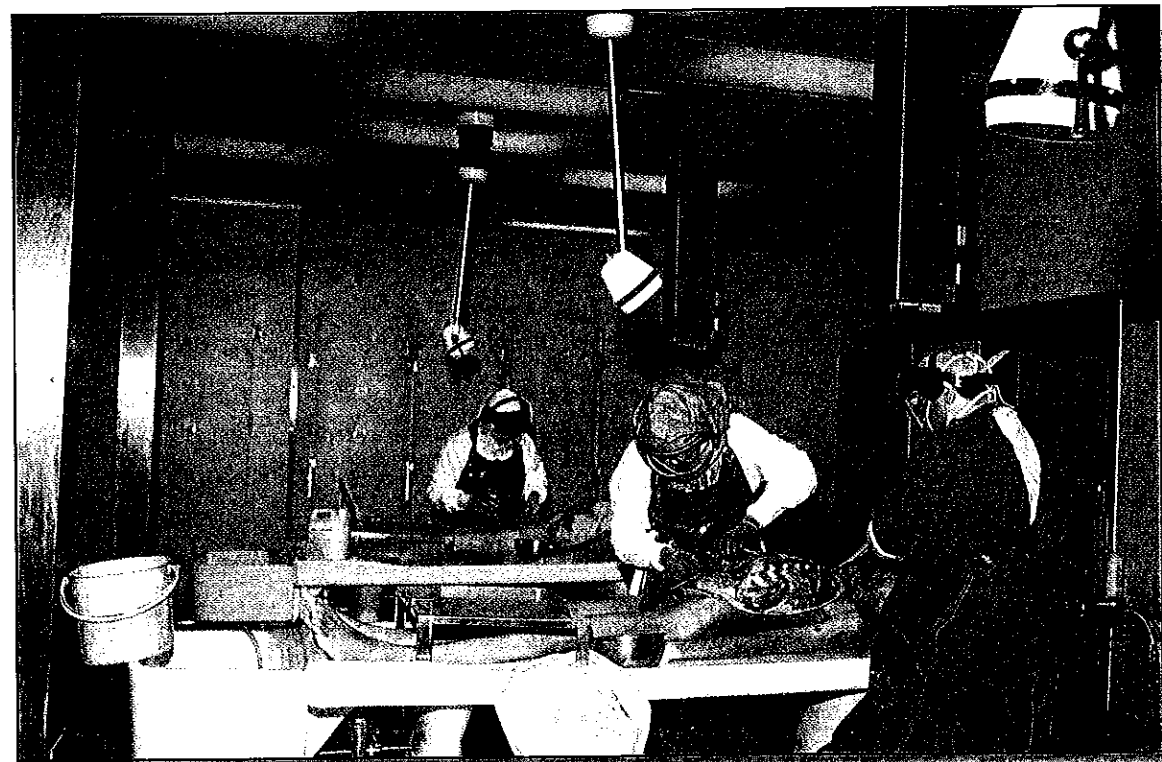


FIGURE 2-15 Medical examiners work on a dissected corpse laid on an examination table in a morgue. Courtesy Alamy Images

**MyCrimeKit:
WebExtra 2.2**

See How an Autopsy Is Performed
www.mycrimekit.com

After a human body expires, it goes through several stages of decomposition. A medical examiner can often estimate the time of death by evaluating the stage of decomposition in which the victim was found. Immediately following death, the muscles relax and then become rigid. This condition, **rigor mortis**, manifests itself within the first 24 hours and disappears within 36 hours.

Another condition occurring in the early stages of decomposition is **livor mortis**. When the human heart stops pumping, the blood begins to settle in the parts of the body closest to the ground. The skin appears dark blue or purple in these areas. The onset of this condition begins immediately and continues for up to 12 hours after death. The skin does not appear discolored in areas where the body is restricted by either clothing or an object pressing against the body. This information can be useful in determining whether the victim's position was changed after death.

Other physical and chemical changes within the body also help approximate the time of death. **Algor mortis** is the process by which the body temperature continually cools after death until it reaches the ambient or room temperature. The rate of heat loss is influenced by factors such as the location and size of the body, the victim's clothing, and weather conditions. Because of such factors, this method can only estimate the approximate time period since death. As a general rule, beginning about an hour after death, the body loses heat at a rate of approximately 1–1½°F per hour until the body reaches the environmental temperature.

Another approach helpful for estimating the time of death is to determine potassium levels in the ocular fluid (fluid within the eye, also known as the vitreous humor). After death, cells within the inner surface of the eyeball release potassium into the ocular fluid. By analyzing the amount of potassium present at various intervals after death, the forensic pathologist can determine the rate at which potassium is released into the vitreous humor and use it to approximate the time of death. During the autopsy, other factors may indicate the time period in which death occurred. For example, the amount of food in the stomach can help estimate when a person's last meal was eaten. This information can be valuable when investigating a death.

Role of the Forensic Anthropologist

Forensic anthropology is concerned primarily with the identification and examination of human skeletal remains. Skeletal bones are remarkably durable and undergo an extremely slow breakdown process that lasts decades or centuries. Because of their resistance to rapid decomposition, skeletal remains can provide a multitude of individual characteristics. An examination of bones may reveal their sex, approximate age, race, height, and physical injury.

Recovering and Processing Remains Thorough documentation is required throughout the processes of recovery and examination of human remains. The sites where human remains are found must be treated as a crime scene (see [Figure 2-16](#)). These sites are usually located by civilians who then contact law enforcement personnel. The scene should be secured as soon as possible to prevent any further alteration of the scene. The scene should then be searched to locate all bones if they are scattered or other aspects of evidence such as footwear impressions or discarded items. Some tools can be useful in the search for evidence at a "tomb" site, including aerial photography, metal detectors, ground-penetrating radar, infrared photography, apparatuses that detect the gases produced by biological decomposition, and so-called cadaver dogs that detect the odors caused by biological decomposition. All items that are found must be tagged,

rigor mortis

A medical condition that occurs after death and results in the stiffening of muscle mass; the rigidity of the body begins within 24 hours of death and disappears within 36 hours of death

livor mortis

A medical condition that occurs after death and results in the settling of blood in areas of the body closest to the ground

algor mortis

A process that occurs after death in which the body temperature continually cools until it reaches the ambient or room temperature

photographed, sketched, and documented in notes. Once all bones and other evidence are found, a scene sketch should be made to show the exact location of each item (preferably using Global Positioning System [GPS] coordinates) and the spatial relationship of all evidence. Once the skeletal remains have been recovered, they can be examined to deduce information about the identity of the decedent.

FIGURE 2-16
Crime-scene site showing a pelvis partly buried in sand and a femur lying across a pistol. Courtesy Paul Sledzik/National Transportation Safety Board.



Determining Victim Characteristics The gender of the decedent can be determined by the size and shape of various skeletal features, especially those in the pelvis and skull or cranium. Female pelvic bones tend to show a wider, more circular opening than that of a male pelvis because of a woman's child-bearing capabilities. The female sacrum (flat bone above the tailbone) is wider and shorter (see Figure 2-17[a]); the length and width of the male sacrum are roughly equal (see Figure 2-17[b]). The angle formed at the bottom of the pelvis (subpubic angle) is approximately a right angle (90 degrees) in females and acute (less than 90 degrees) in males. In general, male craniums are larger in overall size than those of females. A male cranium tends to have a more pronounced brow bone and mastoid process (a bony protrusion behind the jaw) than a female cranium (see Figure 2-18). See Table 2-1 for a summary of the differing features of female and male skeletons from head to toe. These are typical cases; not all skeletons may display the given characteristics to indicate the gender of the decedent.

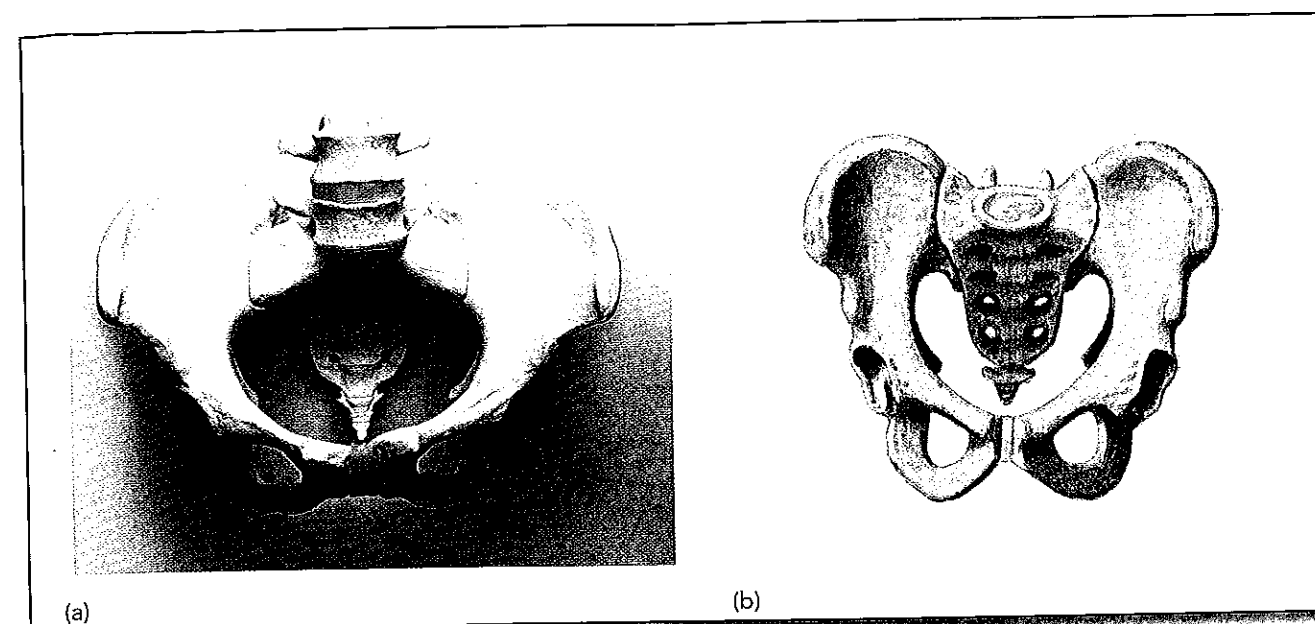


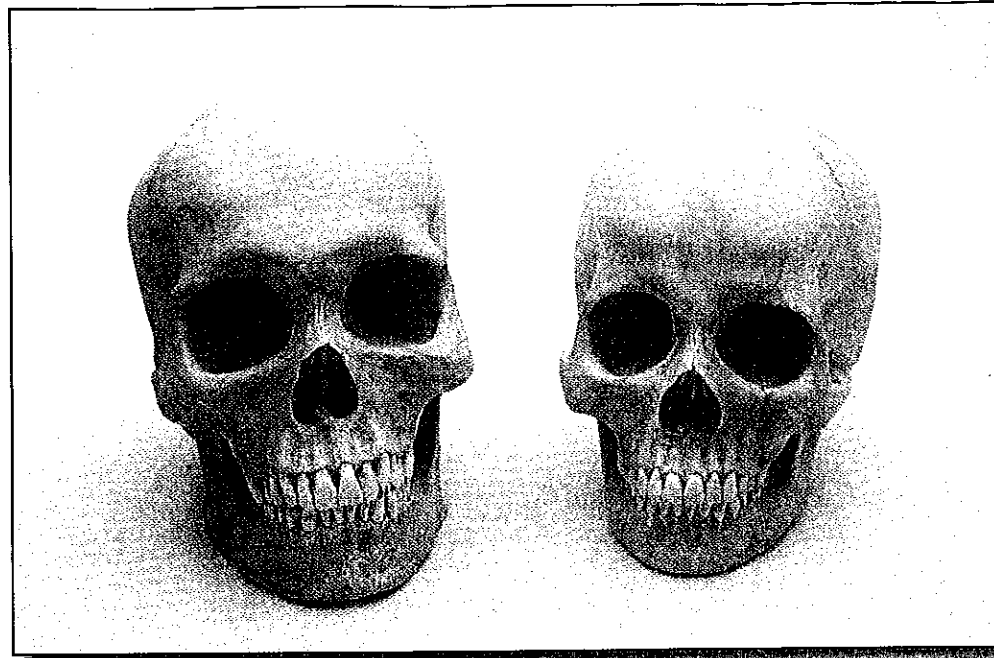
FIGURE 2-17 (a) Frontal shot of female pelvis and hips. This view shows the wide, circular nature of the pelvic opening and the short, wide nature of the sacrum. (b) Human male pelvis. This view shows the narrow pelvic opening and long, narrow sacrum. Courtesy of Dorling Kindersley Media Library

Table 2-1
Summary of Skeletal Features by Gender

	Female	Male
Cranium (skull)	Medium to large in size	Large in size
Forehead	High in height, vaulted, rounded	Low in height, sloped backward
Brow bone	Diminished	Pronounced
Mastoid process	Diminished or absent	Pronounced
Mandible (jaw) Angle	Obtuse (>90 degrees)	Approximately right (90 degrees)
Pelvis opening	Wide, circular	Narrow, noncircular
Sacrum	Short, wide, turned outward	Approximately equal width/length, turned inward
Subpubic angle	Approximately right (90 degrees)	Acute (<90 degrees)
Femur	Narrow, angled inward from pelvis	Thick, relatively straight from pelvis
Overall skeleton	Slender	Robust

FIGURE 2-18

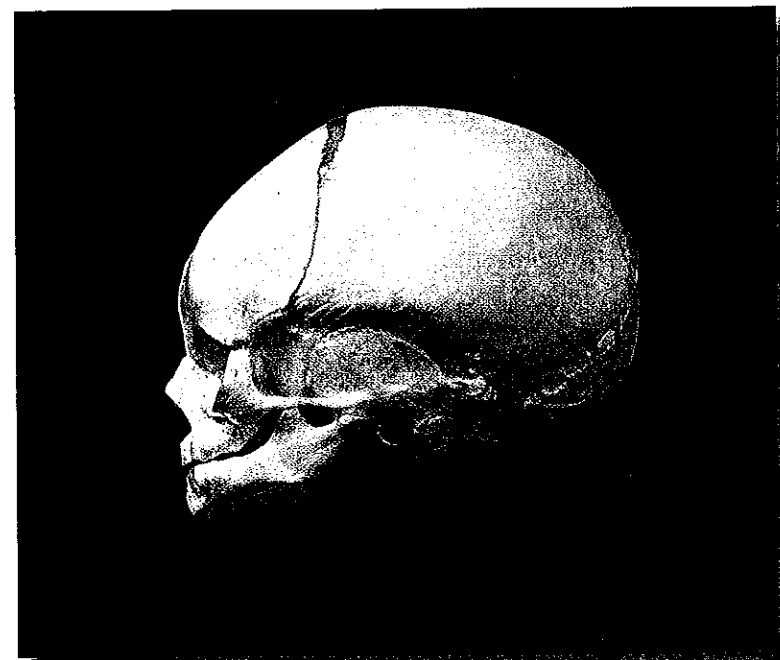
Male (left) and female (right) human skulls showing male skull's larger size and more pronounced brow bone. Courtesy Corbis



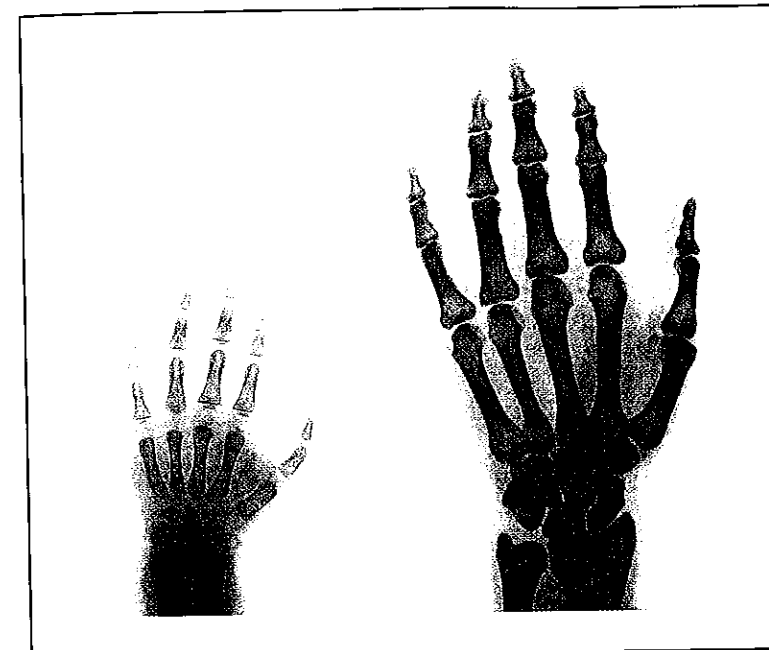
The method for determining the age of a decedent varies depending on the victim's growth stage. For infants and toddlers, age can be estimated by the length of the long bones (femur and humerus) when compared to a known growth curve. Different sections of the skull also fuse together at different stages during early development, and the appearance of fused or divided sections can be used to estimate the age of bones still in early developmental stages (see [Figure 2-19](#)). In infant skeletons, formation of teeth can be used in age determination. This is based on the fact that permanent teeth start to form at birth. If the skeletal remains belong to a child, the age of the decedent may be determined by observing the fusion or lack of fusion of epiphyseal regions of bones such as

FIGURE 2-19

A lateral view of a fetal skull showing the separated bones of the skull before they have had a chance to fuse. Courtesy Ralph T. Hutchings



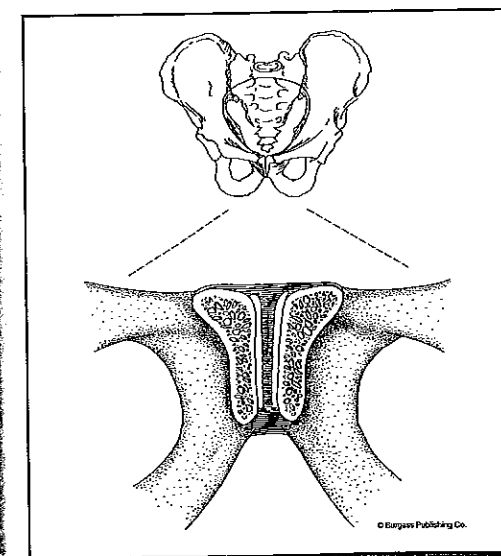
those of the mandible (lower jaw), fingers, wrist, long bones, and clavicle (see [Figure 2-20](#)). The average age at which each of these regions fuses is known and can be compared against the state of the remains to provide a range of possible ages for the decedent. A child's cranium may also be identified by the smaller size and the presence of developing teeth (see [Figure 2-21](#)). After age 21, age is estimated by the level of change experienced by the surfaces of the bones, especially in areas of common wear such as the pubic symphysis. The pubic symphyseal face shown in [Figure 2-22](#) is a raised platform that slowly changes over the years from a rough, rugged surface to a smooth, well-defined area. See [Table 2-2](#) for a summary of the skeletal closures by age. It is important to note that these are average ages for closures; not all skeletons display closures at the given ages.

**FIGURE 2-20**

Colored X-rays of healthy human hands at 3 years (left) and at 20 years. Bones are red with flesh blue. The child's hand has areas of cartilage in the joints between the finger bones (epiphyseal areas), where bone growth and fusion will occur. In the adult hand, all the bones are present and the joints have closed. Courtesy Photo Researchers Inc.

**FIGURE 2-21**

The skull of a young child, with part of the jaw cut away to show the developing teeth. Courtesy Ralph T. Hutchings

**FIGURE 2-22**

The symphysis pubis shown magnified beneath human pelvic bones. Courtesy Pearson Education Custom Publishing

Table 2-2
Summary of Skeletal Closures by Age

Age (months)	Closure
6-9	Mandible (jaw) fused
4-6	Humerus head bones fused
7-8	Pelvis frontal bones fused
4-16	Femur shaft sections built
9-13	Elbow bones fused
10	Finger bones fused
16-18	Femur head bones fused to shaft bones
18	Wrist bones fused
18-21	Humerus head bones fused to shaft bones
18-24	Sternum fused to clavicle
20-25	Pelvic bones fully formed
21-22	Clavicle fused
21-30	Labodial suture (rear of cranium) fused
24-30	Sacrum bones fused
30-32	Sagittal suture (center of cranium) fused
48-50	Coronal suture (front of cranium) fused

Although the categorization of "race" has come under scrutiny and is hard to define, forensic anthropologists use broad classes to characterize the likely (but not definite) ancestry of skeletal remains. The possible racial ancestry of the decedent can be assessed by the appearance of various cranial features on the skeletal remains. For example, eye orbits tend to be circular in Mongoloid skeletons (Asian descent), oval in Caucasoid skeletons (European descent), and square in Negroid skeletons (African descent). The frontal plane of the cranium may also vary. The frontal plane of Mongoloid craniums may be flat or projected outward, that of Caucasoid craniums is flat, and that of Negroid craniums is projected outward. The nasal cavity tends to be small and rounded in Mongoloids, long and narrow in Caucasoids, and wide in Negroids. Skeletal remains of Asian ancestry, including those of Native American descent, also tend to have "scooped-out" or shovel-shaped incisor teeth. See [Table 2-3](#) for a summary of the differing features of skeletons that can indicate ancestry. These are typical cases; not all skeletons may display the given characteristics to indicate the ancestry of the decedent.

Table 2-3
Summary of Skeletal Characteristics Indicating Racial Ancestry

	Eye Orbitals	Nasal Cavity	Incisors	Cranium Frontal Plane
Caucasoid	Oval	Long, narrow	Smooth	Flat
Mongoloid	Circular	Small, rounded	Shoveled interior	Flat or projected outward
Negroid	Square	Wide	Smooth	Projected outward

The height of the victim when alive can be estimated by measuring the long bones of the skeleton, especially in the lower limbs. Even partial bones can yield useful results. However, meaningful stature calculations from known equations must be based on the determined sex and race of the remains. See [Table 2-4](#) for example equations used to calculate the height of the decedent from skeletal remains. These equations should yield estimations within 5 cm of actual height.

Table 2-4
Equations for Height Calculation from Skeletal Remains

	Caucasoid	Negroid	Unknown Ancestry
Female	Height (cm) = femur length (cm) \times 2.47 + 54.10	Height (cm) = femur length (cm) \times 2.28 + 59.76	Height (cm) = femur length (cm) \times 3.01 + 32.52
	Height (cm) = humerus length (cm) \times 3.36 + 57.97	Height (cm) = humerus length (cm) \times 3.08 + 64.67	Height (cm) = humerus length (cm) \times 4.62 + 19.00
Male	Height (cm) = femur length (cm) \times 2.32 + 65.53	Height (cm) = femur length (cm) \times 2.10 + 72.22	Height (cm) = femur length (cm) \times 2.71 + 45.86
	Height (cm) = humerus length (cm) \times 2.89 + 78.10	Height (cm) = humerus length (cm) \times 2.88 + 75.48	Height (cm) = humerus length (cm) \times 4.62 + 19.00

Case Files

Identifying a Serial Killer's Victims



John Wayne Gacy. Courtesy © Bettmann/CORBIS.
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The worst serial killer in America calmly admitted his guilt as he led investigators to a crawl space under his house. There, John Wayne Gacy had buried 28 young men, after brutally raping and murdering them in cold blood. Because no identification was found with the bodies, the police were forced to examine missing-person reports for leads. However, these boys and men were so alike in age, race, and stature that police were unable to make individual identifications for most of the victims. Clyde Snow, the world-renowned forensic anthropologist from Oklahoma, was asked to help the investigators make these difficult identifications.

Snow began by making a 35-point examination of each skull for comparison to known individuals. By examining each skeleton, he made sure each bone was correctly attributed to an individual. This was crucial to later efforts because some of the victims had been buried on top of older graves, mingling their remains. Once Snow was sure all the bones were sorted properly, he began his in-depth study. Long bones such as the femur (thigh bone) were used to estimate each individual's height. This helped narrow the search when attempting to match the victims with the descriptions of missing people.

After narrowing the possibilities to missing people fitting the general description, investigators consulted potential victims' hospital and dental records. Evidence of injury, illness, surgery, or other unique skeletal defects were used to make identifications. Snow also pointed out features that gave clues to the victim's behavior and medical history. For example, he discovered that one of Gacy's victims had an old fracture of his left arm, and that his left scapula (shoulder blade) and arm bore the telltale signs of a left-handed individual. These details were matched to a missing-person report, and another young victim was identified.

For the most difficult cases, Snow called in the help of forensic sculptor and facial reconstructionist Betty Pat Gatliff. She used clay and depth markers to put the flesh back on the faces of these forgotten boys in the hopes that someone would recognize them after their photographs were released to the media. Her efforts were successful, but investigators found some families unwilling to accept the idea that their loved ones were among Gacy's victims. Even with Gatliff's help, nine of Gacy's victims remain unidentified.

Other Contributions of Forensic Anthropology A forensic anthropologist may also create facial reconstructions to help identify skeletal remains. Facial reconstruction uses the victim's actual cranium and takes into account the estimated age, ancestry, and gender (see [Figure 2-23](#)). With the help of this technique, a composite of the victim can be drawn and advertised in an attempt to identify the victim.

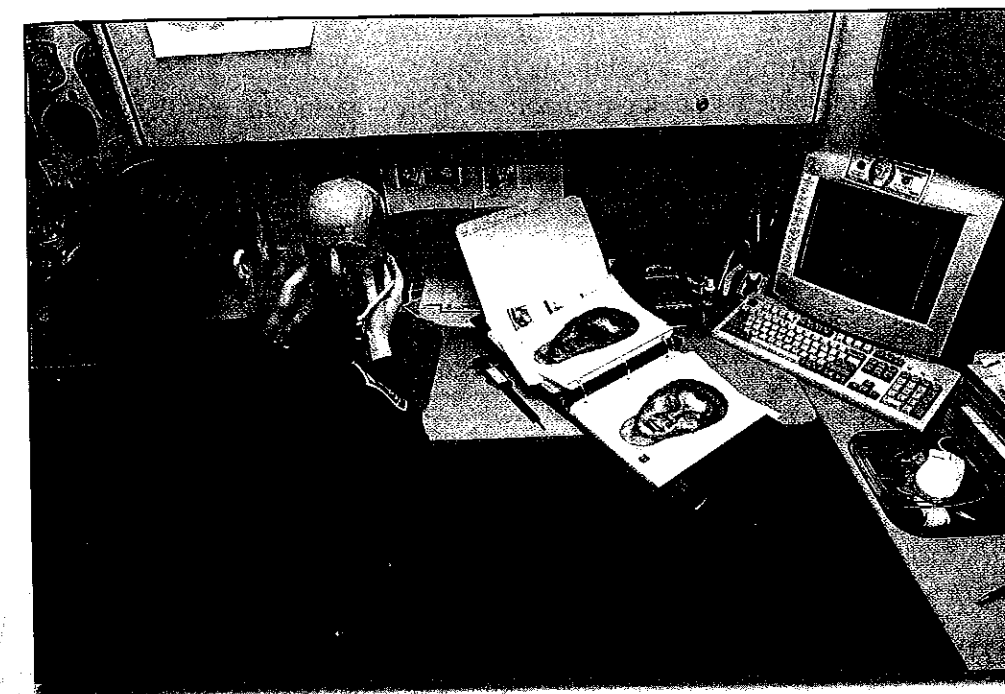


FIGURE 2-23
Trooper Sarah Foster, a Michigan State Police forensic artist, works on a three-dimensional facial reconstruction from an unidentified human skull at Richmond post in Richmond, MI. Courtesy AP World Wide Photos

Forensic anthropologists are also helpful in identifying victims of a mass disaster such as a plane crash. When such a tragedy occurs, forensic anthropologists can help identify victims through the collection of bone fragments. Definite identification of remains can be made only by analyzing the decedent's DNA profile, fingerprints, or medical records. Recovered remains may still contain some soft tissue material, which may yield a DNA profile for identification purposes. Sometimes the tissue of the hand is still present, though dried out. It may be possible to rehydrate the tissue to recover fingerprints. However, usually the identification of the remains will depend on medical records, especially dental records of the individual.

Role of the Forensic Entomologist

The study of insects and their relation to a criminal investigation is known as forensic entomology. Such a practice is commonly used to estimate the time of death when the circumstances surrounding the crime are unknown. This determination can be carried out by studying the stage of development of maggots or insect sequence of arrival.

Determining Time of Death After decomposition begins, necrophilous insects, or insects that feed on dead tissue, are the first to infest the body, usually within 24 hours. The most common and important of these is the blowfly rec-

ognized by its green or blue color. Blowfly eggs are laid in human remains and ultimately hatch into maggots, or fly larvae, which consume human organs and tissues (see Figure 2-24). Typically, a single blowfly can lay up to 2,000 eggs during its lifetime. The resulting larvae gather and feed as a "maggot mass" on the decomposing remains. Forensic entomologists can approximate how long a body has been left exposed by examining the stage of development of the fly larvae. This kind of determination is best for a timeline of hours to approximately one month, because the blowfly goes through the stages of its life cycle at known time intervals and sequence. By determining the most developed stage of fly found on the body, entomologists can approximate the postmortem interval (PMI), or the time that has elapsed since death (see Figure 2-25). Newly emerged flies are of important forensic interest, as they indicate that an entire blowfly cycle has been completed on the decomposing body. Likewise, empty pupal cases indicate that a fly has completed its entire life cycle on the body. Flies known as cheese skippers are primarily found on human corpses in the later stages of decomposition long after the blowflies have left the corpse.

FIGURE 2-24

A scanning electron micrograph of two-hour-old blowfly maggots. Courtesy Dr. Jeremy Burgess/Photo Researchers, Inc.



These determinations are not always straightforward, however. The time required for stage development is affected by environmental influences such as geographical location, climate, weather conditions, and the presence of drugs. For example, cold temperatures hinder the development of fly eggs into adult flies. The forensic entomologist must consider these conditions when estimating the PMI.

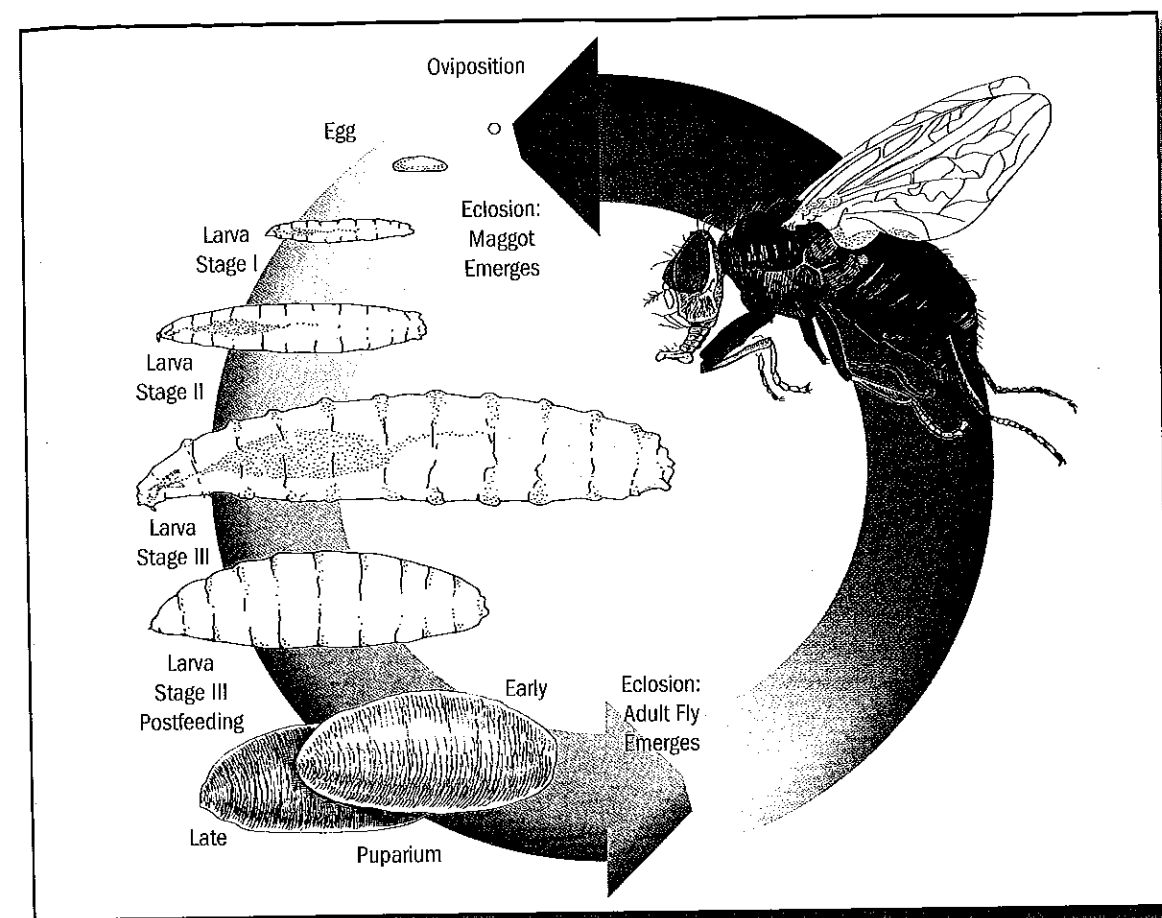


FIGURE 2-25 Typical blowfly life cycle from egg deposition to adult fly emergence. This cycle is representative of any one of nearly 90 species of blowflies in North America. Courtesy E. P. Catts, Ph.D., deceased, and Neal H. Haskell, Ph.D., forensic entomology consultant, www.forensic-entomology.com

Information about the arrival of other species of insects may also help determine the PMI. The sequence of arrival of these groups depends mostly on the body's natural decomposition process. Predator insects generally arrive and prey on the necrophilous insects. Several kinds of beetles will be found, either feeding directly on the corpse's tissues or as predators feeding on blowfly eggs and maggots present on the corpse. Next, omnivore insects arrive at the body. These insects feed on the body, on other insects, and on surrounding vegetation. Ants and wasps are an example of omnivore insects. Last comes the arrival of indigenous insects, such as spiders, whose presence on or near the body is coincidental as they move about their environment.

Case Files

The Danielle Van Dam Murder Case

Sometime during the night of February 1, 2002, 7-year-old Danielle Van Dam disappeared from her bedroom in the Sabre Springs suburb of San Diego, California. On February 27, three and a half weeks later, searchers found her naked body in a trash-covered lot about 25 miles from her home. Because of the high degree of decomposition of the girl's remains, the medical examiner could not pinpoint the exact time of the girl's death. Her neighbor, 50-year-old engineer David Westerfield, was accused of kidnapping Danielle, killing her, and dumping her body in the desert. During the subsequent investigation, Danielle's blood was found on Westerfield's clothes, her fingerprints and blood were found in his RV, and child pornography was found on his home computer.

The actual time of the 7-year-old's death became a central issue during the murder trial. Westerfield had been under constant police surveillance since February 4. Any suggestion that Danielle was placed at the dump site after that date would have eliminated him

as a suspect. Conflicting expert testimony was elicited from forensic entomologists who were called upon to estimate when the body was dumped. The forensic entomologist who went to the dump site, witnessed the autopsy, and collected and analyzed insects from both locations estimated that Danielle died between February 16 and 18. A forensic entomologist and a forensic anthropologist both called to testify on behalf of the prosecution noted that the very hot, very dry weather at the dump site might have mummified Danielle's body almost immediately, thus causing a delay in the flies colonizing the body.

The jurors convicted Westerfield of the kidnapping and murder of Danielle Van Dam, and a San Diego judge sentenced David Westerfield to death. Danielle Van Dam's parents filed and settled a wrongful death suit against Westerfield requiring his automotive and homeowners' insurance carriers to pay the Van Dams an undisclosed amount, reported to be between \$400,000 and \$1 million.

The known sequence of arrival of different insect groups can help determine the PMI. This method is usually used when months have elapsed between the time when the decedent died and when the body was found. In order to make an accurate estimate, the forensic entomologist must compare the species found on the body to experimental data from that geographical area. The entomologist then looks first for what earlier groups are missing. This sets a minimum PMI. For example, if experiments in that area have shown that all necrophilous insects leave the body after about 3 months and no necrophilous insects are found on the body, it can be deduced that the decedent has been deceased for at least 3 months. If a particular entomologist is very familiar with the insect patterns of an area, he or she may be able to further define the PMI range by looking for what groups have not yet arrived. This method may also be useful to determine season of death. However, it is important to remember that the diversity of insects found on a body is also affected by the body's location, weather and temperature conditions, habitat characteristics, indigenous species, and characteristics of the body.

Other Contributions of Forensic Entomology Entomological evidence can also provide other pertinent information. In general, insects first colonize the body's natural moist orifices. However, if open wounds are present, they prefer to colonize there first. Because decomposition processes may conceal wounds,

colonization away from natural orifices may help locate wounds on the body. If maggots are found extensively on the hands and forearms, for example, this suggests the presence of defensive wounds on the victim. Insects that have fed on the body may also have accumulated any drugs present in the flesh, and these insects can yield the identity of these drugs.

If resources allow, all insect evidence should be carefully collected by a forensic entomology expert. When this is not possible, collection should be carried out by an investigator with experience in death investigation. The entire body and the area where insect evidence was found must be photographed and documented before collection. Specimen samples should be taken from each area on the body where they are found and labeled to show where they were collected from.

Quick Review

- An autopsy is normally performed if a death is suspicious or unexplained.
- Rigor mortis occurs after death and results in the stiffening of body parts in the position they are in when death occurs. Livor mortis occurs after death and results in the settling of blood in areas of the body closest to the ground. Algor mortis refers to postmortem changes that cause a body to continually cool to ambient or room temperature.
- Forensic anthropology is concerned primarily with the identification and examination of human skeletal remains.
- A forensic entomologist studies the development of insect larvae in a body to estimate time of death.

Chapter Review

- Physical evidence includes any and all objects that can establish that a crime has been committed or can link the crime and its victim or its perpetrator.
- Forensic science begins at the crime scene, where investigators must recognize and properly preserve evidence for laboratory examination.
- The first officer to arrive must secure the crime scene.
- Investigators record the crime scene by using photographs, sketches, and notes and make a preliminary examination of the scene as the perpetrator left it.
- The search pattern selected at a crime scene depends on the size and locale of the scene and the number of collectors participating in the search.
- Many items of evidence may be detected only through examination at the crime laboratory. For this reason, it is important to collect possible carriers of trace evidence, such as clothing, vacuum sweepings, and fingernail scrapings, in addition to more discernible items.
- Each item of physical evidence collected at a crime scene must be placed in a separate appropriate container to prevent damage through contact or cross-contamination.
- Investigators must maintain the chain of custody, a record for denoting the location of the evidence.
- Proper standard/reference samples, such as hairs, blood, and fibers, must be collected at the crime scene and from appropriate subjects for comparison purposes in the laboratory.
- An autopsy is normally performed if a death is suspicious or unexplained.
- Rigor mortis occurs after death and results in the stiffening of body parts in the position they are in when death occurs. Livor mortis occurs after death and results in the settling of blood in areas of the body closest to the ground. Algor mortis refers to postmortem changes that cause a body to continually cool to ambient or room temperature.
- Forensic anthropology is concerned primarily with the identification and examination of human skeletal remains.
- A forensic entomologist studies the development of insect larvae in a body to estimate time of death.

Quick Lab: Crime-Scene Sketch

Materials:

Graph paper Notepad Rulers
Tape measure/meter stick Mock crime scene

Procedure:

You have been introduced to the appropriate steps to process a crime scene. An important part of this process is surveying the scene, taking diligent notes, and creating a sketch of the scene. With a partner or small group, create a sketch of the scene presented to you and keep notes of what evidence you find. In your sketch, provide an accurate depiction of the entire scene with dimension measurements as well as location measurements for all pieces of physical evidence.

Follow-Up Questions:

1. Why is it important to take diligent notes when processing the crime scene?
2. What is the chain of custody?
3. Why do we sketch the crime scene as well as take photographs of it?

Quick Lab: Anthropometric Activity

Materials:

Meter sticks Rulers/tape measures Student worksheets

Procedure:

First, read the section on anthropometry from the chapter. Next, pair up with two other students and pick up your materials. Each person should measure both of the other people in the group and record the results on the Anthropometric Measurements worksheet. Afterward, discuss the follow-up questions below.

Follow-Up Questions:

1. Did any of your measurements match those of your partners? Were there any measurements for which several members of your group showed identical results? What might that suggest about the usefulness of that measurement for identification?
2. Compare all the measurements recorded for a single individual. Did every person who measured that individual obtain the same results? What factors may contribute to any differences in the results?
3. Do you believe that anthropometry would be a good way to identify people who are trying to hide their identity? Explain your answer.

Quick Lab Worksheet: Anthropometric Measurements

Directions: Please record each measurement in centimeters for each member of your group.

1. Height: cm _____
2. Sitting height: cm _____
3. Length of outstretched arm from one index fingertip to the other: cm _____
3. Length of outstretched arm from shoulder to the index fingertip: cm _____
4. Length of lower arm from elbow to wrist: cm _____
5. Length of right ear: cm _____
2. Length of head from front to back: cm _____

Review Questions

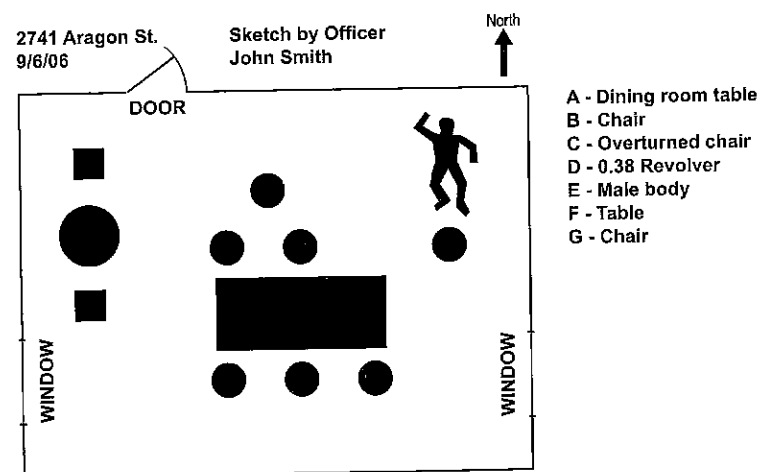
1. All of the following are items to be collected from a deceased's body and sent to the forensic laboratory except:
 - a. ocular fluid.
 - b. head and pubic hairs.
 - c. fingernail scrapings.
 - d. blood.
2. Which of the following is not an allowance made to justify a warrantless search?
 - a. the need to prevent the eventual loss of evidence over time
 - b. the existence of emergency circumstances
 - c. a search made by consent of the parties involved
 - d. a search made incident to a lawful arrest
3. The most important prerequisite for photographing a crime scene is
 - a. to place items in indirect light so that nuances can be picked up in the photograph.
 - b. to place rulers or other items in the photographs to show scale.
 - c. that the crime scene is in an unaltered condition.
 - d. that the photographer start with close-ups of any important object and back up to get the full scale.
4. Uncontaminated surface material close to an area where physical evidence has been deposited is
 - a. a standard sample.
 - b. a reference sample.
 - c. a substrate control.
 - d. ground material.

5. Physical and chemical changes that occur following death include all of the following except:
 - a. livor mortis
 - b. biogor mortis
 - c. algor mortis
 - d. rigor mortis
6. True or False: In order for physical evidence to be used effectively for aiding an investigator, it must first be photographed and tagged as evidence and turned over to the officer in charge of the crime scene.
7. True or False: Before taking photographs of the crime scene, the investigator first draws a rough sketch, containing an accurate depiction of the dimensions of the scene and showing the location of all objects.
8. True or False: If bloodstained materials are stored in airtight containers, such as pill bottles or vials, the accumulation of moisture may encourage the growth of mold, which can destroy the evidential value of blood.
9. True or False: The examination of evidence requires comparison with a substrate control to ensure the evidentiary value of the crime-scene evidence.
10. True or False: Charred debris recovered from the scene of a suspicious fire may be sealed in a plastic evidence container.
11. What is physical evidence? Give three examples of physical evidence that may be found at a crime scene.
12. What is the first step in processing a crime scene?
13. Why is it important to exclude onlookers from a crime scene?
14. Name three methods for recording a crime scene and list one unique advantage of each.
15. What is the most important prerequisite for video recording a crime scene?
16. Name and describe the two kinds of sketches prepared for a crime scene.
17. What information must be included in written notes made at the crime scene?
18. List at least four pieces of evidence from a murder scene that must be collected and sent to the forensic laboratory. Why must these items be collected at the crime scene instead of later?
19. What is the best way to maintain the integrity of physical evidence?
20. Describe the best way for an investigator to handle trace evidence found on articles collected at the crime scene. Name two exceptions to this general rule.
21. Describe a druggist's fold and explain why it is a better way to store trace evidence than an ordinary mailing envelope.
22. Why should all items of evidence be placed in separate containers?
23. Name one type of evidence that should be stored in an airtight container and one type that should not be stored in such a container. Explain why each type of evidence should be stored (or not stored) in this way.

24. What is chain of custody and why is it important to maintain chain of custody?
25. What is a substrate control and how is it used by the crime-scene investigator?
26. In what situations is an autopsy typically performed?
27. Define the terms *rigor mortis*, *livor mortis*, and *algor mortis* and explain how they are important to a forensic pathologist.
28. What is forensic anthropology? List two ways in which a forensic anthropologist may identify a victim.
29. What does a forensic entomologist study to estimate time of death? Explain why such estimates are not always straightforward.

Application and Critical Thinking

1. Give at least three examples of how evidence may be destroyed by onlookers at a crime scene.
2. What important elements are missing from the following crime-scene sketch?



3. An investigator at a murder scene notes signs of a prolonged struggle between the attacker and victim. Name at least three types of physical evidence for which the investigator would likely collect standard/reference samples and explain why he or she would collect them.
4. Rigor mortis, livor mortis, and algor mortis are all used to help determine time of death. However, each method has its limitations. For each method, describe at least one condition that would render that method unsuitable or inaccurate for determining time of death.
5. What kind of forensic expert would most likely be asked to help identify human remains in each of the following conditions?
 - a. a body that has been decomposing for a day or two
 - b. fragmentary remains of a few arm bones and part of a jaw
 - c. a skeleton that is missing the skull

6. Creating a Forensic Anthropology Victim Profile

A nearly complete human skeleton has been found. The skeleton has the features shown in the accompanying table and images. Approximate the gender, ancestry, age range, and height of the individual based on this information.

CRANIUM	Size Forehead Mastoid process Jaw Teeth Sagittal suture Coronal suture Eye orbits Nasal cavity Incisors	Medium Rounded, projected outward Absent Angle = 110 degrees All permanent Not fused Not fused Squared Large, wide Smooth
PELVIS	Opening Sacrum Subpubic angle	See Figure PH-02-2 See Figure PH-02-2 90-100 degrees
LONG BONES	Femur Clavicle	Fully fused, 44.1 cm long Fully fused

Gender _____ Ancestry _____

Age Range _____ Height _____

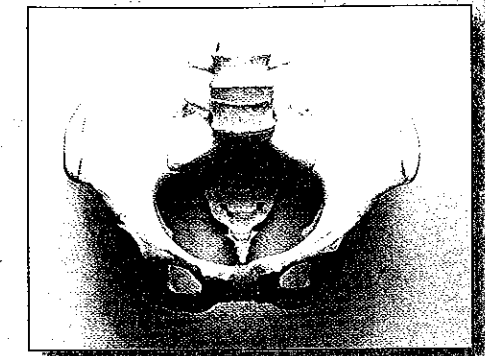


FIGURE PH-02-2
Frontal shot of pelvis and hips. Courtesy Dorling Kindersley Media Library

7. Sequence of Insect Arrival in Forensic Entomology

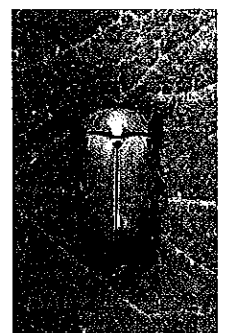
The following images depict the sequence of events at the site of a decomposing body. Place the arrival events in order of occurrence from earliest to latest.



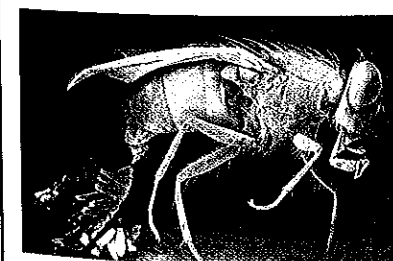
(A) _____



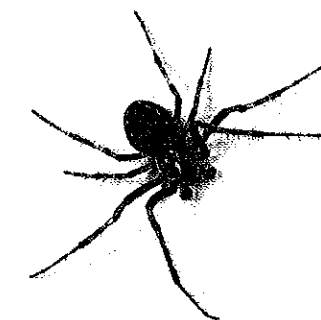
(B) _____



(C) _____



(D) _____



(E) _____



(F) _____