

# Suspect Identification

## ▶ ▶ STUDENT LEARNING OUTCOMES

*Upon completion of this chapter students will demonstrate an understanding of:*

- A basic history of the evolution of fingerprinting
- The various methods of developing fingerprints
- The importance of photographing fingerprints
- Lifting fingerprints
- A basic introduction to DNA typing

Often an investigator is confronted with a plethora of physical evidence but no suspect to whom the evidence relates. Technicians and laboratory equipment form the front lines of the battle in the investigation in these cases. Three identification methods require the services of a forensic or investigative specialist: fingerprint comparison, DNA comparison, and composite drawing. A more common identification method, the police lineup, involves investigators, witnesses or victims, and a known suspect. This chapter discusses the investigative, scientific, and legal aspects of these four identification methods.

## ■ Biometric Identification

The government has long attempted to identify people by biological characteristics, from bumps on a person's head to the ridges on his or her fingers. New trends in identification involve the use of iris patterns and voice recognition systems. Banking and government agencies are the primary users of biometric identification systems, and biometrics has become a growth industry. The state of Connecticut began to use fingerprint scanning in 1996 as a way to deter welfare fraud, and both the Department of Defense and the Department of Veterans Affairs are considering using digitized fingerprinting systems to identify employees.

All biometric systems require similar equipment, including a high-resolution scanning device to digitize an image of some part of the human body and a computer to run the pattern-recognition and sorting software for the specific type of identification in use. Various biometric systems scan human body parts, including fingerprints, irises and retinas, faces and hands, and software and scanning devices are also being developed to identify signatures and voices.

### Iris Scanning

Iris scanning has generated much interest in biometric measurement. The iris has several advantages as an identifying body part: It is an integral part of the body and is not easily modified. Unlike fingerprints, the iris can be imaged from a distance. Iris patterns are unique. No two persons have the same iris pattern; in fact, no two eyes have the same iris pattern. The patterns are stable throughout life and only change in a highly predictable manner as the pupil opens and closes (Lerner, 2000).

Sensar Incorporated has developed camera technology that identifies a person's head and then locates the eyes and the irises. The IriScanAA algorithm locates the outer and inner borders of the iris and detects and excludes the eyelids if they get in the way. The system uses a mathematical technique called wavelet analysis to translate the image of the iris into a digitized pattern. Wavelet analysis breaks down the image into a set of spatially limited waves called an **iris code**. This code is defined in a coordinate system (grid). Once an iris code is prepared, the computer compares a specific individual code against a group of codes (iris patterns) previously stored in the computer. The computer calculates the number of agreements and disagreements between two iris codes. Because the iris code is so short, it can be compared quickly with large databases at a rate of 100,000 codes per second (Lerner, 2000).

### Digital Fingerprints

Fingerprinting is the most widespread biometric technology and the one favored by most government agencies. In **digital fingerprinting**, an individual places a finger on an optical scanner, which creates and saves digitized image of the person's fingerprint. Software then searches the fingerprint image for the location of **minutiae**, points where a finger friction ridge ends or splits in two. Minutiae are highly individualized and can be used to recognize an employee or can be compared to a database of stored fingerprints of criminals in search of a match. Portable digital scanners are being developed that will allow the investigator to scan crime scene fingerprints directly into a computer and communicate them to a national database for comparison and storage.

Other biometric techniques are under development, but all of them have a higher error rate than either iris scanning or digital fingerprint imaging. Hand dimensions remain relatively stable but are not sufficiently unique to distinguish people in a large population. There has been considerable research on facial recognition, but faces vary depending on expression and are easy to disguise or alter. Voice identification is desirable for remote access applications; however, a person's voice varies with emotion, age, and health, so this approach has not reached the application stage.

### ■ Fingerprints

Fingerprint identification began over 4000 years ago when King Hammurabi used fingerprint seals on contracts. Nearly 600 years before Marco Polo visited China, the law book of Yung-Hwui required that a husband in a divorce decree had to seal the document with a fingerprint. In 1823 a graduate student named Johannes Purkinje described fingerprint types in his doctoral thesis and classified them into nine major groups.

In general, however, until the late 19th century there was no unified system of physical identification beyond a general description of age, weight, marks, and scars. With Alphonse Bertillion's new measurement system, people were looking at ways to catalog suspects. In 1888, Sir Francis Galton met with Sir William Herschal. Out of that meeting

arose a classification system based on various points of identification in a fingerprint, known as *Galton details*. In the 1890s, Sir Edward Richard Henry, Inspector General of Police in Bengal, India, experimented with Sir William Herschal's system of using Indian natives' palm prints on contracts. Henry eventually joined the Metropolitan Police of London and initiated his fingerprint identification system, which is the basis for the modern American fingerprint system.

Friction skin is made up of ridges running parallel to one another and is found on the soles of the feet and the palms of the hands. These friction **ridges** run in parallel rows that form patterns. The individual ridges form various shapes or characteristics that do not appear in the same place or sequence from one finger to another.

A close examination of the friction ridges reveals that all along their length the surface is broken in an irregular fashion by sweat pores. The pores are openings for the ducts leading from the sweat glands found in the subcutaneous tissue. The human body has three kinds of sweat glands:

- Eccrine glands are found on all parts of the body and are the only sweat gland found on the palms of the hands and the soles of the feet.
- Apocrine glands are located in the pubic, mammary and anal areas.
- Sebaceous glands are located on the forehead, chest, back, and abdomen and produce an oily secretion, sebum.

All three kinds of glands secrete water as well as many different organic and inorganic substances. Water is secreted to help control body temperature. As the water moves to the surface it evaporates and picks up waste products from other parts of the body. Only the sebaceous glands secrete oily substances; fingers touching those areas are likely to pick up oily residues and transfer them upon contact, leaving fingerprints.


Television, books, and movies often emphasize the value of fingerprints in solving serious crimes. Until the advent of computer technology, however, that value was mostly mythical. Fingerprints were used to inculcate or exculpate based on a suspect group. A search of fingerprint files for the match to a fingerprint found at the scene of a crime occurred only in fiction. The classification system used in categorizing stored fingerprints and the large number of fingerprints stored made it impossible to check through a fingerprint collection manually looking for a match. Computers have turned art into reality. Automated fingerprint identification systems now allow police to do what screenwriters and movie directors have long pretended they could.

The possibilities offered by this technology can only be appreciated when we consider the size of the fingerprint database the federal government has collected. The FBI has been receiving copies of fingerprint cards from all state and federal agencies that require employees to be fingerprinted. They have copies of all the prints of persons who served in wars from Korea to Iraq. Additionally, they have copies of all persons arrested and booked, as a juvenile or an adult, for a misdemeanor or a felony.

### **Fingerprint Individuality**

No two fingers have yet been found that have identical characteristics. **Fingerprint individuality** is not dependent on age, size, gender, or race. The identifiable aspects of a fingerprint are called minutiae (ridge characteristics). The shape, location, and number of minutiae individualize a fingerprint.

There is no agreement as to how many ridge characteristics must be shared by a discovered print and the fingerprint of a suspect before they can be said to be identical.

After a three-year study, the International Association for Identification determined that “no valid basis exists for requiring a predetermined minimum number of friction ridge characters which  be present in two impressions in order to establish positive identification” (Saferstein, 2007). In each and every instance when identification is made between two impressions, that identification is the product of a comparison done by an expert. The value of the expert opinion is based upon the following criteria:

- The number of comparable ridge characteristics
- The knowledge of the expert
- The experience of the expert
- The ability of the expert to explain how the comparison was done
- The quality of the testimony of the adverse expert

### Fingerprint Immutability

From birth to death, a person’s fingerprints retain their classifiable characteristics. The hands and fingers will grow and the print will enlarge with that growth, but the ridge characteristics remain **immutable**. Efforts to eradicate prints are futile, and the scar tissue that results from attempts to do so is as individual as the small number of ridge characteristics that may have been destroyed.

**Fingerprints** are a mirror image of the friction ridge skin of the palm, fingers, and thumb. It is the friction ridges that are reproduced by the black lines of an inked fingerprint impression. When examined under a microscope, the friction ridges of the fingers reveal a single row of pores that are ducts through which sweat is deposited. That sweat, along with body oils that have been picked up when the fingers touch other parts of the body, may be deposited upon a touched surface. The touching may result in a transfer of sweat and oils in the shape of finger friction ridges (a fingerprint) onto the surface touched.

Prints deposited onto a surface but invisible to the naked eye are known as **latent prints**. Technically, only prints that cannot be readily seen with the unassisted eye are latent prints, yet police frequently use the term latent to refer to any fingerprint left at a crime scene, whether visible or not. Fingerprint characteristics must be gleaned by computer or by an individual examination of the pattern (**Figure 6-1**). A magnified examination of the pattern will reveal the individual characteristics that make up the pattern (**Figure 6-2**). When done by hand, the work of determining fingerprint characteristics is tedious and painstaking.

### Classifying Prints

Fingerprints fall into three classes based on general patterns. The most common class is the loop; about 65% of the population has loop patterns on at least one finger. Approximately 35% of the population has a whorl pattern on a finger or thumb, and only about 5% of the population has arches.

#### Loop Patterns

**Loops** must have one or more ridges that enter from one side of the print, recurve, and exit from the same side. Loops are divided into two groups: ulnar loops, which open toward the little finger, and radial loops, which open toward the thumb (**Figure 6-3**).

Additionally, a loop pattern must have a core and a delta. The **core** is the centermost point of the loop at the apex of the innermost ridge of the loop. The **delta** is a two-sided

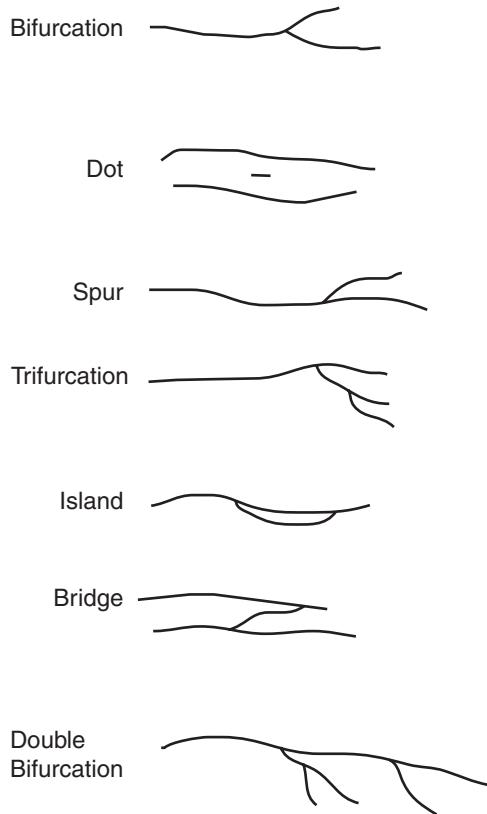


Figure 6-1 Fingerprint characteristics.



Figure 6-2 Fingerprint enlarger.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

triangular shape to one side of the loop that resembles a river delta (loop prints have only one delta per print). These two points are necessary for classifying a print based on the number of friction ridges between the delta and the core of the loop.

#### Whorl Patterns

As is often the case in things technical, the classification of **whorls** is needlessly confusing. The confusion arises as a result of the four groupings into which a whorl pattern may fall: (1) plain whorl, (2) central pocket loop whorl, (3) double loop whorl, and (4) accidental whorl (Figure 6-4). The problem, for those unaccustomed to fingerprint classification, is that the word *loop* is used in distinguishing among whorl patterns but is also used as the name of a nonwhorl pattern. It helps to keep in mind that the names of the two loop patterns, radial and ulnar, are related to the radial and ulnar bones in the arm. The terms *central pocket loop* and *double loop* refer to loops occurring inside whorls—central pocket loop whorls and double loop whorls. Remember that a radial and an ulnar loop each have only one delta, and that any whorl pattern has a minimum of two deltas. What appears to be a loop having two deltas is a double loop whorl or a central pocket loop whorl. Any pattern that is not covered by one of the categories or is a combination of two patterns is called an **accidental**.





**Figure 6-3** Loop pattern.

Courtesy of the Federal Bureau of Investigation



**Figure 6-4** Whorl pattern.

Courtesy of the Federal Bureau of Investigation

### Arch Patterns

The least common pattern is also the simplest to classify. **Arches** are either plain or tented (Figure 6-5). A plain arch is formed by friction ridges entering from one side of the print and exiting on the opposite side, rising to a peak in the center of the ridge to form a hill-like pattern. A tented arch, instead of rising gently to the center and sloping easily away, thrusts up in the center and falls quickly away.

Understanding fingerprint patterns is essential for doing fingerprint comparisons. Once two prints are seen to have the same pattern, they can be examined further for similarities in ridge numbers and configuration.

### Detecting Prints

Although police often use the term latent print to describe all fingerprints found at a crime scene, many of the prints discovered are visible and should not be called latent. Any investigator, lawyer, or expert who unartfully uses *latent* to describe a visible print can expect to be challenged on competent cross-examination. Such a simple point is



**Figure 6-5** Plain arch and tented arch.

Courtesy of the Federal Bureau of Investigation

not lost on jurors, who generally are swayed by simple reasons to find one witness more believable than another.

There are three distinct types of prints found at a crime scene and a fourth type used by police: (1) visible prints, (2) plastic prints, (3) latent prints, and (4) inked impressions. Just as a photographic print is a representation of, but not identical to, the original scene, a fingerprint is a representation of, but not identical to, the actual finger skin friction ridges.

#### Visible Prints

Visible prints are readily identifiable as fingerprints with the unassisted eye. Fingers that have been in contact with a colored material such as toner, ink, blood, paint, oil, or chocolate leave visible prints. Once the material has soiled the fingers, the material may be transferred to a surface with which the ridges come into contact.

#### Plastic Prints

If fingers come into contact with a soft material such as soap, wet putty, wet cement, wet plaster, or dust, a ridge impression may be left sufficient for performing comparisons. As children, most of us have left hand, foot, or finger impressions in wet cement. In Hollywood, a cultural artifact has been built around celebrities embedding their hands and feet in a wet cement pavement, leaving hand- and footprints. These are **plastic impressions**, and they can be used for fingerprint comparisons. If a movie star were a suspect in a crime and refused to allow inked impressions to be taken by the police, the star's concrete hand impression could probably be compared with a print at the scene of the crime to help determine the star's guilt or innocence.

#### Latent Prints

Body perspiration and oils may conspire to leave invisible residues on surfaces that if **visualized** (made visible) would constitute a usable impression of the finger skin friction ridges. Visualizing latent prints requires the use of techniques, chemicals, and powders appropriate for the type of surface upon which the prints repose. **Developing prints** on a nonabsorbent surface requires a different approach than developing prints on a softer, more absorbent surface (**Figure 6-6**). The following section provides details.

#### Developing Prints

Fingerprints discovered on absorbent surfaces can be made visible through the application of powder. The type of powder to use depends on a number of variables.

#### Powders

Latent prints may be developed (visualized) by applying one of a variety of **fingerprint powders** available from distributors of fingerprinting equipment. These powders differ in

### OFFICER'S NOTEBOOK

#### Handling Visible Prints

It is important that visible prints be photographed immediately (**Figure 6-6**). They can often be preserved by bagging the object upon which they were found, by rendering the surface upon which they were found small enough to be bagged, or by being lifted (see the description of the lifting of latent prints later in this chapter). A dry bloody fingerprint on the body of a victim can be lifted using lift tape, avoiding mutilation of the body in an attempt to preserve the print. Any efforts to lift prints should be preceded by taking a set of photographs in case the lifting procedure is not successful.



**Figure 6-6** Fingerprint camera and fingerprint kit.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

color, consistency, density, and polarity. Whatever powder is selected may be applied by brush or by magnetic wand or blown onto the latent print. The powder will cling to the fluids that created the fingerprint. Excess powder can be removed by whirling a feather brush above the print (Figure 6-7). On backgrounds that are complicated or distracting, fluorescent powders offer advantages over conventional powders. They are applied in the same fashion but ultraviolet light is necessary to view them. Using ultraviolet light requires an orange filter to see the fluorescent prints. The print can be lifted as any other powdered print but must use a specialized camera and lights to be photographed (see Figures 6-8 through 6-10).

#### Chemical Development

The most common chemical used for developing latent prints on porous surfaces such as paper and cloth is **ninhydrin**. Ninhydrin chemically reacts with the amino acids in sweat and renders a purple-blue print. (The color is similar to that of old-fashioned mimeographed handouts.) Ninhydrin (triketohydrindene hydrate) is sprayed on the surface that is being checked for prints. The chemical is commercially available in fuming spray cans and wet wipes for ease of application. The development time, which ranges between 1 and 24 hours, can be hastened by heating the specimen to 100A1C. Diazafluorene one (DFO) can produce a similar result and is more reliable. It is a fluorescing





**Figure 6-7** Fingerprint brush and use of brush to develop the print and remove excess fingerprint powder.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

ninhydrin analog and is useful on porous surfaces, including paper. DFO is also used to develop weak blood stains but requires ultraviolet light for fluorescing.

**Superglue fuming** is gaining acceptance in technical circles for the development of fingerprints on nonporous surfaces, such as Formica, metal, or plastic bags. Superglue is cyanoacrylate ester, which is the chemical that develops the print. Cyanoacrylate fumes

## OFFICER'S NOTEBOOK

### Capturing Prints with Powders

Technical expertise is needed for the selection of the appropriate powder for the print, surface composition, and surface color. Light powders are best for dark surfaces, and dark powders are best for light surfaces. The method whereby the print is visualized is referred to as the *development* of the print (heavy hands do not an investigator make). On horizontal surfaces, once the print is developed, the technician can write in the excess powder around the impression his or her name, the date, the crime scene location, and the case number. The information written in the excess powder can be lifted at the same time as the impression, thereby creating a record that is part of the impression. If the surface is horizontal, a *tag board* (a white piece of rigid cardboard) can be propped up against the vertical surface or taped next to it; the same information is recorded upon this board.

Once developed and tagged, the print should be photographed. What may seem like an obsession with photography will make sense to anyone who has lost a print during the lift process or misplaced a print once lifted. Also, photographs of prints found at the crime scene and taken from the suspect can be enlarged and presented to the jury during expert testimony to assist the jury in understanding why the defendant and only the defendant could have left the print.



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**Figure 6-8**

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

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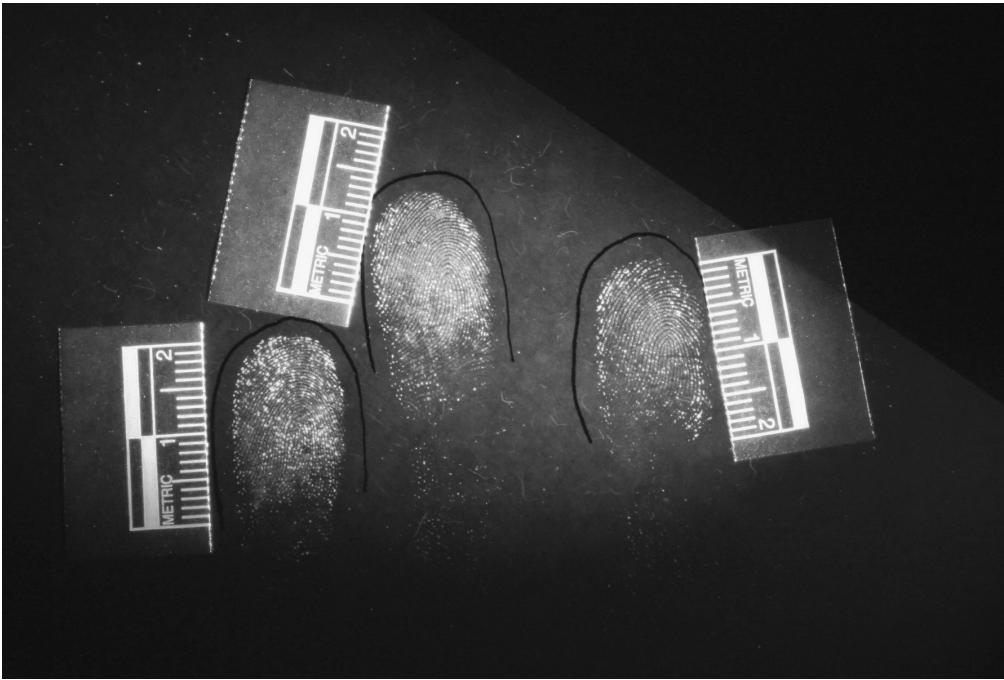
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**Figure 6-9**

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

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are created when superglue is heated or placed on a piece of cotton with sodium hydroxide. The item upon which the latent print is impressed must be placed, along with the super glue, in an airtight container and allowed to work (Figure 6-11). After 5 hours, the fumes will begin to adhere to the latent print and produce a hard whitish deposit in the form of the deposited print. A handheld cyanoacrylate wand can be used at the crime scene to develop latent prints in lieu of powder. Superglue is useful on non-porous surfaces and works well on Styrofoam and plastic bags. The developed prints can be dusted with powders and photographed in place.



**Figure 6–10**

Courtesy of Maine State Police Crime Laboratory



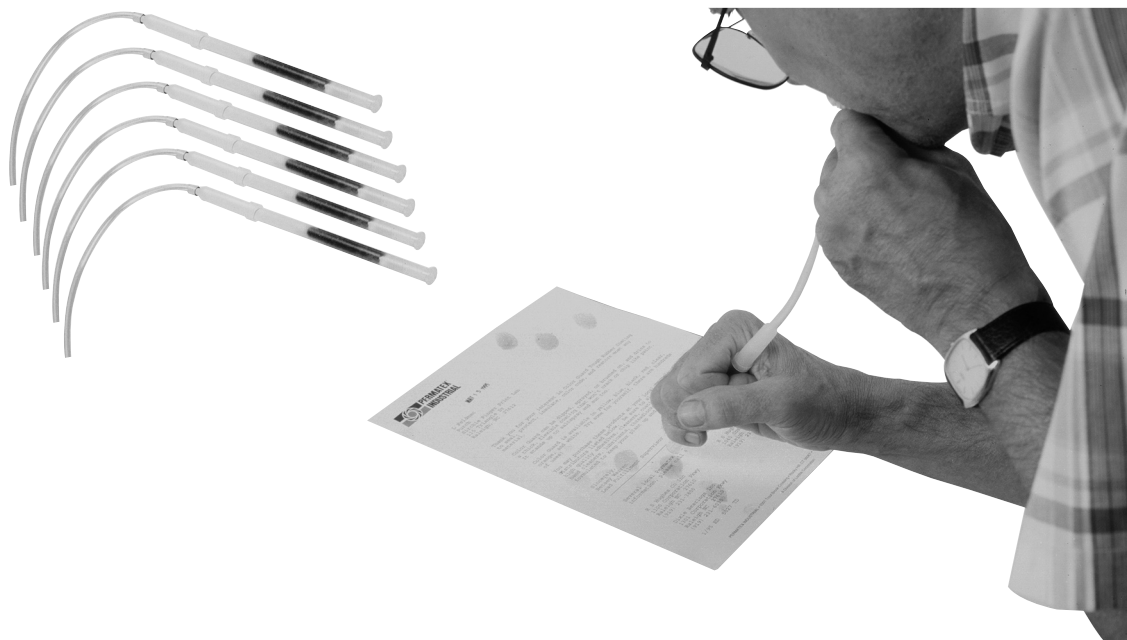
**Figure 6–11** Superglue fuming in airtight box (also shown disassembled)..

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

Prints on paper can best be developed by exposing the surface to iodine fumes or crystals. A variety of commercial products provide iodine in a form appropriate for fuming, such as in ampoules that are dispensed using a breath-activated fuming gun or, for larger surfaces, an electronically fired fuming gun (Figure 6-12). Single sheets of paper can be developed for fingerprints by using dry iodine crystals. By placing the sheet of paper in a plastic bag, then breaking the ampoule that holds the iodine crystals, a series of wave-like motions can run the crystals across the surface of the paper. As the crystals cross the paper, they adhere to the oils and fatty deposits (Figure 6-13). Developed prints must be fixed or photographed immediately, because the reaction is temporary and will fade; commercial fixing agents are available. If the investigator is going to employ a series of methods to develop prints, he or she should use iodine crystals before ninhydrin and silver nitrate development.

Silver nitrate can be used to develop prints on paper; it reacts with the chlorides in skin secretions to form silver chloride, which turns gray when exposed to light. These developed prints are very fragile and will turn as black as the background in very short order. Photographs must be taken as soon as the prints are developed. Silver nitrate can be used on paper, cardboard, plastics and unvarnished, light-colored woods. When considering using a series of developers, silver nitrate (Figures 6-14 and 6-15) should be used after ninhydrin and iodine.

In processing the underwater crime scene, a process that can be used on wet metal and glass surfaces would be an advantage. One such process is the application of small particle reagent (SPR). SPR is a suspension of fine molybdenum disulfide particles that adhere to the fatty components of skin secretions, forming a gray deposit. The reagent is sprayed on the suspect surface, given a few seconds to develop, then gently washed away. Wherever a print resides, it can be developed further by additional applications of SPR



**Figure 6-12** Iodine fuming guns and use of breath-activated gun to develop fingerprints.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.



Figure 6-13

Courtesy of SIRCHIE Finger Print Laboratories, Inc.



Figure 6-14

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

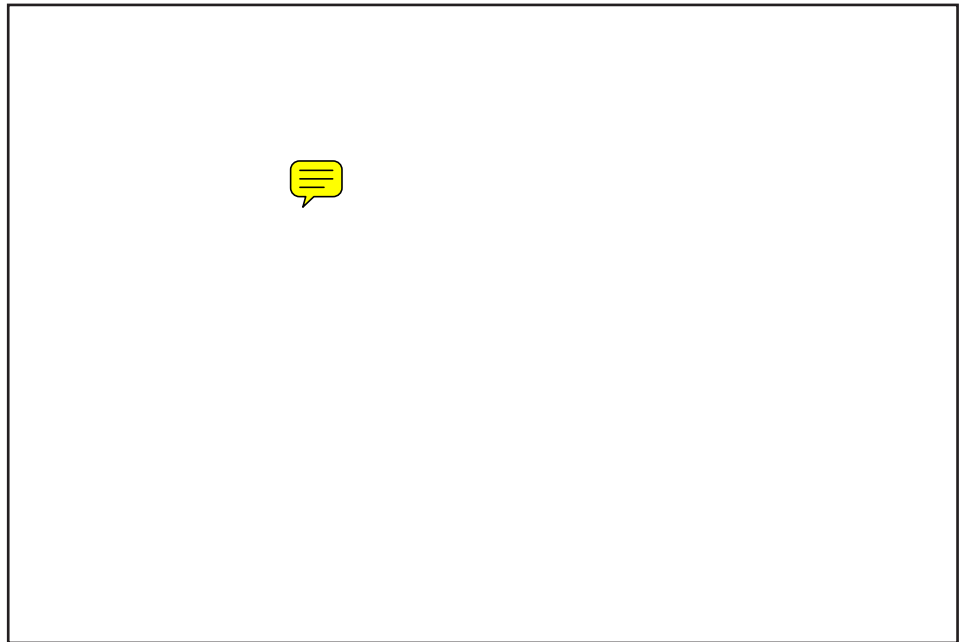


Figure 6-15

Courtesy of SIRCHIE Finger Print Laboratories, Inc.



until the print is of photographic quality. Conventional lifting methods can be used to lift and preserve the developed prints.

Another process useful to the underwater investigator is the use of adhesive-side powders to develop fingerprints from the adhesive side of tapes. In homicide crime scenes, duct tape is a one common type of evidence; often, the perpetrator leaves prints on overlapping tape on a victim or balled up discarded tape. During an underwater investigation workshop taught at Chaminade University, the author submerged balled up and folded pieces of duct tape in water for 24 hours. The tape was removed from the fresh water and allowed to dry. Once dry, the tape was untangled and unfolded using an adhesive remover (such as Undo). The tape was left to dry and weighted on the ends to prevent it from curling as it dried. Once dried, an adhesive side powder was mixed with a film developer from Kodak called photoflo, and applied to the adhesive side of the tape. The mixture was applied with a camel hair brush and allowed to sit for about 10 seconds, after which the mixture was washed from the tape with a slow steady stream of water. It was possible to recover fingerprints placed on the tape. It is not necessary to lift the prints when they have been developed; they can be preserved by placing lift tape over the developed prints on the adhesive side of the duct tape (see **Figure 6–16**). **TABLE 6–1** provides information about the development methods that are appropriate for surfaces with different characteristics.

#### Fluorescence and Alternate Light Sources

The earliest use of fluorescence to visualize fingerprints occurred when it was discovered that the blue-green light of the argon-ion laser made sweat fluoresce (like the black-light posters of the 1960s). It was later discovered that the treatment of fingerprints with ninhydrin and then zinc chloride or with the dye rhodamine 6G after superglue fuming caused fluorescence and sensitivity to laser light. Further experimentation focused on the use of alternate light sources as a method of visualizing fingerprints (Saferstein,



**Figure 6–16**

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

**TABLE 6–1 Guide to Surfaces and Development Methods**

Surface Characteristics	Development methods
smooth, non-porous	powders, iodine, SPR, superglue
rough, non-porous	SPR, superglue
paper, cardboard	iodine, ninhydrin, DFO, silver nitrate, powders
vinyl, rubber, leather	iodine, SPR, superglue, powders
unfinished wood	ninhydrin, powders, silver nitrate
wax and waxed surfaces	powder, superglue
adhesive surfaces	adhesive-side powders

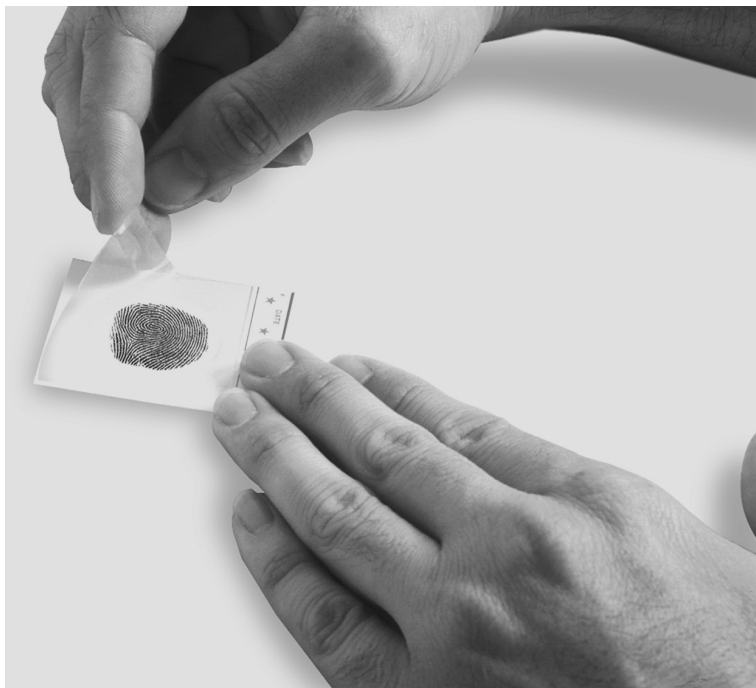
Source: Sirchie Fingerprint Laboratories

1995). Today, there are numerous products that use light to visualize fingerprints, and they have decreased the time and effort necessary to find and develop fingerprints.

One word of caution: The use of various powders and chemicals to develop fingerprints can interfere with the gathering of blood-related evidence. All common fingerprint developers affect the tests used to classify bloodstains.

**Handling and Preserving Prints**

As with plastic and visible prints once an investigator has developed a latent print, he or she must prepare and preserve it for possible use in the laboratory and courtroom. First, it must be photographed. Next, the investigator should attempt to remove the print from the crime scene, either by preserving the item upon which the print lies or by **lifting** the print. Numerous manufacturers provide specialized adhesive lifters (Figure 6–17).



**Figure 6–17** Lifting a fingerprint with an adhesive lifter.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.



**Figure 6–18** Fingerprint comparator.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

A lifter is a transparent tape that is placed on the powdered print with the adhesive side down. When the tape is removed, the fingerprint powder is removed with it. The lifter is provided with a black or white card upon which the transparent tape and powdered print can then be placed, adhesive side down. The colored card provides contrast to the colored powder used, helping to visualize the print. Lift tape comes in a variety of sizes and configurations so that the right type can be chosen for the size, number, and location of the prints to be lifted. Lifted fingerprints can be checked against the fingerprints of a suspect by sending both to the crime laboratory for classification and comparison (Figure 6–18).

## ■ DNA Typing

In every creature, DNA carries the coded messages of heredity, governing everything from eye color to toe length. It is present in every one of the trillions of nucleated cells in the human body. Based on the work of Alec Jeffreys at the University of Leicester, a method was developed to extract DNA from a specimen of blood, semen, or other tissue; slice it into fragments; and tag the fragments with a radioactive probe so that they expose X-ray film. The resulting pattern of stripes on the film is a so-called DNA fingerprint, and the process for isolating and reading DNA markers is known as DNA fingerprinting (see Chapter 2).

### **Restriction Fragment Length Polymorphism Analysis**

As researchers uncovered new variations and applications of the original technique, the term *DNA typing* came to be applied to the forensic use of DNA comparisons. The method

## CASE IN POINT

### DNA Solves an Early Case

Based on his groundbreaking research and his publications, Alec Jeffreys at the University of Leicester was called upon to resolve an immigration case involving a boy who was living in Africa with his father but who had been born in Britain of Ghanaian parents. The boy wanted to return to Britain and live with a woman he claimed was his mother, but the immigration service believed the woman to be his aunt and had denied him British residency.

Jeffreys had to somehow match the genetic fingerprint of the child with that of a father who was not present to supply a DNA sample. The genetic fingerprints of the undisputed children of the woman in question were taken. The intent was to match those fingerprints with those of the mother, thereby establishing the fingerprint of the absent father. When Jeffreys compared the pattern of the boy with those of his ostensible brothers and sisters, the reasonable conclusion was that the man had fathered all of the children (Wambaugh, 1985).

devised by Jeffreys is called **restriction fragment length polymorphism (RFLP) analysis**. The initial research in DNA focused on inherited diseases. Today, forensic research has developed a significant body of literature for use in criminal investigations. Growing out of paternity contests and immigration cases, DNA typing has quickly become the forensic tool of the century.

Inside each of 60 trillion cells in the human body are strands of genetic material called chromosomes. Arranged along the chromosomes, like beads on a thread, are nearly 100,000 genes (the fundamental units of heredity). The genes instruct the body cells to make proteins, which determine everything from hair color to a person's susceptibility to diseases. In the nucleus of all human cells is a ribbon of deoxyribonucleic acid (DNA). The ribbon is a twisted double strand, referred to as a double helix. It is 2 microns wide, but, if uncoiled, it stretches to 6 feet in length. DNA is a **polymer**, that is, a very large molecule made by linking together a series of repeating units. In DNA, the repeating units are nucleotides. A **nucleotide** is composed of a sugar molecule, a phosphorus-containing group, and a nitrogen-containing molecule called a base. There are only four types of bases associated with DNA: adenine (A), thymine (T), guanine (G), and cytosine (C).

The twin strands of the double-helix configuration are connected, like the rungs of a ladder, by pairs of bases, in a process called base pairing. The average human chromosome has DNA containing 100 million **base pairs**. All the human chromosomes taken together contain about 3 billion base pairs. DNA is like a book of instructions. The alphabet used to create the book is simple: A, T, G, and C (i.e., adenine, thymine, guanine, and cytosine). Because of the shapes of the structures involved, a G can link only to a C, and an A can link only to a T; the DNA of the strands is complementary. The order in which these chemicals are arranged defines the role and function of a DNA molecule (Saferstein, 1995). Portions of the DNA molecule contain sequences of A, G, C, and T bases that randomly repeat themselves (tandem repeats). As with any genetic trait, these repeating sequences are inherited from the parents.

The key to understanding DNA typing lies in understanding that among the world's population there are numerous possibilities for the number of times a particular sequence of base letters is repeated on a DNA strand. The possibilities increase with the number of chromosomes, because each chromosome contains different lengths of repeating

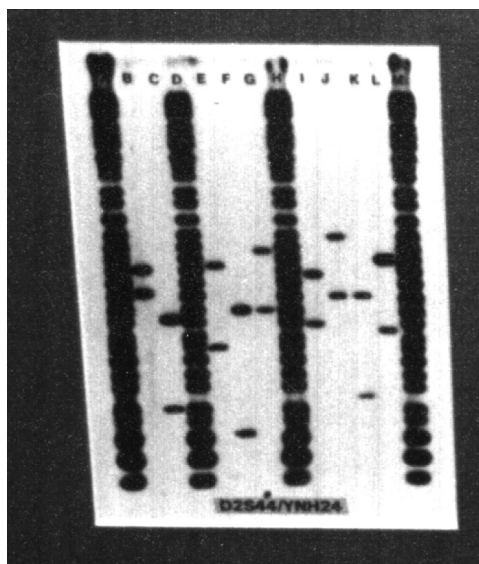
sequences. In RFLP DNA typing, **restriction enzymes** are used to cut up chromosomes into hundreds of fragments, some containing repeating sequences from the DNA molecule. These fragments (restriction fragment length polymorphisms) will be cut into different lengths, depending on the length of the repeating sequences.

Once the DNA molecules have been cut up by the restriction enzyme, the resulting fragments must be sorted out, which is accomplished through electrophoresis. Electrophoresis separates materials according to their migration rates across a starch or agar gel. When the gel is electrically charged, substances that possess an electrical charge, such as DNA, will migrate across the gel. The longer the DNA fragment, the greater the resistance to the migration. The shorter fragments move farther and faster across the gel. The movement of the various-sized fragments sorts them by length.

When the electrophoresis process is completed, the double-stranded fragments of DNA are chemically treated so that the strands separate from each other. The fragments are then transferred to a nylon membrane much the way lipstick is blotted from the lips. This transfer process is called Southern blotting, named after Edward Southern, its originator (Saferstein, 1995).

At this juncture, the DNA fragments, although transferred to the nylon membrane, cannot be seen. In order to visualize them, the nylon membrane is treated with radioactively treated fragments containing a base sequence complementary to the cut, migrated fragments. Such complementary base sequences are called *probes*, and the process of attaching the probes to the fragments to be identified is called *hybridization*. If one were attempting to identify RFLPs composed of repeats of the sequence TAG, for example, one would use a probe consisting of the complementary sequence ATC. Note that once the double strand has been separated, the single remaining strand can be hybridized.

The next step is to place the nylon sheet against X-ray film and expose it for several days. As the radioactivity of the probes decays, it strikes the unexposed film. When the film is processed, bands appear where the radioactive probes stuck to the fragments on the nylon sheet (**Figure 6–19**). The length of each fragment is determined by running



**Figure 6–19** DNA radiogram.

Courtesy of Austin Police Department, Austin, Texas.



known DNA fragment lengths alongside the test specimens and comparing the distances they migrated across the gel plate (Waye and Fourney, 1993). A typical DNA fragment pattern will show two bands (one RFLP from each chromosome). When comparing the DNA fragment patterns of two or more specimens, one looks for a match between the band sets. Individualization cannot be accomplished with a single probe; however, by using additional DNA probes, each of which recognizes different repeating DNA segments, a high degree of discrimination or near individualization can be achieved (Saferstein, 1995).

### **Polymerase Chain Reaction Analysis**

Many forensic specimens contain only limited amounts of DNA, making them unsuitable for RFLP analysis. **Polymerase chain reaction (PCR)** procedures replicate limited quantities of DNA and generate reliable copies of what was previously subanalytic or degraded DNA. Each cycle can double the quantity of DNA (Fierro, 1993). PCR has enabled laboratories to develop DNA profiles from extremely small samples of biological evidence. The PCR technique replicates exact copies of DNA contained in a biological evidence sample without affecting the original, much like a copy machine. RFLP analysis requires a biological sample about the size of a quarter, but PCR can be used to reproduce millions of copies of the DNA contained in a few skin cells.

Because PCR analysis requires only a minute quantity of DNA, it can enable a laboratory to analyze highly degraded evidence for DNA. On the other hand, because the sensitive PCR technique replicates any and all of the DNA contained in an evidence sample, greater attention to contamination issues is necessary when identifying, collecting, and preserving DNA evidence. These factors may be particularly important in the evaluation of unsolved cases in which evidence might have been improperly collected or stored.

### **Advances in DNA Analysis**

When properly documented, collected, and stored, biological evidence can be analyzed to produce a reliable DNA profile years, even decades, after it is collected. Just as evidence collected from a crime that occurred yesterday can be analyzed for DNA, so too evidence from an old rape kit, bloody shirt, or stained bedclothes may contain a valuable DNA profile. Newer DNA analysis techniques enable laboratories to develop profiles from biological evidence invisible to the naked eye, such as skin cells left on ligatures or weapons. These new analysis techniques, in combination with an evolving database system known as the **Combined DNA Index System (CODIS)**, make a powerful argument for reevaluating unsolved crimes to look for potential DNA evidence.

Unsolved cases should be evaluated by investigating both traditional and nontraditional sources of DNA. Valuable DNA evidence might be available that previously went undetected in the original investigation. If biological evidence is available for testing or retesting in unsolved case investigations, it is important that law enforcement and the crime laboratory work together to review evidence. Logistical issues regarding access to and the cost of DNA analysis will be a factor, as well as issues related to the discriminating power of each technology and how it might affect the outcome of the results. Laboratory personnel can provide a valuable perspective on which evidence might yield valuable and probative DNA results. Finally, if previously tested biological evidence produced a DNA profile but excluded the original suspect, revisiting those exclusion cases for the purpose of comparing them with DNA databases might prove to be very valuable to solving old cases.

### Short Tandem Repeat Analysis

**Short tandem repeat (STR) analysis** evaluates specific regions (loci) that are found on nuclear DNA. The variable (polymorphic) nature of the STR regions that are analyzed for forensic testing intensifies the discrimination between one DNA profile and another, such that the likelihood that any two individuals (except identical twins) will have the same 13-loci DNA profile can be as high as 1 in 1 billion or greater. The FBI has chosen 13 specific STR loci to serve as the standard for CODIS. The purpose of establishing a core set of STR loci is to ensure that all forensic laboratories can establish uniform DNA databases and, more important, share valuable forensic information. For the forensic or convicted-offender CODIS indices to be used in the investigative stages of unsolved cases, DNA profiles must be generated by using STR technology and the specific 13 core STR loci selected by the FBI.

### Mitochondrial DNA Analysis

**Mitochondrial DNA (mtDNA) analysis** allows forensic laboratories to develop DNA profiles from evidence that may not be suitable for RFLP or STR analysis. Whereas RFLP and PCR techniques analyze DNA extracted from the nucleus of a cell, mtDNA technology analyzes DNA found in the mitochondrion. Old remains and evidence lacking nucleated cells—such as hair shafts, bones, and teeth—that are not amenable to STR and RFLP testing may yield results if mtDNA analysis is performed.

### Y-Chromosome Analysis

Several genetic markers that have been identified on the Y chromosome can be used in forensic applications. Y-chromosome markers target only the male fraction of a biological sample. Therefore, this technique can be very valuable if the laboratory detects complex mixtures (multiple male contributors) within a biological evidence sample. Because the Y chromosome is transmitted directly from a father to all of his sons, it can also be used to trace family relationships among males. Advancements in Y-chromosome testing may eventually eliminate the need for laboratories to extract and separate semen and vaginal cells (for example, from a vaginal swab of a rape kit) prior to analysis.

### Combined DNA Index System

The Combined DNA Index System (CODIS) is a computer network that connects forensic DNA laboratories at the local, state, and national levels. Every state in the nation has a statutory provision for the establishment of a DNA database that allows for the collection of DNA profiles from offenders convicted of particular crimes. CODIS software enables state, local, and national law enforcement crime laboratories to compare DNA profiles electronically, thereby linking serial crimes and identifying suspects by matching DNA profiles from crime scenes with profiles from convicted offenders.

DNA database systems that use CODIS contain two main criminal indices (the convicted-offender index and the forensic index) and a missing-persons index. The convicted-offender index contains DNA profiles of individuals convicted of specific crimes, ranging from certain misdemeanors to sexual assault and murder. Each state has different qualifying offenses for which persons convicted of the offense must submit a biological sample for inclusion in the DNA database. The forensic index contains DNA profiles obtained from crime scene evidence, such as semen, saliva, or blood.

When a DNA profile is developed from crime scene evidence and entered into the forensic (crime scene) index of CODIS, the database software searches thousands of DNA profiles of individuals convicted of offenses such as rape and murder. Similar to the Automated Fingerprint Identification System (AFIS), CODIS can aid investigations

by efficiently comparing a DNA profile generated from biological evidence left at a crime scene against convicted offender DNA profiles and forensic evidence from other cases contained in CODIS.

CODIS can also aid investigations by searching the missing persons index, which consists of the unidentified-persons index and the reference index. The unidentified-persons index contains DNA profiles from recovered remains, such as bone, teeth, or hair. The reference index contains DNA profiles from related individuals of missing persons so that they can be periodically compared to the unidentified-persons index.

A match made between profiles in the forensic index can link crime scenes to each other, possibly identifying serial offenders. Based on these forensic matches, police in multiple jurisdictions or states can coordinate their respective investigations and share their leads. Matches made between the forensic and convicted-offender indices can provide investigators with the identity of a suspect or suspects. It is important to note an offender hit typically is used as probable cause to obtain a new DNA sample from that suspect so the match can be confirmed by the crime laboratory before an arrest is made.

#### **Design of CODIS**

CODIS is implemented as a distributed database with three hierarchical levels (or tiers): local, state, and national. All three levels contain forensic and convicted-offender indices and a population file (used to generate statistics). The hierarchical design provides state and local laboratories with the flexibility to configure CODIS to meet their specific legislative and technical needs.

- **Local DNA Index System (LDIS):** Typically, the LDIS installed at crime laboratories is operated by police departments or sheriffs' offices. DNA profiles originated at the local level can be transmitted to the state and national levels.
- **State DNA Index System (SDIS):** Each state has a designated laboratory that operates the SDIS, which allows local laboratories within that state to compare DNA profiles. SDIS also is the communication path between the local and national tiers.
- **National DNA Index System (NDIS):** The NDIS is the highest level of the CODIS hierarchy and enables qualified state laboratories that are actively participating in CODIS to compare DNA profiles. NDIS is maintained by the FBI under the authority of the DNA Identification Act of 1994.

#### **Limitations of Using CODIS**

The more data contained in the forensic and offender indices of CODIS, the more powerful a tool it becomes for law enforcement, especially in its application to unsolved case investigation. However, because many jurisdictions are in the process of developing and populating their DNA databases, there are convicted-offender and forensic casework backlogs that continue to grow. As states recognize the crime-solving potential of DNA databases, they continue to expand the scope of their convicted-offender legislation, which increases the number of samples to be collected and analyzed by the DNA laboratory. As a result, more than 1 million uncollected convicted-offender DNA profiles are "owed" to the system.

#### **Handling DNA Evidence**

Because of the O.J. Simpson trial, the country discovered the effects of mishandling blood evidence. We watched on national television as a forensic technician, trained and experienced in handling blood evidence, in fact handled and packaged prospective DNA evidence with his bare hands. The defense was quick to raise issues of contamination and

**OFFICER'S NOTEBOOK****Guidelines for Handling DNA-Bearing Evidence**

- Wear gloves. Change them between handling each item of evidence.
- Use disposable instruments or clean the instruments thoroughly before and after handling each evidence sample.
- Avoid touching the area where you believe DNA may exist.
- Avoid touching your face, nose, and mouth when examining and packaging evidence.
- Put dry evidence into new paper bags or envelopes; do not use plastic bags.
- Do not use staples.
- Handle all evidence as though a jury were watching.
- Photograph or videograph the handling and packaging process.

violation of a scientific protocol. The cumulative impact of questionable investigative conduct loomed over the jury during its deliberations. The guidelines in the Officer's Notebook are provided to avoid mishandling DNA-bearing evidence.

**Sample Contamination**

Any crime scene is unlikely to meet the hygienic standards characteristic of research and medical laboratories. Defendants tend to believe that anything less than absolute purity in body samples raises questions as to the reliability of the DNA typing process (TABLE 6-2). The word contamination raises the specter of something unnatural or careless happening to the samples before they reach the laboratory. It is imperative for an expert in DNA analysis who is called as a witness to address the nature of the environment in which DNA samples were deposited and to explain that contamination and age are an integral part of the nonsterile real world. Possible questions include the following:

- The question is not one of contamination but rather of how much contamination, is it not?
- Can the contaminants be removed from the sample without altering the sample?
- Were the contaminants removed before the typing protocol began?
- Could you describe the nature of the contaminants present and the method of removal?

**TABLE 6-2 DNA Defenses and Responsible Parties**

<b>Defense</b>	<b>Responsible Party</b>
Contaminated crime scene	The nature of the crime
Improper labeling	Investigator (technician)
Improper handling	Investigator (technician)
Improper packaging	Investigator (technician)
Broken chain of custody	Investigator (technician, laboratory)
Contaminated lab sample	Laboratory
Improper lab protocol	Laboratory
Acceptability of protocol	Laboratory witness
Acceptability of expert	Laboratory witness

## CASE IN POINT

### The Innocence Project

The Innocence Project at the Benjamin N. Cardozo School of Law, created by Barry C. Scheck and Peter J. Neufeld in 1992, is a nonprofit legal clinic. The Project only handles cases in which postconviction DNA testing of evidence can yield conclusive proof of innocence. Because it is a clinic, students handle the casework while being supervised by a team of attorneys and clinic staff.

Most of the clients are poor, forgotten, and have used up all of their legal avenues for relief. The hope they all have is that biological evidence from their cases still exists and can be subjected to DNA testing. All Innocence Project clients go through an extensive screening process to determine whether DNA testing of evidence could prove their claims of innocence. Thousands currently await evaluation of their cases.

As a forerunner in the field of wrongful convictions, the Innocence Project has grown to become much more than the court of last resort for inmates who have exhausted their appeals and their means. The Project is helping to organize the Innocence Network, a group of law schools, journalism schools, and public defender offices across the country that assists inmates trying to prove their innocence whether or not the cases involve biological evidence that can be subjected to DNA testing. Project managers consult with legislators and law enforcement officials on the state, local, and federal level, conduct research and training, produce scholarship, and propose a wide range of remedies to prevent wrongful convictions while continuing work to free innocent inmates through the use of postconviction DNA testing (Innocence Project, 2003).

- How was the sample contaminated?
- Where did the contamination occur?
- Was the contamination a result of laboratory handling?
- Was the contamination a result of police handling?
- Was there enough of the sample to run more than one test?
- Were additional tests run?
- Were the results the same?
- Were known samples that were contaminated with similar contaminants cleaned and typed?
- Were the results consistent with the results for uncontaminated samples?

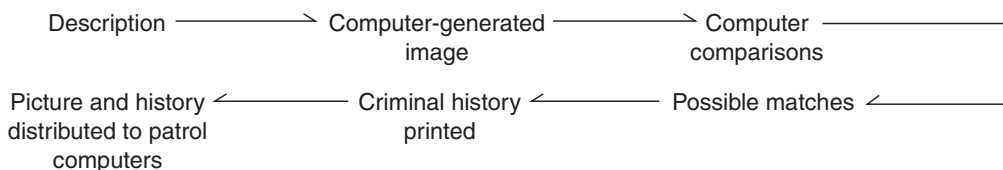
Contamination is only a problem if left to the defendant to use as an issue with which to obfuscate or confuse. The jury should be comfortable with the idea that all forensic DNA samples are contaminated and that nothing unique or unusual happened to the samples in question.

## ■ Composite Identifications

Often the only way to identify a suspect is to translate a verbal description into something police and the media can use easily (Figure 6–20). Although all-points bulletins historically have provided a verbal description of the suspect sought, a more elaborate method of identification is available through the services of artists, computers, and kits with interchangeable facial features.

A **sketch artist**, given a description, can create a picture that, through continual refinement based on witness input, begins to bear a strong resemblance to the suspect. Most agencies do not have the financial resources to employ a person with the artistic skills necessary to provide an artist's rendition, and so a number of manufacturers have



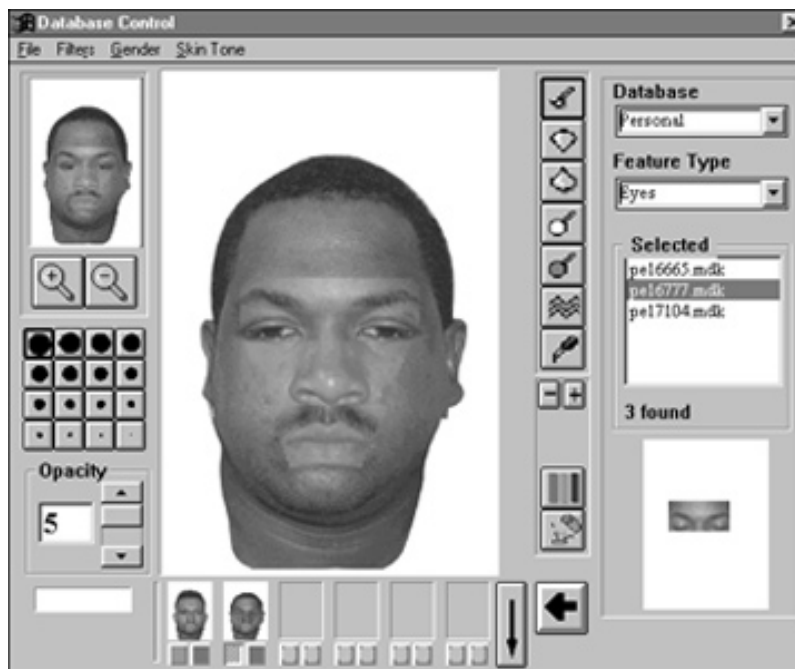


**Figure 6–20** Flowchart showing the process of generating a suspect's composite picture and criminal history for use by patrol officers.

produced kits that offer predrawn facial features from which to choose. By selecting the one feature that best meets the witness's verbal description, a nonartist can begin to construct a **composite picture**.

Not surprisingly, there are software programs that render composite drawings by means of mouse commands and pull-down menus. These programs pose queries to which the witness provides a response. Because the questions are not suggestive of an answer, the final product tends to be more objective than an artist's sketch. A computer program such as Compusketch provides more than 100,000 selections from which the witness can choose, and the choices can be superimposed to the satisfaction of the witness. The final product is a laser-printed computer rendition of the facial features of the suspect ready to be distributed. Often such images are photo quality.

There are obvious advantages to distributing sketches rather than verbal descriptions to a patrol force. Most agencies require that a photograph and the fingerprints of every arrested adult suspect be taken and stored. The mug shots make up an agency's **rogues' gallery**, a ready supply of photographs for witnesses to leaf through in the attempt to



**Figure 6–21** Sample screen of a criminal identification computer software program.

Courtesy of SIRCHIE Finger Print Laboratories, Inc.

identify a perpetrator. The gallery is generally divided into either offense categories or categories based on modus operandi (the method employed by the perpetrator). The gallery may be further divided into patrol areas, precincts, or neighborhoods. In addition to a photo, identification information is also recorded, such as scars, hair color, height, weight, tattoos, and age. Computer programs can retrieve photos that meet a set of typewritten descriptors or are similar to a composite drawing (Figure 6–21). When a typewritten description or a composite drawing is entered into the computer, a search is made of the computer's database, and mug shot matches are identified. One of the problems associated with looking at mug shots is the viewer burnout that is bound to occur. Restricting the number of mug shots a witness has to peruse avoids or at least postpones viewer overload.

## ■ Lineups

In virtually every criminal trial, there must be an identification of the suspect. The prosecution has a responsibility to identify the defendant as the person who perpetrated the offense or was arrested for the offense charged. Often, a prior identification has taken place at the hands of a witness or victim. That pretrial identification generally occurs in one of two ways: a review of the rogues' gallery or a viewing of a police lineup. The controlling case pertaining to police pretrial lineups is *United States v. Wade* (1967). It should be noted that the requirement from *Wade* that counsel be present applies to **postindictment lineups**, not to preindictment lineups (lineups conducted before an indictment is handed down).

Lineups traditionally have been used by police to identify suspects. Their format is generally the same, although the number of participants varies (the range is from 4 to 10). The participants are selected on the basis of their similarity to the suspect in gender, age, race, build, coloring, and so on. The participants are allowed to select the position in which they stand. Each position is designated by a number, and the background is calibrated to allow witnesses to better assess height and weight. The idea behind requiring legal representation at lineups is that the presence of counsel averts prejudice in the selection and display of the participants.

### **CASE IN POINT**

#### ***United States v. Wade, 1967***

Officials were conducting an investigation of the robbery of a federally insured bank in which two men with pieces of tape affixed to their faces stuffed the bank's money into a pillowcase and fled. A federal indictment was returned prior to the arrest of Wade. Fifteen days later, without notice to his counsel, Wade was placed in a lineup to be viewed by bank personnel. Wade was identified as the robber. At trial, witnesses who had made the lineup identification testified that they had seen Wade earlier in the custody of officials. At trial, the witnesses identified Wade and reconfirmed their lineup identification. Wade was convicted of robbery.

The US Supreme Court concluded that there was grave potential for prejudice, intentional or not, in the pretrial lineup. The Court stated that counsel itself can often avert prejudice and ensure a meaningful confrontation at trial. For Wade, the postindictment lineup was a critical stage of the prosecution and therefore one at which he was entitled to counsel. The Court said that both Wade and his counsel should have been notified of the impending lineup, and counsel's presence should have been a prerequisite for conducting a lineup, absent an intelligent waiver.

**OFFICER'S NOTEBOOK****Crucial Factors in Lineup Identification**

The following questions are relevant to both preindictment and postindictment lineups.

- Did the witness have the opportunity to get a good look at the suspect at the time of the offense? Various ingredients come together to make an adequate opportunity: time viewed, weather conditions, visibility, lighting, and the visual acumen of the viewer.
- How much attention was the witness paying to what was happening and to what he or she was seeing at the time of the offense?
- How certain is the witness that the suspect is the same person perceived at the crime scene?
- How much time has passed from the commission of the crime to the identification?
- How consistent is the identification with the original report provided to the police?
- Was there anything about the lineup that pointed to the suspect as the person to choose?

The last issue is the one of most concern to the courts. If there was something that suggested one participant over another—position, clothing, or whatever—any further inquiry into the quality of the lineup would be preempted, because suggestibility is fatal to a lineup whenever it may occur.

Some investigators believe that the presence of legal counsel at postindictment lineups serves as an obstacle to the successful completion of the investigation. The prudent investigator will welcome the input of defense counsel and recognize that such input will assist in conducting a constitutionally permissible lineup. It is better to find out during the lineup what objections, if any, the defendant's lawyer might raise than to wait until trial and discover that an impermissible lineup was conducted.

**Summary**

In every instance in which fingerprints are left at a crime scene, it becomes a game of hide and seek to ferret out where they may have been left. Because most fingerprints are invisible, it becomes important to preserve the entire scene for those with the expertise in locating, developing, photographing, and lifting such prints. It is important to remember that no matter how expert the processing, fingerprints will be destroyed during development and lifting; that is why photographing fingerprints is part of the protocol. Additionally, photographs can be enlarged for trial exhibits. At the time of trial it is helpful for the jury to see the development and lifting process. One of the best courtroom demonstration aids for fingerprinting is the overhead projector. A fingerprint can be left on the glass of the projector, and when the projector is turned on, the jury can watch the development and lifting process, enlarged, on screen, and with a live narrative.

One of the skills every investigator must have is the ability to manage people at a crime scene. It might be said that a crime scene is processed only as well as the investigator in charge can manage people. The next chapter introduces us to the concept of crime scene management and the ways in which those management skills might be employed.

**Key Terms**

**accidental:** Any fingerprint pattern that is not covered by one of the categories or is a combination of two patterns

**arches:** The least common fingerprint patterns; they are either plain or tented

**base pair:** Pair of two of the four types of bases (A, T, G, and C) in DNA; pairing of bases helps form the double-helix configuration of DNA

**biometric identification:** Identifying people by biological characteristics

**Combined DNA Index System (CODIS):** Database system that can aid investigations by efficiently comparing a DNA profile generated from biological evidence left at a crime scene against convicted offender DNA profiles and forensic evidence from other cases contained in the database

**composite picture:** Picture drawn of a suspect by selecting the one feature that best meets the witness's verbal description and continuing refinement based on witness input

**core:** In fingerprints, the centermost point of the loop at the apex of the innermost ridge of the loop; this shape is always found in a loop pattern

**delta:** A two-sided triangular shape found to one side of a loop that resembles a river delta; this shape is always found in a loop pattern

**developing prints:** Making fingerprints visible by applying a powder or chemical

**digital fingerprinting:** Digital recording of a fingerprint made by having an individual place a finger on an optical scanner, which creates a digitized image of the person's fingerprint

**fingerprint individuality:** The shape, location, and number of minutiae that individualize a fingerprint

**fingerprint powders:** Powders used to develop fingerprints by clinging to the fluids that created the fingerprints

**fingerprints:** Mirror images of the friction ridge skin of the palm, fingers, and thumb

**friction ridges:** Ridges on fingers that are the identifiable characteristics of fingerprints

**immutable:** Unchangeable; refers to the retention of fingerprint characteristics throughout a person's life

**iris code:** Set of spatially limited waves that is produced by wavelet analysis of the iris

**latent prints:** Prints deposited onto a surface that are invisible to the naked eye.

**lifting:** Removing a fingerprint from a crime scene by sticking a print developed with powder to transparent tape and then placing the tape (adhesive side down) on a black or white card

**loops:** Fingerprint pattern that has one or more ridges that enter from one side of the print, recurve, and exit from the same side, as well as a core and a delta

**minutiae:** Points where a finger friction ridge ends or splits in two; these are highly individualized

**mitochondrial DNA (mtDNA) analysis:** Analysis of DNA found in the mitochondrion, used to develop DNA profiles from evidence that may not be suitable for RFLP or STR analysis, such as hair, bones, and teeth

**ninhydrin:** The most common chemical used for developing latent prints on porous surfaces; it reacts chemically with the amino acids in sweat and renders a purple-blue print

**nucleotide:** The repeating unit of DNA

**plastic impression:** Fingerprints left on soft materials such as soap, wet cement, or dust that can be used for fingerprint comparisons

**polymer:** A very large molecule made by linking together a series of repeating units

**polymerase chain reaction (PCR):** Technique used to replicate exact copies of DNA contained in a biological evidence sample without affecting the original material

**postindictment lineup:** Lineup conducted after an indictment is handed down, during which counsel must be present

**restriction enzymes:** Substances used to cut up chromosomes into hundreds of fragments

**restriction fragment length polymorphism (RFLP) analysis:** Analysis of the banding pattern formed by cutting DNA with restriction enzymes, separating the fragments, exposing the fragments to DNA probes, and looking at the pattern of radioactive bands that results from the radioactive probe binding to the DNA fragments; several probes are used to create a profile for an individual.

**rogues' gallery:** A ready supply of photographs for witnesses to leaf through in the attempt to identify a perpetrator

**short tandem repeat (STR) analysis:** A forensic analysis that evaluates specific regions (loci) that are found on nuclear DNA

**sketch artist:** Person who can create a picture that, through continual refinement based on witness input, begins to bear a strong resemblance to a suspect

**super glue fuming:** Technique used for the development of fingerprints on nonporous surfaces

**visualize:** To make visible

**whorl:** Fingerprint pattern having a minimum of two deltas; this pattern is classified into four groupings: (1) plain whorl, (2) central pocket loop whorl, (3) double loop whorl, and (4) accidental whorl

## ■ Review Questions

1. What is it about fingerprints that suggest individuality?
2. Why is it incorrect to refer to visible fingerprints at a crime scene as latent prints?
3. What is it that leaves fingerprints?
4. What are fingerprint patterns, and of what value are they to the criminal investigator?
5. How is a latent print visualized, developed, and lifted?
6. Why is it important to photograph a fingerprint that the investigator plans to lift anyway?
7. What is superglue fuming?
8. For what is ninhydrin spray used?
9. How would you develop fingerprints on the sticky side of duct tape?
10. What is small particle reagent used for?
11. What are iodine crystals used for?
12. What chemical is used to test for blood that luminesces under ultra violet light?
13. What is a composite picture, and in what ways might an investigator obtain one?
14. What is a suggestive lineup?
15. What is the main legal difference between a preindictment and a postindictment lineup?
16. What is a rogues' gallery, what is in it, and how is it created?
17. Describe different ways of analyzing DNA evidence.
18. What is CODIS? Describe the three-tiered identification system.



19. Discuss crime scene DNA contamination.
20. What is STR?
21. How does mitochondrial DNA differ from nuclear DNA?
22. List the considerations in the handling and packaging of items that may bear DNA evidence.
23. Describe the Innocence Project. What is its objective?

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## ■ Key Legal Cases

- United States v. Wade*, 388 U.S. 218 (1967).

