Friction ridge evidence. Fingerprints are the impressions left by the friction ridge skin at the tips of fingers. Similar marks are made by friction ridge skin at other sites on the hands, and on feet. These marks are a special example of the general category of impression evidence, that includes footwear and tire tracks. The figure shows, clockwise from the left: shoe prints, footprints, fingerprint, hand print, fingerprint, print of whole finger. From Stockxpert.
This is an almost everyday story in detective fiction and in fact, of how fingerprints can give a positive identification of a suspect leading to his arrest and trial. This was no ordinary case, however. Clarence was Clarence Hiller, the year was 1910, and the trial and subsequent appeal of the suspect, Thomas Jennings, established the admissibility of the fingerprint evidence in U.S. courts. The Illinois Supreme Court found that “there is a scientific basis for the system of fingerprint identification, and that the courts are justified in admitting this class of evidence; that this method of identification is in such general and common use that the courts cannot refuse to take judicial cognizance of it.” Fingerprint evidence remains today as the forensic science gold standard for personal identification, despite more than a century of challenge and despite the advances in DNA evidence.

**CENTRAL QUESTIONS**

What can be answered:

- Do the fingerprints belong to the individual in question?
SECTION II: Pattern Evidence

We cannot answer the following:

- When were the fingerprints deposited?

We are learning or researching the following:

- What is the race/gender/age of the person who deposited the fingerprints?
- Obtaining DNA from fingerprints.

FINGERPRINTS AND IDENTITY: A BRIEF HISTORY

Fingerprints have imparted a sense of identity for hundreds of years. In ancient China, fingerprints were used to seal documents, and at around the end of the eighteenth century, the English naturalist Thomas Bewick identified his engravings with “his mark” — his fingerprint. The systematic use of fingerprints as a means of identification is more recent, with the following significant timeline:

1858: William Herschel required recipients in Bengal, India, to “sign” for their pensions by leaving their fingerprint.

1880: The first-recorded suggestion that fingerprints could be used to identify someone was made in a letter to Nature by the Scottish physician, Dr. Henry Faulds.

1891: Argentine criminalist Dr. Juan Vucetich began to devise a way to group fingerprints. Confronted with a growing data management problem, he developed a classification system capable of sorting prints efficiently. The framework of his early classification system is still in operation in many Spanish-speaking countries.

1892: Francis Galton set out three principles of fingerprints that formed the basis of a classification system still in use today. In Finger Prints, the first book on the subject, Galton suggested that fingerprints were unique to the individual, unchanging throughout one’s lifetime, and contained sufficient detail to create a classification system by assigning fingerprints to three patterns: loops, whorls, and arches. An ethical scientist, he noted that his system lacked the ability to identify heredity, race, or gender. (Even today, such information cannot be determined from a fingerprint alone.)

1897: Sir Edward Richard Henry created a classification system that is the basis of the one used in the U.S. today. Building on Galton’s work, Henry published a treatise on dactyloscopy in 1900.

1902: First systematic use of fingerprints in the U.S. was conducted by the New York City Civil Service Commission, to avoid fraud in tests.

1904: Fingerprint records used in Leavenworth Federal Penitentiary.

1918: Edmund Locard proposed that if 12 points are the same in two fingerprints, then they are from the same person.

1924: Congress established the Identification Division of the FBI.
THE ANATOMY OF A FINGERPRINT

Fingerprints can be regarded as a special category of mark evidence. The main difference is that the marks are created in skin and therefore offer a means of personal identification. Skin is the largest organ of the body. It provides our first line of defense to infection and the mechanism for our sense of touch. Friction skin provides grip to the hands and feet. In fact, the same friction skin ridges that allow you to hold an object (say, the lid of a cookie jar) may tell a criminalist that you touched it.

Looking at the tip of your finger, you will see a pattern of ridges and grooves. The pattern seen on the epidermis, the outermost layer of skin, is generated by a layer of cells that lie below it. These cells are the dermal papillae. They form a layer between the outer skin and the inner skin, or dermis. Though they grow as we mature, the patterns created by the dermal papillae do not change. Hence, our fingerprints do not become more (or less!) complex over our lives.

Deep in the dermis are the mechanical works of the skin: nerves, capillaries, and sweat glands. Sweat travels up ducts from the dermis to emerge through tiny pores in the cells of the skin ridge. When an object is touched, the fingers work like a self-inking stamp pad.

Figure 4.1 illustrates how the dermal papillae produce the characteristic patterns of friction ridge skin.

FINGERPRINTS AS EVIDENCE OF IDENTITY

Taken together, the principles that Galton outlined in his 1900 text are the reason why fingerprints may be used as evidence in court. We will explore each in turn.

Fingerprints Are Unique

So far, no two fingerprints have been found to be the same. If fingerprints were found to be coincidentally the same, there would be no way to use them to identify individuals. In his early work, Galton calculated there might be 64 billion different fingerprints. More recently, mathematicians have considered that there may be no limit to the number of possible fingerprints. Due to the large number of features present in a fingerprint, the probability for the existence of two identical impressions is extremely small.

Fingerprints Do Not Change over Your Lifetime

Fingerprints do not grow or lessen in complexity as we mature. However, wounds that disturb the dermal papillae will form scars that manifest in the epidermis. Suspects have cut into their fingertips and burned them with heat or chemicals. However, the results are often less than successful. The irony is that any scar formed would in itself become a distinguishing mark identifying the individual.
SECTION II: Pattern Evidence

Fingerprints Have Sufficient Detail to Allow Them to Be Classified Systematically

All fingerprints can be divided into three classes on the basis of their general pattern: loops, whorls, and arches. From 60 to 65% of the population has loops, 30 to 35% has whorls, and about 5% has arches (see Figure 4.2).

FINGERPRINT CLASSIFICATION

Fingerprint records are classified and stored by systems that depend on the three fundamental characteristics described previously. Each of the three pattern types has distinguishing focal points, which are the basis for all 10-finger classification systems presently in use. Systematic classification is aided by other features in the print. Deltas are triangular formations, or a dividing of the ridges, and are found between loops. Loops have a defined center, the core, which provides a reference point.

Loop

The loop pattern is the most common in fingerprints. Occurring in 60 to 65% of fingerprint patterns, loops are concentric hairpin ridges that enter and exit from the same side of the pattern and contain two distinct focal points: the core and...
a delta. The ulnar loop, which tilts toward the ulna bone, or little finger, is the most common. Radial loops, tilting toward the radius bone or index finger, are less common and most often found on the index finger. Deltas can be seen at the bottom left of the highlighted area in the whorl and the loop in Figure 4.2.

**Whorl**

Found in about 30% of fingerprint patterns, the whorl is a rounded or circularly shaped pattern containing two or more deltas. Whorls are divided into plain, central pocket loop, double loop, and accidental types. Plain whorls and a central pocket loop have at least one ridge that makes a complete circuit. To tell the difference between them, an imaginary line is drawn between the two deltas. If the line touches any of the spiral ridges, the pattern is called a plain whorl. If not, the pattern is a central pocket loop. Double loop patterns must contain two separate loops, each with a distinct core in the same fingerprint. Finally, accidental patterns are a broad, catchall class containing combinations of patterns or patterns that do not fit into any other categories. (See Figure 4.3.)

**Arch**

The arch pattern has no delta or core and occurs only in about 5% of fingerprint patterns. In a plain arch, the ridge pattern rises in the middle but does not form a loop. In a tented arch, the center rises sharply in the middle but still does not form a loop.

**The FBI Fingerprint Classification System**

The FBI database contains more than 47 million records and is the largest in the world. The physical records in the FBI classification system are called 10-print cards.
because they contain inked images of each finger. These are the marks labeled "Rolled Impressions" in Figure 4.4 and are—as the name implies—obtained by rolling each inked finger individually over the card. The rolling ensures that all ridge detail is captured. The "Plain Impressions" at the bottom of the card are taken by pressing all fingers directly onto the card and are used as a quality control check of the sequence of rolled prints.

The primary classification comes from the Henry system. It is called the primary classification because it is the first step in the FBI classification system. Ridge patterns from all 10 fingers are used to divide fingerprints into classes. To find the primary classification, the ridge patterns of fingerprints are converted into letters and numbers, and the scores are paired in a fraction as follows:

R. Index R. Ring L. Thumb L. Middle L. Little + 1
R. Thumb R. Middle R. Little L. Index L. Ring + 1

The basis for the determination of the primary classification is the presence or absence of the whorl pattern. Arch and loop patterns are given values of zero. Whorl patterns have different values depending on where they occur. In the first pair, the value of the whorl pattern is 16, and it decreases by a factor of 2 for each pair. The reason for adding 1 to the sum of values in the numerator and denominator is to avoid a zero classification and avoid dividing by zero.
LIMITATIONS OF THE PRIMARY CLASSIFICATION

Using the primary classification, fingerprints can be grouped into 1024 categories. For example, if no whorls occur, the primary is 1/1. About 25% of people fall into this primary classification. Hence, even the FBI system can identify not an individual but rather a group of likely suspects.

Because they depend on complete prints from all 10 fingers, the Henry and FBI classification systems best serve cases where a full set of fingerprints is collected for comparison. Most crime scenes do not afford the investigator that luxury.

FINGERPRINTS AND IDENTIFICATION

Although loops, whorls, and arches, together with deltas and cores, provide an effective method for classification of fingerprints, they do not contain sufficient unique detail to permit identification of the person who left a print at the scene of a crime. Identification depends on the finer detail contained in ridge patterns. The broad categories described by Galton are described as general ridge flow and pattern features, or level 1 detail. Level 1 detail may be used for exclusion but, as we saw earlier with the primary classifications in the FBI database, it cannot provide identification. The next level of detail—level 2—found in minutiae does permit individualization and is discussed in the next section. There is a further degree of detail—level 3—but we will focus on the widely used information present at level 2, leaving level 3 for more advanced study.

Minutiae

Despite their pattern, all fingerprint types have many distinguishing characteristics in their ridge details, collectively termed minutiae. These fine details are the basis for individualization from a fingerprint lift. Examples of minutiae include ridge endings (where a ridge terminates), bifurcations (the branching of one ridge into two), and islands (short ridges; sometimes the island is extremely small and is classed as a dot). Minutiae are mapped by scanning a recovered print into a computer and then analyzing the resulting image. A single rolled print may have as many as 100 individual points, the number depending on the location of the print, there being more in the region near a delta. (See Figure 4.5.)
SECTION II: Pattern Evidence

COMPARING MINUTIAE

Comparison of minutiae—sometimes referred to as *Galton points*—is the accepted method for identification of latent prints. The basis of the comparison lies in the relative spatial orientation of the minutiae, sometimes assisted by reference to a fixed point such as a delta. A typical “map” is shown in Figure 4.6.

Many examiners in the U.S. now follow the so-called ACE-V method for identification: analysis, comparison, evaluation, and verification. *Analysis* consists of the objective qualitative and quantitative assessment of level 1, level 2, and (in some cases) level 3 details to determine their proportion, interrelationship, and value to individualize. *Comparison* is the objective examination of the attributes observed during analysis in order to determine agreement or discrepancies between two friction ridge impressions. *Evaluation* is the cyclical procedure of comparison between two friction ridge impressions to effect a decision, that is: made by the same friction skin, not made by the same friction skin, or insufficient detail to form a conclusive decision. *Verification* is the independent analysis, comparison, and evaluation by a second qualified examiner of the friction ridge impressions. Evaluation is a subjective step, and that is why the verification process is so important.

With poor-quality images, sometimes the data must be enhanced before a comparison can be attempted. Enhancing an image often requires an adjustment of the contrast. The process uses filters similar to those found in commercial digital photography software. A low-pass filter decreases contrast, while a high-pass filter increases it. Filters and algorithms with different selectivity are used to increase the contrast of a fingerprint from a colored or patterned background. A similar process can be applied to deconvolute overlapping prints. It is important that any process used only enhances the quality of the data and does not result in qualitative changes. Finally, examiners are increasingly turning to computers to assist with the task of comparing minutiae. Ridge detail data can be scanned in from the image of a latent print or analyzed from a digital photograph. Once digitized, information from the latent image can be compared to known information on file.
METHODS OF DETECTING FINGERPRINTS

Natural fingerprints transferred to articles at a crime scene arise from deposits of secretions from eccrine sweat glands, or from secondary residues from sebaceous or apocrine glands picked up on the fingers by touching surfaces such as the nose and that are then left in the fingerprint. Other sources include prints left in blood or imprints from greasy materials such as lubricants that might have been used in a rape.

Processing the crime scene or evidence items for fingerprints starts with a search for visible prints. They might be rendered in dirt, blood, or grease and found on hard or soft, porous or nonporous surfaces. On very soft surfaces like wax, clay, or paint, the criminalist may find plastic prints, an actual impression of the friction skin ridges. Plastic prints are almost like castings of fingerprints. Both of these types of fingerprints can be seen with the unaided eye.

After completing the search for visible (or patent) prints, the examiner will look for latent prints, or those that are not readily visible. There are many procedures available for development of latent prints, and the choice depends on several factors. In all cases—visible and developed latent prints—it is essential to record the evidence by photography and to process the items in a manner that preserves the integrity of the print.

To find a latent print, the examiner will select an appropriate method based on properties of the surface being examined, such as whether it is hard or soft, porous or nonporous, absorbent or nonabsorbent. Porous surfaces generally will preserve the print because it penetrates into the material, but they can present problems to some of the reagents used, as they too soak into the substrate. In contrast, nonporous surfaces such as glass require careful handling to prevent the latent print from smearing or being wiped off. The techniques applied will proceed from the least destructive method. Generally, the order of application is the use of lights, dusting, chemical staining or developing, and lifting/preserving.

BOX 4.1 HOW MANY POINTS?

There is no standard for, nor do experts agree on, the number of minutiae required for two fingerprints to be considered the same. Ninety years ago Locard suggested 12 points, and most jurisdictions subsequently established rules requiring somewhere between 12 and 16 points, although some required as few as 8. However, in 1973 the International Association for Identification (IAI) published a report that concluded, “No valid basis exists at this time for requiring that a predetermined minimum number of friction ridge characteristics must be present in two impressions in order to establish positive identification.” An international conference in June 1995 came to the same conclusion.
SECTION II: Pattern Evidence

The importance of the integrity of recording and development of latent prints is illustrated by the case of Ray Mickelberg and his brothers. Because latent prints are a physical deposit, it is theoretically possible to lift a print from one solid object and transfer it to another. The transfer could also be made from a facsimile of the original finger. The Perth (Australia) mint was hit by a sting operation in 1982. Two men made a series of small purchases of gold bullion, and, having established credibility, bought $650,000 (Australian) of bullion with a check that then bounced. Police arrested and charged three brothers, Peter, Ray, and Brian Mickelberg. The brothers were tried and convicted in 1983 on evidence that included a partial print recovered from the check that was a match to Ray. The Mickelbergs protested their innocence, claiming that the fingerprint was a plant. During the investigation, the police had raided the brothers’ apartment and found a bucket of silicone rubber casts of the hand and fingers of Ray. The brothers claimed that the police had then used one of the finger casts to plant the partial print by coating it with sebaceous secretions from the nose and rolling it over the check. There were several appeals, and points concerning the fingerprint were never completely resolved. One of the issues was whether the photographs of the latent print images were positives or negatives. If the partial print on the check had been planted as alleged, then the developed print would have been a negative of a natural print because the sweat secretions on the cast would be on the surface of the ridges rather than in the valleys, as is the case with natural prints. The records of the print processing could have been better, opening the door to several challenges. There were also disagreements as to whether the pattern of a print rolled from a firm object such as the cast would look the same as a rolled print from much a softer finger. None of the several appeals succeeded.

An interesting postscript to the cases was written 20 years after the trial when one of the officers involved admitted that the confessions produced in evidence were false. The Mickelbergs were freed, but no judgment was made regarding the prints.

Case Study

The Mickelberg Finger

The importance of the integrity of recording and development of latent prints is illustrated by the case of Ray Mickelberg and his brothers.

We will consider the main techniques in the order that they are generally applied and then review some of the recommended protocols for approaching the development of latent prints.

Lights

Using light to visualize and record a print photographically is a nondestructive technique that does not interfere with the application of subsequent visualization methods. Using fiber-optic cables, light can even be made to bend around corners for a better look. There are several systems available, but the underlying principle of most is to use high-energy beams of ultraviolet (UV) light in the 400 to 200 nm wavelength range to locate prints on nonabsorbent surfaces. UV light is invisible to the naked eye but interacts with organic chemicals to cause fluorescence, resulting in the emission of light in the visible spectrum. The interaction can be with components of sweat or with chemicals applied to the surface. Natural fingerprints detected in this way are then photographed or further developed and preserved.
There was considerable interest in using lasers as the light source, but due to their cost and advances in chemical techniques, lasers have largely been replaced by alternative light sources. The differences between the two light sources are narrowing as lasers become less costly and more portable on the one hand and alternate light sources become more powerful on the other. (See Figure 4.8.)

**ALTERNATIVE LIGHT SOURCES**

Alternative light source (ALS) is the term generally used to describe a portable, high-intensity light source, such as halogen and xenon or indium arc lamps. These powerful light sources can be tuned to a particular wavelength using filters. Tuning the wavelength modulates the contrast of the print from its surface.
Dusting

Dusting powders consist of an adhesive and a contrast agent or colorant. When dusting for fingerprints, contrast is key. Dark powders, such as pulverized charcoal, are applied to light-colored surfaces and vice versa. The dusting agent is gently applied with a brush and either adheres to or reacts with components in the fingerprint, giving definition to the ridge pattern.

Many common powders are formulated with metals. Aluminum agents are generally adherents, while silver salts may be used to actually react with the print. Despite their toxicity and expense, these powders offer great stability. On rough surfaces, or to avoid smudging the print with a bristled brush, a criminalist can employ magnetic-sensitive powder using a magna brush, a magnetic wand.

Newer powders are formulated with a variety of fluorescent and phosphorescent dyes. Once these agents bind to a print, they can be illuminated and photographed under various light sources. These powders give good contrast for prints on uneven or multicolored surfaces but often need to be used in.
controlled conditions, making them poor choices in the field. Examples of dyes include crystal violet, acridine orange and yellow, Nile blue, and rhodamine B. (See Figure 4.9.)

**Developers and Stains**

**IODINE**

The oldest chemical technique in the book is the use of iodine. Fuming iodine is an excellent method for finding fingerprints on paper and cloth. Iodine reacts with fatty acids and moisture, visualizing a latent print with a yellow-to-brown color within a few seconds. However, because iodine sublimes so easily, developed prints will fade. The visualized prints must be immediately photographed or fixed.

**FIGURE 4.9**

Various techniques are used to develop latent prints, often depending on the color and nature of the substrate. Clockwise from top left: Camel hair brushes used to apply powders and light print developed on dark background by applying silver powder; magnetic brush and print on golf ball developed using magnetic gray powder formulated for use on plastic surfaces; fluorescent powder and print developed on multicolored background by application of the powder. Images courtesy BVDA America Inc.
SECTION II: Pattern Evidence

Fixing the prints, like fixing a photograph, requires one more chemical step. The simplest method is treatment with a starch solution, which results in a long-lasting, blue-tinted print. On fine porous surfaces, such as facial tissue or tissue paper, 7,8-benzoflavone is used as the fixative.

More durable surfaces can be rubbed with silver foil or dusted with silver powder. Iodine adsorbed on the fingerprint residue will react with silver atoms to give a yellow salt, silver iodide. This salt eventually oxidizes in air and light to silver oxide, turning the print black.

**NINHYDRIN**

Ninhydrin has surpassed iodine as the most popular chemical method for processing latent fingerprints on porous, absorbent surfaces like paper, cardboard, and wood. Because amino acids do not react with the cellulose in paper or wood, the technique can be used on old prints. Ninhydrin reacts with amino acids in sweat, coloring the print purple (Ruhemann’s purple). The color develops slowly and may take several hours to fully react. To increase their contrast, nonfluorescent Ruhemann’s purple prints may be treated with metal salts to form photoluminescent complexes that reflect well when illuminated with laser light. Similar to ninhydrin but more sensitive, 1,8-diazafluoren-9-one (DFO) reacts with the amino acids and can be used to visualize fingerprints on paper using a tunable light source.

**CYANOACRYLATE**

Also called the “fuming Superglue technique,” cyanoacrylate is used for processing latent prints on paper, plastic, and skin. Cyanoacrylate undergoes base-catalyzed polymerization. The polymer binds with sweat to visualize a latent print in a flat, white color over a few hours. To improve the visibility and contrast, the white prints can be dusted with fluorescein or crystal violet dye or a rhodamine-based magnetic powder and then photographed using an appropriate light source. The technique is so successful that small handheld devices have been created to allow the criminalist to work on prints in place at the scene. (See Figure 4.10.)

**PHYSICAL DEVELOPER**

When ninhydrin does not work, chemists often turn to Physical Developer (PD), an excellent reagent for paper and wood surfaces. PD reacts with oils, and, as such, it can be used on wet paper or paper that has been washed. Unfortunately, PD is a destructive method. Because it destroys any trace proteins, it must be used last. Further, the reagent solution is both difficult to prepare and unstable once made.

The formulation contains an aqueous solution of silver ions (silver nitrate), a buffered iron redox reaction, and a detergent. The detergent prevents the premature deposition of silver ions. Silver reacts with the print to produce a black image. Silver nitrate can be used on its own to develop prints on surfaces such as paper. The development of the latent print is caused by the reaction between the silver and chloride ions in sweat in the latent print. The silver chloride is light sensitive and turns black on exposure to light.
SMALL PARTICLE REAGENT

A small particle reagent is a suspension of small particles of molybdenum disulfide that adheres physically to fatty substances in the latent print. It is notable for being resistant to water and can even work under water.

VACUUM METAL DEPOSITION

Vacuum metal deposition is a mechanical recovery method that works on the principle that fingerprint contamination hinders the deposition of a metallic film following evaporation under vacuum. This extremely sensitive technique for fingerprint detection on a variety of surfaces can be used in conjunction with cyanoacrylate fuming. (See Figure 4.11.)
BLOODSTAINS
Contact between bloody fingers and objects often results in deposition of a patent fingerprint. However, latent prints deposited by bloodstained fingers where there is insufficient blood for a patent image can be developed using reagents that stain proteins or those that react with the heme in blood and that are used as screening reagents in forensic biology. The general protein stains include amido black, coomassie blue, and Hungarian red. Heme reactants include leucomalachite green and luminol. All these reagents, other than luminol, produce a color that can be seen by the naked eye and recorded by conventional photography. Luminol, which is by far the most sensitive, produces a short-lived fluorescence that needs a darkened environment to see and special photography. Luminol is also toxic and must be used with care. Latent print examiners must always remember that blood itself can carry lethal pathogens such as HIV and hepatitis C and should treat every blood scene as potentially infective.

TAPES
Adhesive tapes, such as those used to bind and gag victims, present a challenge to the examiner because of their surface nature—usually one shiny nonporous surface and the other porous and sticky. Reagents that work with tapes include gentian violet, Sticky Side powder, and titanium dioxide. Gentian violet reacts with fatty substances in the sebaceous secretions, and the other two physically fill the print.

Selection of Reagent for Development of Latent Prints
There are dozens, if not hundreds, of reagents available for development of latent prints. In many cases the choice reflects the personal experience and preference of the examiner. However, the more commonly used reagents can be classified according to the surface on which they are best suited for use. Table 4.1 is based on the recommendations of the FBI for reagent selection. See also Figure 4.11.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Reagent</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous or nonporous</td>
<td>Powders</td>
<td>Physical adherence to moisture and lipids. Includes metallic powders and luminescent dye-tagged powders. Very wide range available; select to give optimum contrast with substrate.</td>
</tr>
<tr>
<td></td>
<td>Iodine</td>
<td>Physical process, fumes react with sebaceous secretions.</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Substrate</th>
<th>Reagent</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous</td>
<td>DFO</td>
<td>Chemical reaction with amino acids.</td>
</tr>
<tr>
<td></td>
<td>Ninhydrin</td>
<td>Chemical reaction with amino acids.</td>
</tr>
<tr>
<td></td>
<td>Physical Developer</td>
<td>Chemical reaction with lipids. Works on previously wet materials.</td>
</tr>
<tr>
<td>Nonporous</td>
<td>Cyanoacrylate fuming</td>
<td>Chemical reaction, polymerization of latent print residues. White deposit, which can be enhanced with fluorescent dyes and viewing under UV light. Physical process, adheres to sebaceous secretions. Can be used on wet surfaces and is one of the few reagents that will work after print has been treated with cyanoacrylate.</td>
</tr>
<tr>
<td></td>
<td>Small particle reagent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vacuum metal deposition</td>
<td>Metal is deposited on fatty components of latent residues. Works on plastic and is good for use on older prints.</td>
</tr>
<tr>
<td></td>
<td>Sudan black</td>
<td>Chemical reaction with fatty components. Good for use on greasy prints.</td>
</tr>
<tr>
<td></td>
<td>Coomassie blue, crystal violet, Hungarian red, leucomalachite green, luminol</td>
<td></td>
</tr>
<tr>
<td>Reagents for use on tapes</td>
<td>Gentian violet</td>
<td>Reacts with skin cells and lipids. Use on light-colored adhesive tape.</td>
</tr>
<tr>
<td></td>
<td>Sticky Side powder</td>
<td>Physical process. Use on light-colored tape.</td>
</tr>
<tr>
<td></td>
<td>Titanium dioxide</td>
<td>Use on plastic, electrical, and duct tape — both sides.</td>
</tr>
</tbody>
</table>
SECTION II: Pattern Evidence

Preservation of Developed Prints

The two most common ways to preserve fingerprint evidence are photography and lifting the print. As a first step in preservation, fingerprint evidence is usually photographed. The crime scene photographer will take an image of the print where it was discovered, a context photograph, and several close-up images. Depending on how the print was visualized, the photography might be done under an alternate light source.

If the print is on an object that is too big to be used in court or impossible to remove from the crime scene, the criminalist may “lift” it using tape. When removed, an image of the developed print will strip away with the tape. The image then can be attached to a piece of cardboard and easily transported to the courtroom or elsewhere. Today there are also commercial lift kits where the tape and backings—in a variety of colors—are combined. (See Figure 4.12.)

DATABASES OF FINGERPRINTS

Automated Fingerprint Identification System (AFIS)

As fingerprint collections have continued to grow, manual searches of card files have been greatly augmented by computer searches. Automated fingerprint identification systems (AFISs) can encode or search even for single, partial prints with high speed and throughput.

Recovered prints are scanned. Then the resulting digitized images are mapped for ridge details such as terminations, bifurcations, and islands. The maps are stored as geometric patterns in large databases. When a new print is recovered, a search algorithm can look through the database for prints that are similar to the exemplar and provide an estimate of the correlation. The recovered print and the print from the database then can be examined side by side.

Like any system, AFIS has limitations. Poor-quality prints or poorly scanned prints may not show enough correlation to generate a hit. Worse, until recently
there was little interoperability between jurisdictions. The National Institute of Standards and Technology (NIST) created a data template that allowed for freer exchange of fingerprint information.

**Integrated Automated Fingerprint Identification System (IAFIS)**

In 1999, the FBI and its Criminal Justice Information Services (CJIS) Division launched the Integrated Automated Fingerprint Identification System (IAFIS), a national fingerprint and criminal history database. This represented a great breakthrough of interoperability. With more than 47 million entries in its criminal profile register, IAFIS is now the largest biometric data bank in the world. (See Figure 4.13.)

The fingerprints and corresponding criminal histories, as well as queries to the database, are submitted by law enforcement agencies of all levels: municipality, county, state, or federal. Because the submissions and queries are electronic, there is never a delay to starting a search or making a new set of data available. In some cases, information can even be exchanged with the field. The database can also be used for civilian purposes such as for pre-employment background investigations.

**FINGERPRINTS AND COLD CASES**

The advances in technology for latent print identification and in data storage and automated comparisons have meant that fingerprints are one of the most powerful tools in the current wave of interest in reopening old, unsolved cases—cold cases.

**Case Study**

**George Akopian—A Successful Cold Case**

As an illustration, the Los Angeles police cold case detectives solved a decades’ old homicide, bringing bitter-sweet closure to the victim’s family and the investigators themselves.

During the evening hours of March 18, 1973, George Akopian, 54, of Tarzana, was home with his wife when he was shot and killed by a man who had answered Akopian’s advertisement to sell a stamp collection. Akopian was heard arguing with the suspect just prior to the shooting. The suspect shot Akopian once in the chest, killing him.

The case lingered unsolved until 2005, when cold case detectives Rick Jackson and Richard Bengston reopened the investigation. They discovered that a fingerprint had

**Computer searches should not substitute for printing known suspects. Further, computers do not determine identification or testify in court. A trained examiner must render that opinion after comparing the presence and location of minutiae.**

**FIGURE 4.13**

Examiner at CJIS IAFIS station. From www.fbi.gov/hq/cjisd/iafis.html
SECTION II:  Pattern Evidence

In 1901, the first official use of fingerprints for systematic personal identification in the U.S. was adopted by the New York City Civil Service Commission to certify all civil service applications. The use of biometrics has grown considerably in the more than a century since then. Biometrics are measurements of physical characteristics of an individual that can be used to verify his or her identity when checked against a known exemplar in a database. Fingerprints are probably the best known biometric, but others include palm prints, facial recognition, and iris scans. Most of the advances have taken place in the last 10 years, driven by enhanced technology and efforts to control terrorism. For example, many countries have adopted machine-readable passports with biometrics to help ensure better border security.

In the Enhanced Border Security and Visa Entry Reform Act of 2002, the U.S. Congress mandated the use of biometrics for travelers who want U.S. visas. Digital photos and electronic fingerprint scans were chosen as the standard biometric. Both index fingers of a visa applicant are electronically scanned during the required interview with a consular officer at a U.S. embassy. The process is quick, painless, and inkless. The fingerprint scans are stored in a database and made available at U.S. ports of entry to Department of Homeland Security (DHS) immigration inspectors.

Scanned fingerprints are sent electronically with a photo and biographic data to the Consular Consolidated Database (CCD) in Washington, DC. The CCD relays the information to the Department of Homeland Security's IDENT system over a reliable, direct transmission line, which sends the results back to the CCD for relay back to the post. Until a good report from IDENT is received, the visa system is locked with regards to that visa application. For the remaining posts, the IDENT checks are being reviewed in the department and posts are notified of any hits.

Closure has been bittersweet, because Fico died in 1995 from injuries he sustained in a traffic accident in Spokane, Washington, where he was living.

Detective Jackson conceded that “There is pleasure in closing a case, but the true satisfaction comes from providing justice to the families of victims.” In spite of the disappointment of not having the opportunity to hold the suspect accountable for this crime, detectives expressed satisfaction in knowing that they were successful in solving an age-old crime.

The preceding case information comes from http://lapd blog.typepad.com/lapd_blog/2007/02/thirtyyearold_c.html
If no hit is returned from the IDENT lookout database, then the applicant’s data are stored in the US-VISIT database in IDENT and a fingerprint identification number (FIN) is generated. Once the visa has been issued, the nonimmigrant visa system sends to the DHS Interagency Border Inspection System (IBIS) the applicant’s photo and the fingerprint identification number. When the visa applicant arrives at a port of entry, the US-VISIT system will use the fingerprint identification number to match the visa with the file in IDENT and will compare the visa holder’s fingerprints with those on file. This comparison ensures that the person presenting the visa at the port of entry is the same person to whom the visa was issued.

**SUMMARY**

Fingerprints are the impression of friction skin ridges of the fingers and thumbs. Visible prints and plastic prints, those left as an actual impression in soft material, both can be seen with the unaided eye. Latent prints, those that cannot be immediately seen, must be developed chemically or dusted with a contact powder to be detected. Once visualized, the print must be photographed and either preserved in place or lifted. Techniques are employed from the least destructive to the most destructive.

Francis Galton outlined three basic principles of fingerprints that provide the basis for their use in law enforcement: Fingerprints are unique to the individual, remain unchanged during an individual’s lifetime, and have sufficient detail in their ridge patterns to permit them to be systematically classified.

Fingerprint patterns can be divided into three basic types that occur in different frequency: loops (60–65%), whorls (30–35%), and arches (5%).

Verification that a fingerprint belongs to a certain individual is determined by a point-by-point comparison. Today there are databases such as AFIS and IDENT, which store images of fingerprints and analyses of their ridge details, but a trained expert still must make the determination of identity.

**PROBLEMS**

1. Give the word or phrase for the following definitions:
   a. a reproduction or impression of friction skin ridges of the fingers
   b. a fingerprint pattern containing one delta and a defined core
   c. a fingerprint pattern with no delta, core, or type line
   d. a fingerprint that can be seen with the unaided eye
   e. a fingerprint not readily seen with the unaided eye
   f. a circular fingerprint pattern that tilts toward the little finger
   g. the simultaneous printing of all the fingers of each hand
   h. a fingerprint pattern composed of an arch and a loop

2. List the three principles of fingerprints.
3. List the three general patterns of fingerprints in order of decreasing frequency of occurrence.
4. Look at the fingerprint at the bottom center of the introductory illustration to the chapter and identify
   a. a bifurcation point
   b. an island
   c. a ridge ending
5. Look at the photograph and identify the
   a. whorl, arch, or loop if present
   b. delta if present
   c. any other feature that could be used to classify the print
6. Print your right index finger and make a list of as many features as you can find.
7. Describe the appropriate use of the following developing agents:
   a. iodine fixed with starch
   b. ninhydrin
   c. cyanoacrylate fumes
   d. physical developer
   e. high-contrast dusting powder
8. What is the best order to deploy visualization techniques to preserve evidence for additional testing?
9. What techniques can be used to preserve fingerprint information once a latent print has been visualized?
10. Describe the process for determining the primary classification in the Henry system. How are the categories determined? Which is the most populated category?
11. Describe the use of alternative light sources in discovering latent prints.
12. Define fluorescence, phosphorescence, and incandescence.

GLOSSARY
Accidental a pattern of ridge details that does not fit into one of the regular categories.
ACE-V the standard procedure used in the U.S. for fingerprint comparison.
Bifurcation the division of one ridge into two.
Biometrics the use of physical characteristics to establish the identity of someone.
Central pocket loop whorls a pattern with two deltas and at least one recurving ridge that makes a round shape. If the two deltas were connected by an imaginary line, this line would not touch or cut any recurving ridge within the pattern.
Core the center of a loop pattern.
Cyanoacrylate using cyanoacrylate (Superglue) vapor as a method to visualize latent fingerprints.
Dactyloscopy a system of identification developed by Sir Edward R. Henry from work done by Sir Francis Galton.
Delta a triangular formation made by interacting ridge lines.
Dermal papillae the region between the dermis and epidermis responsible for the ridge patterns on the surface of skin.
Double loop two separate loops, each with a distinct core in the same fingerprint.

FBI classification the FBI use eight different types of patterns: radial loop, ulnar loop, double loop, central pocket loop whorls, plain arch, tented arch, plain whorl, and accidental.

Iodine developer the use of sublimating iodine to visualize latent fingerprints. Because iodine turns from a solid to a gas under ordinary conditions, the developed fingerprints are often fixed with a starch solution.

Island a very short ridge giving the appearance of a dot in a fingerprint.

Latent fingerprint a fingerprint for which the detail cannot be seen with the unaided eye. There are a variety of techniques for visualizing latent fingerprints.

Loop fingerprints with concentric hairpin ridges that enter and exit from the same side of the pattern. This pattern containing one delta is found in about 65% of fingerprints.

Minutiae the fine details of a fingerprint such as bifurcations and ridge endings that allow for comparison of samples.

Ninhydrin developer the use of this chemical is to react with amino acids and visualize latent fingerprints.

Physical developer a reagent containing silver ions that is used to locate latent prints on paper or wood.

Plain arch a delta-less pattern that rises in the middle but does not form a loop.

Plain impression/flat impression the simultaneous printing of all the fingers of each hand and then the thumbs without rolling used to verify the sequence and accuracy of rolled impressions.

Plastic print the impression of a fingerprint left in soft or malleable material.

Radial loop a loop that tilts toward the radius bone or index finger and is most often found there.

Ridge ending the terminal point of a ridge.

Rolled impression the individual printing of the thumb, index, middle, ring, and little fingers of each hand done by rolling the finger from one edge of the fingernail to the other.

Silver developer the use of silver salts, which oxidize to silver oxide when exposed to air or other chemicals, as a method to visualize latent fingerprints.

Tented arch a delta-less pattern that rises sharply in the middle but does not form a loop.

Ulnar loop a loop that tilts toward the ulna bone, or little finger, the most typical loop of all.

Visible print a fingerprint that can be detected with the naked eye.

Whorl a circularly shaped pattern containing at least two deltas and occurring in about 30% of fingerprints.