

## Objectives

After reading this chapter, you will understand:

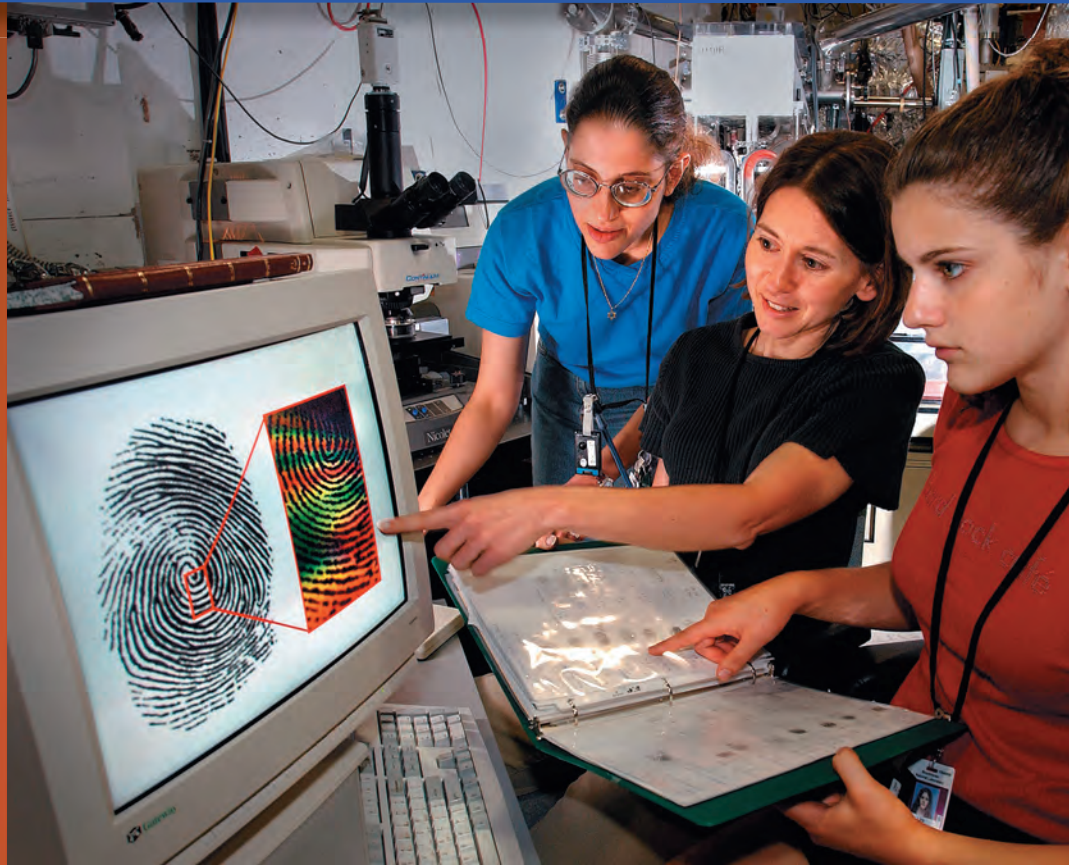
- Why fingerprints are individual evidence.
- Why there may be no fingerprint evidence at a crime scene.
- How computers have made personal identification easier.

You will be able to:

- Define the three basic properties that allow individual identification by fingerprints.
- Obtain an inked, readable fingerprint for each finger.
- Recognize and classify the three general ridge patterns (loops, whorls, and arches) and apply them to the primary Henry-FBI classification.
- Identify and compare friction ridge characteristics and compare two fingerprints with at least ten points of identification.
- Tell the differences among latent, plastic, and visible fingerprints.
- Develop latent prints using physical and chemical methods.
- Use simple probability theory to estimate odds.
- Identify questions and concepts that guide scientific investigations.

**“Fingerprints cannot lie, but liars can make fingerprints.”**

*—unknown*





## At the Crime Scene

### Teacher Note

The TRCD for this chapter includes a PowerPoint presentation, which is an overview of the chapter. It can be used as introductory material or at the end as a review.

The TRCD also contains a crossword puzzle that can be used after students have learned the vocabulary from this chapter.

### Teacher Note

Evidence at the scene might include: fingerprints, footprints, bite marks, pry bar impressions, fabric, blood, handwriting. Potential evidence might also be found with the suspect: fingerprints, shoe prints, the pry bar, dog hair, the torn shirtsleeve, blood type, DNA, handwriting and poor spelling, damaged pants leg, wounds on leg, broken glass, soil, stolen jewelry, teeth.

Fewer than 15 percent of burglaries are solved after one hour has gone by. Right after the crime, a “hot search” may find the burglar in the vicinity. Later, a “cold search” is usually unproductive. The trail grows cold very rapidly.

A burglar approached a house from the backyard late one evening, knowing that the owners were not at home. He tried and failed to pry open several windows behind a flowerbed. Finally, he broke a windowpane with the old pry bar he carried; reached through, scraping his shirtsleeve against a jagged shard of glass; and turned the latch. He raised the window, not thinking about how soft the putty was when his fingers touched the glass. He climbed in over the sill and was promptly bitten on the leg by the owner’s golden Lab, provoking a sharp blow to the dog’s head with the pry bar.

The burglar then went upstairs to the bedrooms to collect jewelry. On his way out through the kitchen, he took a bite from a piece of cheddar cheese that was on the counter. Feeling pretty good about his haul despite his bloody leg, he left a note on a pad near the cheese: “Thanks for everthing, suckers.” He unlatched the back door and disappeared into the misty night.

What evidence could link the burglar to the burglary? Make a list.



Burglar



Magnified finger ridges

Let's concentrate on just the fingerprints for now. Just what is a **fingerprint**? A fingerprint is an impression of the pattern of ridges on the last joint of a person's finger. Properties that make a fingerprint useful for identification are: (1) its unique, characteristic ridges; (2) its consistency over a person's lifetime; and (3) the systematic classification used for fingerprints.

Are humans the only species to have fingerprints? Why do we have them? Ridge patterns may be an evolutionary development that provides a better grip, makes perspiration easier on a hairless surface, and improves the sense of touch. The fingers, for example, are so sensitive that a vibration with a movement of 0.02 **microns** ( $2 \times 10^{-5}$  mm) can be detected. Apes and monkeys also have ridge patterns on their fingers and toes.

**fingerprint:** an imprint made by ridge patterns on the tip of a finger; also used to describe the characteristic pattern of DNA fragments

**microns:** A micron is one-millionth of a meter or one-thousandth of a millimeter.

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#### Teacher Note

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A most interesting treatise on the history of fingerprints can be found in Chapter 1 of Lee and Gaensslen's *Advances in Fingerprint Technology*.

## The History of Fingerprints

Fingerprints left in clay by early artisans and scribes served as a kind of signature. During China's T'ang dynasty (eighth century AD), clerks used inked fingerprints on business contracts; this practice was not so different from using a chop mark or, in Europe, a seal as a mark of authenticity. A number of people throughout history made note of fingerprints and even commented on the different ridge patterns, but the science of **dactyloscopy**, the study of fingerprints, really started in the 19th century in India with William Herschel.

Herschel was a highly placed British civil servant who decided to require Indians to add their fingerprint to contracts. Later (in 1877) he introduced the use of fingerprints as a means of identifying prisoners. Meanwhile, in Japan, molded fingerprints in old pottery piqued the interest of Henry Faulds, a health missionary in Tokyo who published a scientific paper in 1880 about the possibility of using fingerprints to identify criminals. Like Herschel, Faulds thought that fingerprints were unique; he also claimed that fingerprints did not change over a lifetime and that they could be classified for sorting purposes to help

**dactyloscopy:** the study of fingerprints. The word is derived from the Greek *daktulos*, meaning finger.

"When bloody finger marks or impressions on clay, glass, etc. exist, they may lead to the scientific identification of criminals. Already I have had experience in two such cases. . . . There can be no doubt as to the advance of having, besides their photographs, a nature-copy of the forever unchangeable finger furrows of important criminals."

—Henry Faulds in *Nature*,  
October 28, 1880

Henry Faulds found  
bits of pottery  
In the sands of the  
Japan Sea  
From prints in clay  
To images today  
He started dactyloscopy

in identification. He described an ink-and-transfer method of recording prints, and was the first to use fingerprints to solve a crime.

Identification has always been a problem for the criminal justice system. Throughout history, prisoners were often branded or tattooed or even had hands or fingers chopped off so they would be recognized as criminals. This practice was generally abolished in the Western world in the early 1800s. Police recorded descriptions of individuals, even employing men with “photographic” memories. The advent of photography helped, but without a means of classification, the police records were soon overwhelmed with too many photographs to be useful.



Bertillon's foot measurement

In 1881 Alphonse Bertillon, employed as a ledger clerk at the police headquarters in Paris, suggested using certain body measurements as discriminating characteristics to identify habitual offenders. Bertillon first recommended recording 11 measurements, such as height, reach, width of head, length of foot, and so on. Over the years, a very consistent method of measurement, description, and classification was worked out, and by the end of the 19th century it was accepted almost everywhere. The science of human measurements is called **anthropometry**.

Francis Galton, a British anthropologist, studied both dactyloscopy and Bertillon's anthropometry. In 1891 and 1892, he published

two books in which he showed how to classify fingerprints using loops, whorls, and arches, as well as a secondary, more complex method. Most important, however, he showed that a person's fingerprints stay the same from birth until death, that no two fingerprints are identical, that prints cannot be altered, and that it is possible to classify a very large number of prints.

By 1897, working with Galton, Edward Richard Henry, inspector general of police in Bengal, India, had simplified Galton's classification system and established the Henry classification system of identification in India, replacing Bertillon's method. Scotland Yard adopted Henry's system in 1901. Today, most English-speaking countries use some form of the Henry system.

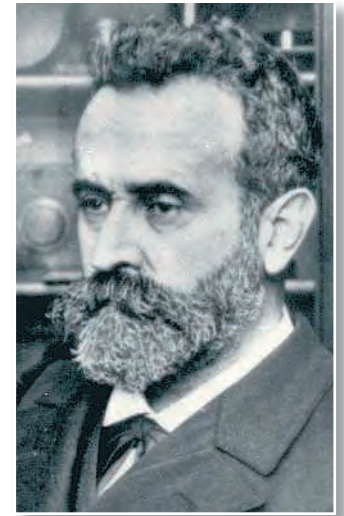
**anthropometry:** the study of human body measurements. The word is derived from the Greek *anthropos*, meaning man.

In 1883 Mark Twain published *Life on the Mississippi*, in which fingerprints were used as evidence to solve a crime. He used this theme again in 1894 in his story “Tragedy of Pudd'nhead Wilson,” in which a lawyer's hobby of collecting fingerprints proved the innocence of two friends. This was two years after Galton's articles were published.

	<b>GO TO</b> <a href="http://www.scilinks.org">www.scilinks.org</a>
	<b>TOPIC</b> biometrics
	<b>CODE</b> forensics2E74

In 1901 an Argentinean police official, Juan Vucetich, set up a workable fingerprint classification system based on Galton's method that has been refined and is used in Spanish-speaking countries. A year later, Vucetich first officially identified a criminal using fingerprints. In a small town in the province of Buenos Aires, Argentina, a woman named Francesca Rojas had murdered her two sons and blamed the attack on a neighbor. Using Vucetich's methods, police identified bloody fingerprints on a doorpost as Rojas's, which led to her confession.

The death knell of Bertillon's anthropometric classification system supposedly came at Leavenworth Prison in 1903 when a man named Will West arrived there to serve time. As was done with all prisoners on admission, his Bertillon measurements were taken and compared to existing files. Prison officials were astonished to find that another man who was serving a life term for murder had almost identical measurements (see Table 4.1); even more amazing, his name was William West, and he looked almost the same as the new prisoner! Subsequently, the two men's fingerprints were taken and, of course, were quite different.



Alphonse Bertillon 1853-1914

Bertillon invented an ID  
Based, in part, upon physiognomy  
It was the best  
Until Willy West,  
Then it failed with ignominy.

**Table 4.1: Bertillon Measurement Comparison of Will West and William West**

Body Part	Will West's Measurements, in cm	William West's Measurements, in cm
Body height	178.5	177.5
Outstretched reach of both arms	187.0	188.0
Trunk height	91.2	91.3
Width of the head	19.7	19.8
Length of the head	15.8	15.9
Length of the right ear	14.8	14.8
Width of the right ear	6.6	6.5
Length of the left foot	28.2	27.5
Length of the left middle finger	12.3	12.2
Length of the left little finger	9.7	9.6
Length of the left forearm	unavailable	50.3





Will West



William West

In the early 1900s, the fingerprint system was adopted by a number of agencies in the United States. In 1924 the Identification Division of the Federal Bureau of Investigation (FBI) was formed; by 1946 it held 100 million fingerprint cards. Currently, the FBI has more than 250 million sets of fingerprint records; if piled on top of each other, these records would make 133 stacks as high as the Empire State Building!

## The Anatomy of Fingerprints

Human skin is the body’s first line of defense against invasion and infection (see Figure 4.1). The hills and valleys (ridges and grooves) you saw when examining your fingers with a magnifying glass make up the skin pattern that is yours alone. Friction ridges, as they are called, can also be found on your palms, feet, and lips. Most amazing, the patterns made by the friction ridges are not genetically controlled, so even identical twins who have the same “DNA fingerprint” will have different fingerprints!

Skin is made up of an outer epidermal layer separated from the inner dermal layer by the papillae. The papillae form a boundary that determines the

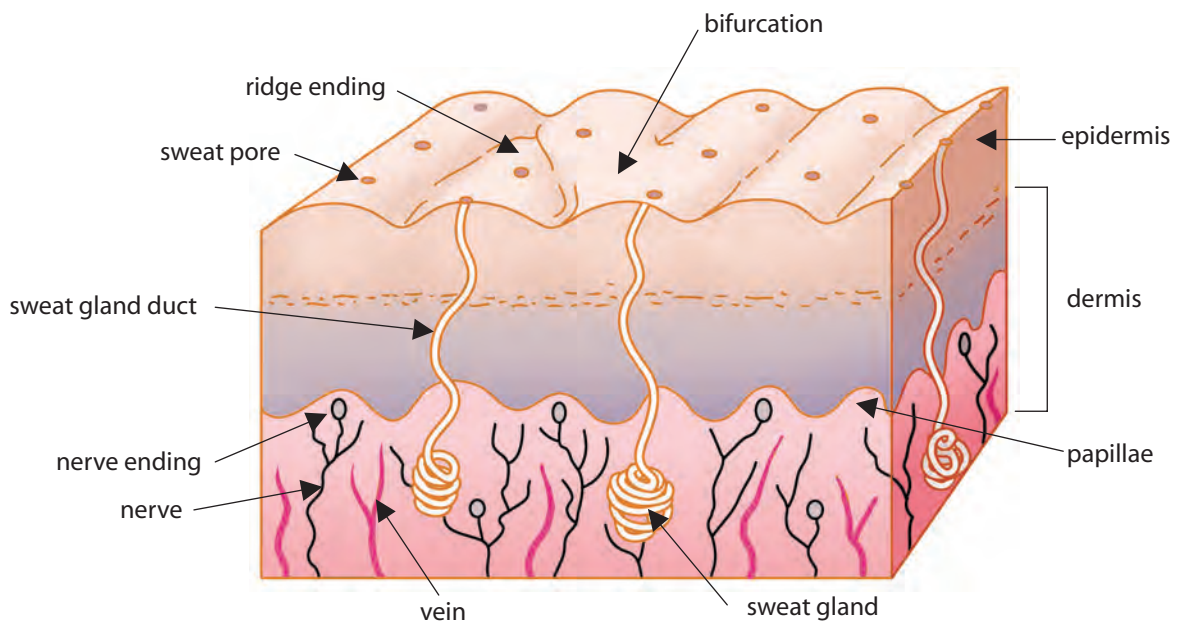


Figure 4.1 Cross section of human skin

friction ridge structure of the epidermis. Chemically or physically erasing the epidermal structure, as John Dillinger tried to do, causes only pain because the original print will soon grow back. Sweat pores along the ridges release perspiration, which is 98 to 99 percent water. It is estimated that a fingerprint initially may weigh 0.1 milligram (1/10,000 of a gram), so after evaporation of the water, we have left about 1 microgram (one-millionth of a gram) of residue, made up of half salt and half complex organic compounds such as amino acids, lipids, vitamins, and perhaps additional body oils picked up on the finger by touching oily or hairy parts of the body. This doesn't leave much for an investigator to work with!



Magnified finger ridges

## Observing and Taking Fingerprints

Although fingerprints can be left casually on anything you touch, there are a number of steps involved in taking clear fingerprints that can be classified and used for identification.

### Materials

For each group:

- stereomicroscopes

For each student:

- magnifying glass
- fingerprint ink or ink pad
- 10-print cards



### SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the laboratory

1. **Observation:** Examine the surface of your fingers beyond the last knuckle with a magnifying glass or a stereomicroscope. Describe what you see in your notebook. Make a sketch.

Ridge patterns are not unique to fingers. Observe your palms, bare feet, and lips; they all have unique patterns.

2. **Ink and transfer:** The object is to obtain as wide and clear a print as possible—not too light, not too dark. This takes practice. The idea is to roll the finger across the ink pad, then roll it across the paper from one edge of the fingernail to the other. Do this just once, not back and forth because that will blur the print. Rolling the finger should make a large, square print showing lots of detail. Keep the finger and forearm parallel to the surface

## Laboratory Activity 4.1

The FBI rejects about 2 percent of submitted criminal cards and about 10 percent of inked civil cards because of illegible fingerprints, even though these cards are prepared by professionals.

### Procedure Notes

You'll need a good magnifying glass or stereomicroscope; a special ink pad for fingerprinting or printer's ink rolled onto a glass or plastic plate (however, a black ink office pad will do); a 10-print card; soap; and towels. A good forensic fingerprint pad, one sold specifically for fingerprinting, is best and will cost about \$20. A less expensive method that works pretty well is to rub a soft, black pencil point on paper, then rub and roll the finger through the graphite. Have someone hold each end of a piece of 2-inch-wide, clear



### Procedure Notes, *continued*

sticky tape while the finger is rolled onto it. The tape can then be stuck to the 10-print card (a 10-print card can also be printed on clear acetate and projected with an overhead for illustrative purposes).

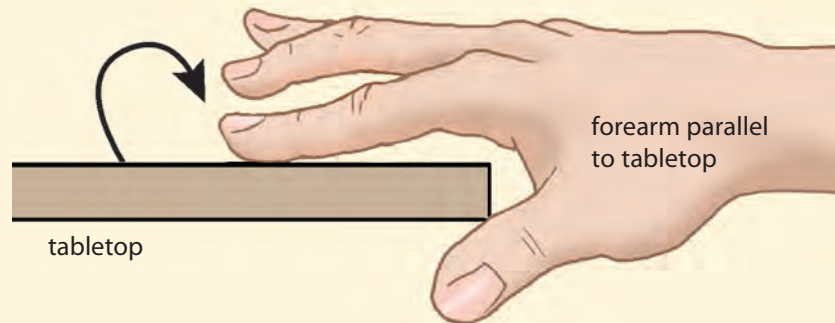
Students should be able to see the pattern of ridges forming beads of sweat at the pores if the finger is close enough to the microscope lamp. Encourage them to look at other things under the scope, such as scars, blisters, cuts, dirt under the fingernails, and jewelry.

You can use the 10-print card provided as Blackline Master 4.1, found on the Teacher Resource CD. Blackline Master 4.2, also found on the Teacher Resource CD, provides a grading chart that can be used to assess proficiency in a number of the activities to follow.

Some states require parental permission to fingerprint students under the age of 18. A permission slip such as that shown can be taken home a few days prior to the lab. This slip is provided as Blackline Master 4.3 on the Teacher Resource CD. Emphasize that all fingerprints will be returned to the students or destroyed at the end of this exercise.

### Laboratory Activity 4.1, *continued*

of the table. Sometimes it helps if your other hand or a partner directs the roll by holding and pressing the finger. See the diagram in Figure 4.2, showing how this is done.



**Figure 4.2** Ink and roll

**Practice on scrap paper.** In a good print, you should be able to follow a ridge as it enters one side of the finger and exits. Then take the cleanest, most legible print for each finger, cut it out, and paste it on the 10-print card distributed by your teacher. Some states require that students have a parent's permission to take part in this activity. If required, your teacher will hand out a permission slip prior to the fingerprinting activities. All fingerprint impressions will be returned or destroyed.



Well-rolled fingerprint (note writer's bump, upper left)

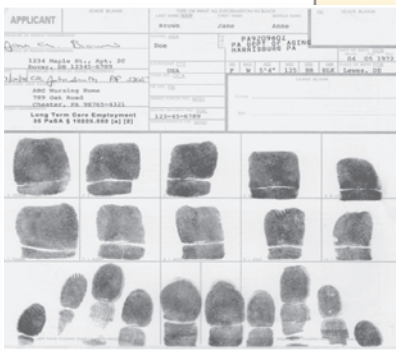


Well-placed fingerprint

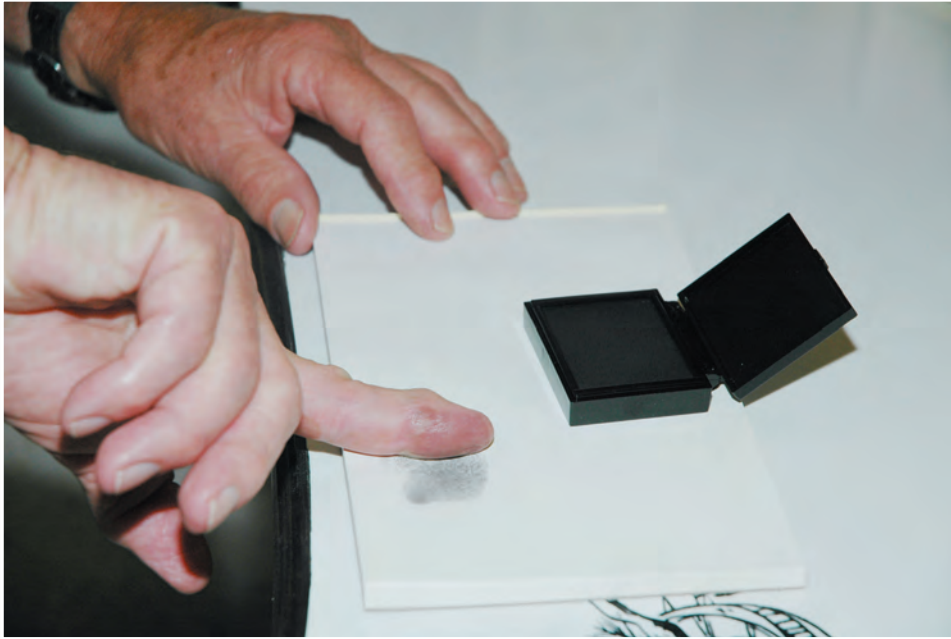


Blurred fingerprint—rolled back and forth

**3. Further observations:** Examine your 10-print card using a magnifying glass. Note basic similarities and differences in the patterns. What are they? Note cracks, scars, and other unique features.



FBI 10-print card



Rolling a print

## Classification of Fingerprints

All fingerprints can be classified into three basic patterns: loops, whorls, and arches.

The **loop** pattern has one or more ridges entering from one side, curving, then going out from the same side it entered from. If even one ridge exits the same side, it is a loop. There are two subgroups to the loop (see Figure 4.3). A radial loop opens toward the thumb, that is, toward the radius, the shorter of the two bones in the forearm; an ulnar loop opens toward the little finger, that is, toward the ulna, the minor bone of the forearm. Without knowing which hand made the print, you cannot tell if the loop is radial or ulnar (ulnar loops are more common, however).

**loop:** fingerprint pattern with one or more ridges entering from one side, curving, then going out on the same side entered

**delta:** triangular area found in all loop and whorl patterns

All loop patterns show a **delta**, a triangular area usually shaped like the silt formation near the mouth of a river flowing into the sea.

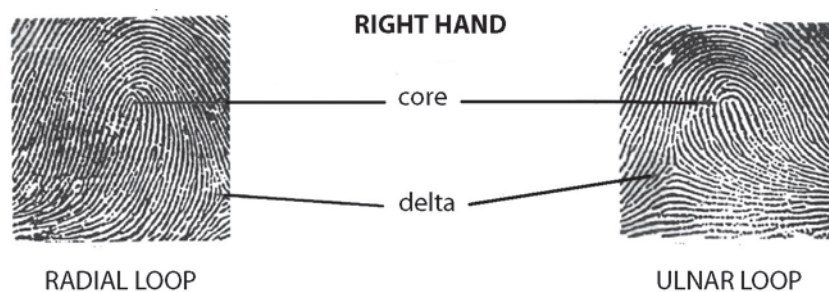


Figure 4.3 Loops

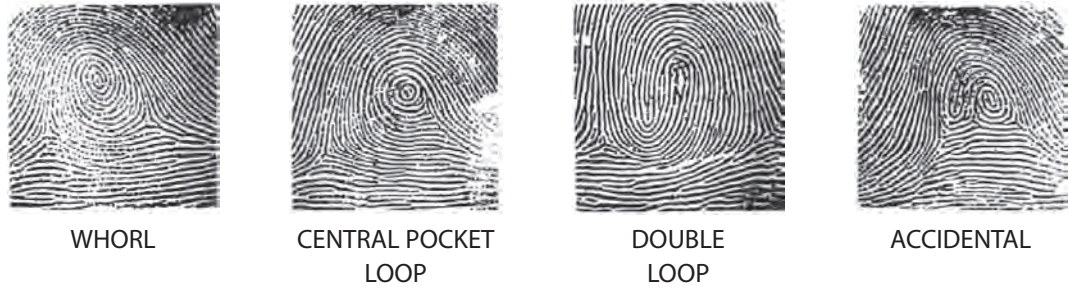


Figure 4.4 Whorls

Loops also have a **core** near the center of the pattern. The relative location of core and delta must be known for complete individual classification and identification. About 65 percent of all fingerprints have loops.

**core:** area found near the center of all loop and whorl patterns

**whorl:** fingerprint pattern with at least two deltas and a core

**arch:** least common and simplest fingerprint pattern. Arches have no delta or core. All ridges enter one side and exit the other.

**Whorl** patterns can be subdivided into four groups, as shown in Figure 4.4. All whorls must have at least two deltas and a core. Approximately 20 percent of fingerprints have plain whorls. Composites (a mixture of two or more basic patterns) and accidentals (prints too irregular to fall into any other group) make up about 10 percent of all fingerprints.

**Arch** patterns are the least common and the simplest of fingerprint patterns but can be confused with

loops by inexperienced observers. The friction ridges enter from one side of the finger and exit the other while rising upward in the middle. Arches do not have a delta or core. They are divided into two groups, plain and tented arches (see Figure 4.5).

On your 10-print card, classify each of your fingerprint patterns according to the eight basic types.

#### Suggested Assignment

Have students go back and label the prints on their 10-print cards as loops, whorls, or arches. Ask each student to have at least two other students check to see if they agree with the identification.

## Henry Classification System

Edward Henry developed a method of classifying fingerprints, later modified by the FBI, that allowed all sets of ten fingerprints in the world to be divided into 1,024 groups. Secondary and even more complex classifications were created to allow for even more groups. This is done so that, when an unknown set of

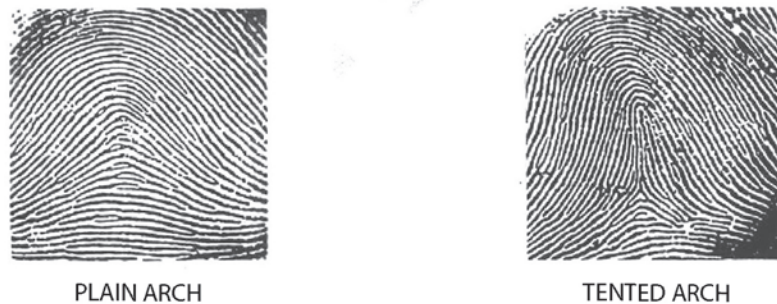


Figure 4.5 Arches



right index 16	right ring 8	left thumb 4	left middle 2	left little 1	+ 1 =
right thumb 16	right middle 8	right little 4	left index 2	left ring 1	+ 1 =

Figure 4.6 Primary classification scheme based on whorls

prints is submitted to the FBI for comparison, most of the millions of sets of prints on file can be weeded out so that only a few dozen sets have to be compared by hand. Now, computer matching of fingerprints is used to make that first big cut; but after this, manual comparison may still be needed.

The first step in classifying a set of fingerprints is to identify the presence of any whorl patterns. These patterns are given a number based on which finger has the whorl, as shown in the chart in Figure 4.6. That number will be set up as a fraction. One is added to the numerator and denominator to avoid having zeros in the classification.

So, for example, if there is a whorl on your left thumb and right middle finger, with the rest of the fingers having loops or arches, then

$$\frac{0 + 0 + 4 + 0 + 0 + 1}{0 + 8 + 0 + 0 + 0 + 1} = \frac{5}{9} = \text{your primary classification}$$

Calculate your primary Henry-FBI classification number.

How many members of your class have the same classification number? How does the number of loops, whorls, and arches compare with the general population? About 25 percent of people have loops and arches with no whorls, so a primary classification of 1/1 is quite common. Be careful not to classify loops as arches. You should have a general idea of the number of arches from the statistics shown in Table 4.2.

Loops, arches, and whorls  
The ridges all end in curls;  
If I see any more  
I'm out the door  
To gather nuts with the squirrels.

#### Suggested Assignment

Have students classify family members' fingerprints, using just a stamp pad, paper, and a hand lens. In the absence of a stamp pad, the student could rub a #1 or #2 pencil on paper, press the finger in the graphite dust, and either transfer the pattern to a

clean white paper or press the dusted finger against clear sticky tape, mounting the tape for examination.

There are racial variations in the distribution of the three fundamental patterns. People of African ancestry have more arches; people of European background have many loops; and Asians have a higher frequency of whorls. Also, certain patterns are more likely to be found on particular fingers; for example, forefingers have most of the radial loops.

Loops		Whorls		Arches	
ulnar	radial	plain	other	plain	tented
60%	5%	20%	10%	4%	1%

## Statistics

This is a good point to think about simpler statistics (see Chapter 2). For example, what is the probability of one person having two arches? Let's start with something simple.



A tossed penny will land “heads up” or “tails up.” The probability that it will land heads up is one out of two possibilities, or  $1/2$ . Probability is merely the likelihood that a specific event will occur and can be defined numerically. So the odds that a penny will land heads up, no matter how often it is tossed or how often heads actually comes up, are 1 to 1.

Probability ( $p$ ) =

$$\frac{n}{N} = \frac{\text{number of one kind of possible outcomes (heads)}}{\text{total number of all possible outcomes (heads and tails)}}$$

$$\text{Odds} = n \text{ to } (N - n)$$

What are the odds that heads will come up twice in two tosses of the coin?

$$n = 1 \quad \text{heads-heads}$$

$$N = 4 \quad \text{the possible outcomes being heads-heads, heads-tails, tails-heads, and tails-tails}$$

so

$$p = \frac{1}{2} \times \frac{1}{2} = \frac{1}{2} = \frac{1}{(2)^2}$$

The odds are

$$\frac{n}{N - n} = \frac{1}{4 - 1}$$

which means 1 to 3 in favor, or 3 to 1 against, getting two heads in two tosses.

In three tosses,

$$p = \frac{1}{(2)^3} = \frac{1}{8}$$

The odds are therefore 7 to 1 against getting three heads in three tosses.

Note that we are determining the probability of a particular sequence of events, that is, the chances that heads is going to come up every time. In 100 tosses, the chances that heads will come up 50 times are 1 to 1 because we aren't being specific about what the sequence has to be.

Mathematical probability as shown above works only if the outcomes do not affect one another, that is, if they are independent.

Forensic science often uses probability when judging the probative value of evidence. For example, what are the odds that a portion of a fingerprint came from a particular suspect, or that a piece of automobile paint came from a particular car? Unfortunately, it is very rare that you can assign a sure number to the odds, except for blood typing and DNA typing where population statistics are well known.

Now let's get back to comparing the primary patterns of the 300 or so fingerprints from your class to those of the general population as given in Table 4.2. The probability, in a large population, of having an arch is 5 percent, which means that, on average, 5 out of 100 fingers would have an arch; that is, there are 5 arches per 10 people, or, on the average, every other person has an arch. However, in a limited population, arches are not necessarily evenly distributed, so it's more likely that some students may have two fingers with arches. This is described in the Rule of Large Numbers, which states that the larger the population, the greater the likelihood that the actual numbers will approach those of the computed probability,  $P$ :

If a given outcome or event is repeated  $N$  times, then

$$\text{as } N \rightarrow \infty, \text{ then } P_{\text{actual}} \rightarrow P$$

What is the probability of one person having two arches? For each finger examined, the probability of an arch is  $1/20$ , even if five arches have been identified. However, the chances of someone having so many arches is low, and can be approximated in a large population the same way we did with the coin toss.

$$P_1 = \frac{1 \text{ arch}}{20 \text{ fingers}} \quad P_2 = \frac{1}{20} \times \frac{1}{20} = \frac{1}{400}$$

So, in a large population, the probability of one person having two arches is 40 to 1. Yet, in a group of 1,000 people, one would expect to find 500 arches, but not necessarily 500 people with one arch each.

What are the odds of one person having three arches?

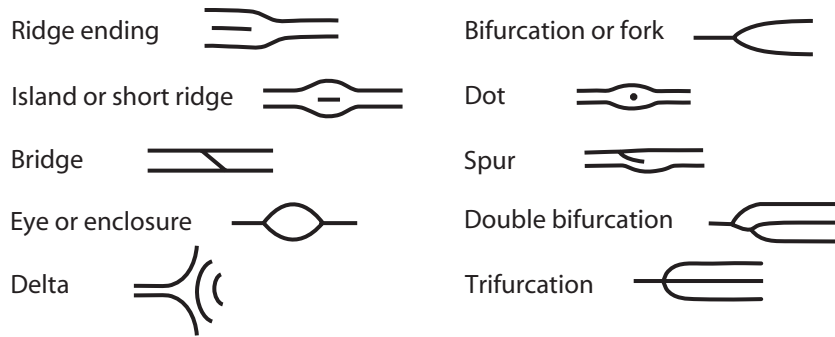
## Ridge Classification (Individualization)

You have now classified fingerprints according to general patterns or groups, but to individualize them you must use the fine structure of ridge characteristics, or **minutiae**. Some common minutiae are shown in Figure 4.7 on the next page.

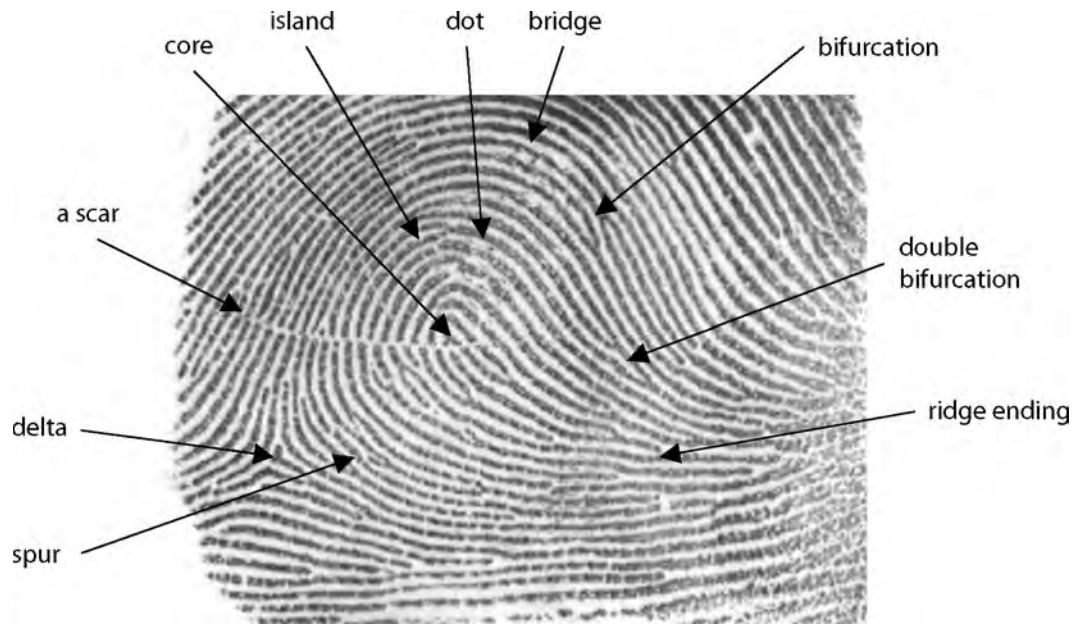
Figure 4.8 shows some ridge characteristics in an inked print.

**minutiae:** in descriptions of fingerprints, ridge characteristics





**Figure 4.7** Individual ridge characteristics



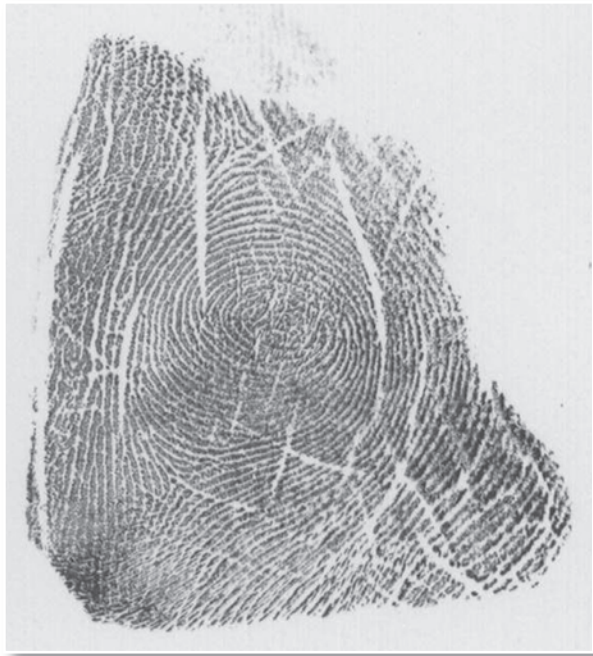
**Figure 4.8** Ridge characteristics in an inked print

**★ FADED FINGERPRINTS COST FORMER WELDER A JOB ★**

One job applicant was turned down for a position at a nuclear power station because his fingerprints did not pass Homeland Security's guidelines. Most adults have more than 80 identification marks on each fingerprint, but years of welding had eroded ridges on this welder's fingers so that only about 30 remained.

## Presenting Fingerprints as Evidence

There are no legal requirements in the United States regarding the number of points (minutiae and their relative location) that must match before deciding that a fingerprint belongs to a certain individual. Criminal courts will generally accept 8 to 12 points of similarity as sufficient proof. Considering there are 150 to 200 minutiae in a properly rolled fingerprint, the problem is getting a good, readable print to work with.



Scarred fingerprint

Fingerprints cannot lie, but the analysis and identification are subject to error. See, for example, the case study “Madrid Bombings” on page 97.

Identify the 15 points in Figure 4.9 on the handout from your teacher. What type of print is this?



Figure 4.9 Fingerprint minutiae

Two items taken from  
the Web.

Is this a scam or is it possible?

**THIS PRODUCT  
WILL TOTALLY  
★ CHANGE YOUR ★  
FINGERPRINTS  
FOR 48+ HOURS**

That new job asking for fingerprints?  
Scared what they might find out?  
With **TOTALLY NEW SKIN** you don't  
have to worry; it will come up “no  
history,” and you can go on with your  
life and your new high-paying job.

*It's possible to change your  
fingerprints!*

**★ HOW TO ★  
CHANGE YOUR  
FINGERPRINTS**

Okay, you're probably thinking, “But it's  
impossible to change your fingerprints!”  
*Everyone knows that! Most blindly  
believe that, but it just isn't true.*  
So shake that particular bit of societal  
programming out of your head and be  
ready for a new life.

#### Suggested Assignment

Ask students to use the minutiae in Figure 4.7 to identify the 15 points on Figure 4.9. Ask what type of print this is. This print can be found on the TRCD, BLM 4.4, as well as on the one with the answers, BLM 4.5.

Have students label 12 ridge characteristics on two of their best prints. If they do not have two that are good enough to ID 12 points, have them make new inked prints.



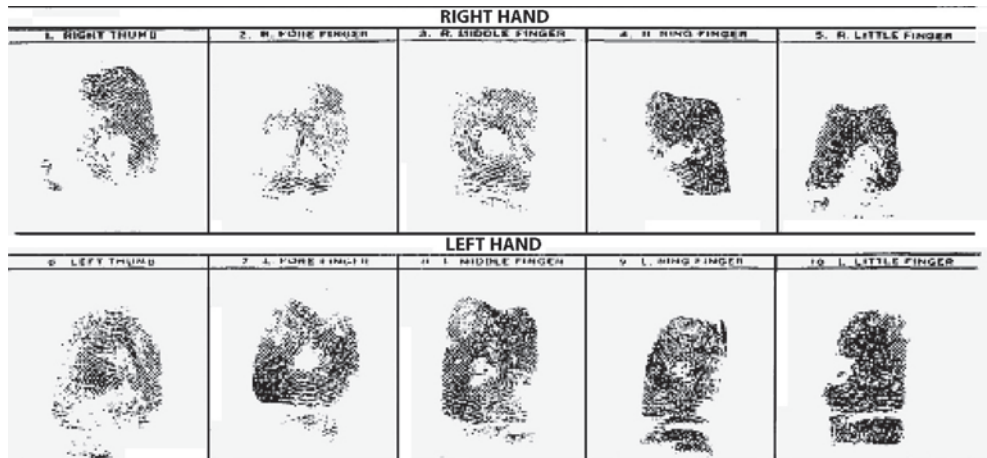


PLATE 1. The prints of John Dillinger, showing partial obliteration of pattern areas produced by application of acid.

Figure 4.10 Dillinger's altered fingerprints

**★ DOCTOR IS FINGERED IN PRINT REMOVAL ★**

It could be a scene straight from a Hollywood movie. The drug dealer is picked up at the border with mysterious bandages on his hands. His Mexican plastic surgeon is later arrested and charged with performing a surgery to remove his fingerprints and replace them with skin from his feet.

— from a Mexican newspaper, June 2007

How would scars affect identification?  
Missing fingers?

Working in certain professions can affect a person's fingerprint. For example, the ridges of concrete workers and plasterers can become rather indistinct over time because the alkalinity of cement and gypsum can dissolve proteins. Sherlock Holmes would note this.

John Dillinger, public enemy number one in the early 1930s, paid a doctor \$5,000, plus \$25 per day for room and board, to "dissolve" his fingerprints with acid and perform some minor surgery on his face.

The operation created lots of scar tissue

that obscured the ridges in the center of his fingers, but there were still plenty of minutiae for identification. Also, if he had been identified with his "new" prints, the scars would have provided a unique characterization (see Figure 4.10).

## Types of Prints

**plastic print:** three-dimensional print made as indentations in soft material such as fresh paint, putty, or wax; also called an indented or molded print

A **plastic print** (or indented or molded print) is made by pressing a finger against a plasticlike material to form a negative impression of a fingerprint. Such material could include fresh paint, putty (as in our crime scene), soap, candle wax,



gum on envelopes or stamps, or a candy bar that has softened in the hand.

A **visible print** is left by a finger that has touched colored material such as blood, paint, ink, grease, chalk, mud, or sometimes even dust.

A **latent print** is essentially invisible and must be developed by chemical or physical means. These prints result from deposits of perspiration and body oils.

**visible print:** fingerprint left by a finger that has touched blood, paint, ink, or the like

**latent print:** fingerprint made by the deposit of perspiration or body oils; invisible to the naked eye until developed

## Back to the Crime Scene

Think back to the crime scene described at the beginning of this chapter. Where would you find the burglar's fingerprints? What types of prints are most likely to be found?

Make a list of the people whose fingerprints you might expect to find in the house. Suppose fingerprints that do not belong to anyone living in the house are found where the burglar went. Which ones have *probative value* or evidentiary value? Why?

### Reminder

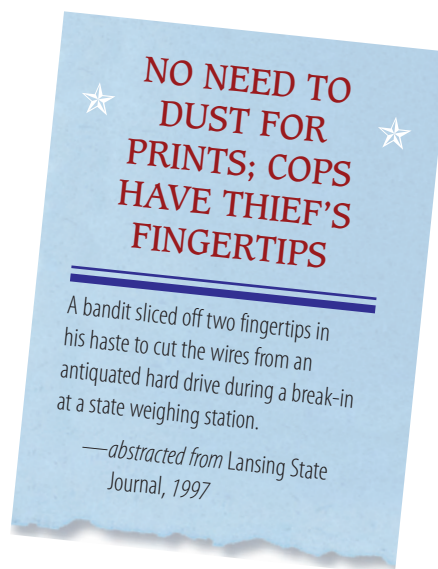
*probative value:* the ability of evidence to prove something that is material to a crime. Fingerprints are said to have high probative value because they can be individualized to one person.

## Visualizing Latent Prints

One of the most common methods of visualizing (developing, or making visible) a latent print is by carefully dusting it with a fine powder. This method is most effective on hard, nonabsorbent surfaces. The color of the powder is chosen to stand out against the surface being examined.

So, for example, a white or gray powder would be used on dark surfaces, a black powder on light ones. The developed print can then be "lifted" by means of clear sticky tape and collected for analysis.

There are various chemical methods for developing latent prints. They are generally more effective for soft, porous surfaces such as paper, Styrofoam cups, and leather. Iodine ( $I_2$ ) reacts with the fatty oils from the finger to form a visible but short-lasting print. Iodine works best for



### Classroom Activity

Here it may be helpful for the students to draw a floor plan of pertinent sections of the house, then take on the role of the burglar as he tries to enter the house, recreating his path and noting what he has touched. The first item would be the latch on the window, where a latent print would possibly be left. Next, the soft putty might yield a plastic print. Prints may have been left on door and drawer knobs and the jewelry cases upstairs; however, these areas may have many of the occupants' prints. On his way out, the burglar took a bite of cheese, possibly leaving a plastic print on what was left. If he was as careless as described, perhaps he even left an oily latent print of cheese on the pad of paper, the pen, or the back doorknob and latch.

The fingerprints in the putty are outside; they could belong to the glazier. Even if matched to a suspect, they only put him at the scene, at some time, outside the house. However, a suspect's prints inside the house place him or her at the crime scene, although not necessarily at the time of the crime. If a suspect had never been inside the house before the crime . . . bingo!

## ★ FINGERING ANCIENT GREEK POTTERS ★

Archeologists have asked experts to help identify individual potters by examining fingerprints left some 2,400 years ago on fragments of the famous black and red vases found in southern Italy.

—abstracted from *Science*, 1997

### Classroom Activity

You may now wish to set up a mock B & E in the classroom and ask the students to sketch the “crime scene,” and locate where to look for fingerprints, and identify the best methods to use.

If you use the fingerprint lab early in the school year, you might have the students make a latent print in some out-of-the-way place so that, at the end of the year, they can see if it still can be visualized. This will test the longevity of undisturbed fingerprints.

**ninhydrin:** a biochemical reagent used to detect free amino and carboxyl groups in proteins and peptides; the resulting color is called Ruhemann’s purple

prints on porous paper. **Ninhydrin** is also most commonly used with paper and porous surfaces. It reacts with the amino acids left by the finger to make an orange to purple image. Silver nitrate ( $\text{AgNO}_3$ ) reacts with salt ( $\text{NaCl}$ ) left from perspiration in a dried print to form silver chloride ( $\text{AgCl}$ ), which is then converted to dark silver oxide ( $\text{Ag}_2\text{O}$ ). This is the same process used in developing photographs.

An interesting method of chemically developing fingerprints was discovered quite by accident in Japan in the late

1970s. This method is now widely used for developing latent prints on nonporous surfaces such as metals, glass, adhesive tapes, and plastic articles. It involves evaporating superglue in an enclosed container.

The glue, a cyanoacrylate ester, reacts with print residues to make a white, permanent impression that can then be treated with powders or fluorescent dyes to create a sharper contrast and allow for easier photography or lifting.

Often, as with many analytical procedures, the order of the steps in developing prints is important. When you have just one piece of evidence, first use tests

that won’t harm that evidence. You want to get as much information as possible, so you may have to perform several tests. For example, to get the best image of latent fingerprints, you might first use iodine fuming; then you might try ninhydrin. You would save the silver nitrate method until last because this procedure will wash away traces of fatty oils and proteins.

### Laboratory Activity 4.2

### Developing Latent Fingerprints

One job of the crime scene investigator is to find latent fingerprints—those that are left by perspiration or grease and are not immediately visible to the naked eye—and develop them, that is, treat them so they can be seen and inspected. There are several physical and chemical methods of visualizing latent fingerprints.

### Materials

- ceramic tiles
- white powder
- fingerprint brushes
- 2-inch cellophane tape
- black or gray fingerprint powder
- white paper
- smooth black paper
- beaker and cover
- glossy white or photo paper
- iodine crystals
- forceps
- starch solution
- ninhydrin solution in atomizer
- zinc chloride solution
- gloves
- heat gun
- UV lamp
- silver nitrate solution
- “fixer”
- paper towels
- microscope slides
- plastic bags
- Styrofoam cups
- fuming chamber and cover
- superglue
- copying machine
- clear acetate sheets
- red markers



#### SAFETY ALERT! CHEMICALS USED

*Always wear goggles and an apron when working in the laboratory*



**SAFETY NOTE** *Also wear goggles when using the zinc chloride solution. Recommend wearing gloves and apron. Do not ingest or inhale. Iodine is toxic by inhalation and ingestion.*

### Physical Methods

#### Dusting and Lifting Latent Fingerprints

1. Clean an area on a black tile.
2. Gently press your thumbprint on the edge.
3. Select a contrasting powder (white) and its brush. *Make sure you do not mix brushes.* When using the brush to apply powder, first fluff it up by rolling the handle rapidly between your fingers or palms.
4. Lightly touch the brush to the powder. Tap off any excess in a petri dish or on a newspaper.
5. Move the brush gently back and forth over the print surface. If a print begins to appear, continue brushing in the direction of the ridges. *If you brush too hard, the print will be wiped away or smeared and become useless.*
6. Gently blow off the excess powder from the print.
7. This takes practice; you may need to repeat several times before you get a good visible print. *Hint: If you are having difficulty getting enough oil on your fingers to make a latent print, run your fingers through your hair several times.* Once your print looks clear, move on to step 8.
8. Cut 3 inches of lifting tape.

A good start on this first part of the lab is to use a chalkboard and have the students press their fingers into chalk dust, then press them against the board. The prints can also be lifted easily off the board.

The dusting activity is a messy one to clean up. You will find black powder everywhere.

Fired, glossy kitchen/bathroom tiles (or pieces) make excellent substrates for practicing lifting, and your lab benches won't get as messy. They come in a variety of colors.

Black dusting powder can be purchased from companies that supply forensic science materials, such as Lightning Powder Company, Inc. ([www.redwop.com](http://www.redwop.com)). Black fingerprint powder costs about \$6 for 2 oz, \$18 for 8 oz. A good substitute is toner from your copier. Be aware that some people are allergic to either or both powders. Fine charcoal can be used, as can soot, but these are messy to collect.

Magnetic and fluorescent powders are also available. The former is not as messy, but is more expensive.

For white dusting powder, talcum powder or chalk dust works well; gray powder can be made by mixing the black and white powders. About 1 percent of fine aluminum powder added to the mix increases adhesion.

There are brushes made specifically for fingerprint work. Good all-purpose brushes are about \$4 each. Soft paint brushes or cosmetic brushes may work, but developing is difficult enough even with the right brush.



### Procedure Notes, continued

Lifting tape can be a clear Scotch brand or similar tape; a 2-inch width works best. You will need white paper or card stock and black smooth paper (copier cartridges are wrapped in such paper). Local printers usually carry a black glossy paper. For skin, use glossy photo paper or a similar white, very glossy paper. See your local print shop.

### Procedure Notes

All the chemicals listed here are pretty standard; your chemistry department should have iodine crystals ( $I_2$ ). If not, they are available from standard chemical suppliers such as Flinn Scientific, P.O. Box 219, Batavia, IL 60510; (800) 452-1261; [www.flinnsci.com](http://www.flinnsci.com). Note that iodine is toxic by inhalation and ingestion.

For cornstarch or any starch product, make up a 2 percent solution by adding 2 g of starch to about 100 ml cold water and bringing to a boil while stirring. Cool.

Ninhydrin is available from most scientific supply houses, such as Carolina Biological Supply Company ([www.carolina.com](http://www.carolina.com)), as a biological reagent; the cost is about \$9 for 5 grams. Make up a 5 percent solution in acetone or alcohol (stir 5 g into 95 ml acetone or alcohol). *Caution: Ninhydrin is a body tissue irritant.*

For zinc chloride solution, add 3 g zinc chloride ( $ZnCl_2$ ), 25 ml ethyl alcohol, and 5 ml acetic acid to 70 ml of water. *Caution: Zinc chloride is a severe skin irritant; work with gloves in the preparation.*

A black light (ultraviolet lamp) positioned over a dark box eliminates the need for darkening the room and makes the procedure a lot safer. Carolina Biological Supply sells

### Laboratory Activity 4.2, continued



Dusting technique



Dusting for fingerprints

9. Attach the tape to the base of the print. Holding the tape taut and beginning at the base of the print, gently begin pressing the tape down as you move upward and beyond the print. This should eliminate air bubbles and smearing.
10. Gently pull back the tape, lift the print, and place it on a 2-inch square of contrasting (black) paper. Place the square with the print in your notebook and label which finger it came from and how you developed it. Your teacher may ask you to identify ridge characteristics.
11. Follow the same procedure using the following: white tile with black powder; glass and metal with gray, white, or black powder.
12. Lift and tape the prints and place them in your notebook. Keep in mind that you may have to develop and lift several prints to get one that is clear enough to identify characteristics.
13. Use porous surfaces such as white paper or an index card and repeat the above procedure. Place the tape on the dusted print to protect it and place it in your notebook. Label your print.
14. A latent fingerprint on the surface of human skin can sometimes be lifted and developed. Try pressing several fingers on your wrist.
15. Press a 1-inch square of glossy photographic paper against the prints on your skin for 2 to 3 seconds. Try a clean microscope slide.
16. Develop with an appropriate powder. Protect it with tape. Most people find it very difficult to lift prints from skin; you may not be able to find very many ridge characteristics. Save one or more latents from your skin for subsequent chemical developing (below).

## Chemical Methods

### Iodine Fuming

*Caution: Iodine is toxic by ingestion or inhalation. This procedure is best performed under a hood.*

1. Place a fingerprint on two pieces of paper or index card.

## Laboratory Activity 4.2, *continued*

- Put each print in a beaker containing several crystals of iodine and cover the beaker. Solid iodine sublimates; that is, it passes directly from the solid phase to the vapor phase without going through the liquid phase. Both mothballs and dry ice also do this.
- When the prints become visible, remove them with forceps or tweezers. Watch carefully as your prints develop. Leaving them in for too little time will not give enough detail; leaving them in for too much time will give you a big brown blotch.
- Dip one of the prints in a starch solution. What happens? Why? Allow to air dry.
- Cover both prints with clear tape to preserve them.
- Wash your hands thoroughly with soap and water.
- Identify five ridge characteristics on each print. Place the prints in your notebook. Label. Check them in a day or two and note any changes. Explain.



Iodine fuming



GO TO [www.scilinks.org](http://www.scilinks.org)  
TOPIC **ultraviolet light**  
CODE **forensics2E91**

### Ninhydrin

*Caution: Ninhydrin will stain skin and clothing. Wear gloves if possible.*

- Place several fingerprints on a piece of paper.
- Hang the paper in a hood or well-ventilated place and spray it with the ninhydrin solution.
- Wait 24 hours for the print to develop, or warm gently with a heat gun.
- Identify five ridge characteristics. Place the print in your notebook. Label.



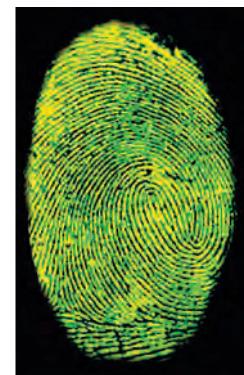
Ninhydrin print

### Further Development with the Ninhydrin Print (*optional*)

- Dip your ninhydrin prints in a zinc chloride solution. This should turn the print orange, making it easier to visualize. *Caution: Zinc chloride solution is a skin irritant; you may wish to wear gloves.*
- Place the print under a black light (ultraviolet [UV] lamp).
- Allow the print to dry and place it in your notebook. Label the print and describe what you saw under the black light. The zinc chloride treatment causes the prints to fluoresce. Basically, **fluorescence** occurs when a material absorbs light and reemits it at wavelengths longer than those of the light source. Substances are added to textiles and papers to cause them to fluoresce white (optical brighteners). Many fingerprint powders now contain fluorescent agents.

### Procedure Notes, *continued*

a portable long- and short-wave lamp for about \$100. Fisher Science Education ([www.fisheredu.com](http://www.fisheredu.com)) has a line of good UV lamps also. Lightning Powder sells a battery-operated (AA) long-wavelength UV light for about \$30, but visualization is severely limited in many applications of chromatography. *Caution: Do not look directly into a black light; the UV radiation can harm your eyes.*



Fluorescent print

**fluorescence:** the absorption of light at one wavelength (often in the ultraviolet range) and its reemission at a longer wavelength (often in the visible part of the spectrum)

### Superglue (Cyanoacrylate) Fuming

**Caution:** Do not get superglue on your skin and do not breathe the fumes, because they irritate the mucous membranes. Keep your face away from the top of the developing chamber when you slowly remove the lid.

#### Procedure Notes

A superglue developing tank can be made from an aquarium, even one with cracked sides (tape them with duct tape). Line three sides with aluminum foil to prevent eventual clouding by cyanoacrylate polymer (superglue) and insert a 40-watt lightbulb and socket, covered by a tin can with a few holes punched in it. Place aluminum foil or a bottle cap on top of the can. Insert a small container of water in the tank (this catalyzes faster development of prints) and a rack to hold objects to be fumed. Use a cover for the aquarium (a piece of cardboard will do) because the fumes are quite irritating to the eyes and throat. It is recommended that you place the chamber in a hood or where there is good ventilation.

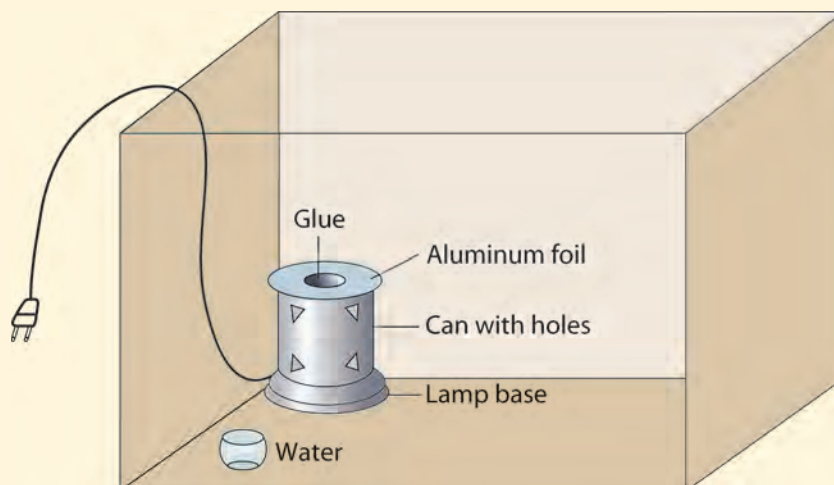


Figure 4.11 Superglue developing tank

1. Wipe clean a microscope slide, a portion of a plastic bag, or a piece of Styrofoam cup. Write your initials on the sample.
2. Add fingerprints.
3. Place in the developing chamber.
4. Squeeze three or four drops of superglue on the aluminum foil or tin can that rests upon the heater (a lightbulb with a can over it).



Prints developed by fuming

Lifting prints from can





## Laboratory Activity 4.2, continued

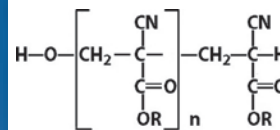
5. Replace the lid on the chamber and turn on the light.
6. Prints should be visible after five to ten minutes. Carefully remove the item from the chamber. Be sure you do not breathe the fumes or allow them to get in your eyes as you lift up the lid.
7. Using a magnifying glass, identify ridge characteristics.
8. You can enhance the prints even more with powder.
9. Place the prints in your notebook. Label them, describe your procedure, and identify at least five ridge characteristics.

### Silver Nitrate (optional)

1. Place a fingerprint on a piece of paper.
2. Using forceps, immerse it in the silver nitrate solution for 5 to 10 minutes.
3. Remove the paper with forceps and drain the excess liquid.

You may want to wear gloves for this one because silver nitrate will darken your skin when it is exposed to sunlight.
4. Sandwich the fingerprint paper between paper towels and dry it. Then expose the print to bright sunlight or long-wave UV light. *Caution: Do not look directly at the UV light. UV radiation can harm your eyes. Wear UV goggles, if available.*
5. Watch the development carefully so that it does not become overexposed.
6. To develop or “fix” the print, immerse it in the fixer solution for 15 to 20 minutes.
7. Remove and blot dry with paper towels.
8. Place in your notebook, label, and identify five ridge characteristics.

This is a good method to use on older fingerprints. The silver nitrate reacts with the sodium chloride that is left after other materials from the print have evaporated or deteriorated. It also works well with fingerprint impressions on wood. Try it on a Popsicle stick, wood splint, or some other small piece of wood.



A cyanoacrylate polymer has a structure such as this, with R = a methyl, ethyl, or butyl group. Polymerization is catalyzed by a base, even water.

### Procedure Notes

Make up a 1 percent solution of silver nitrate, 1 g AgNO<sub>3</sub> in 100 ml H<sub>2</sub>O, and store it in the dark. *Caution: Silver nitrate is a corrosive solid, quite toxic by ingestion.* For a fixer, use 20 g of sodium thiosulfate (“hypo”) plus 14 g of sodium bisulfite per 100 g of water. *Sodium bisulfite is a corrosive solid. Avoid skin contact, inhalation, and ingestion.*

A method that can be used to compare a latent print to an inked one is to use a photocopier to uniformly enlarge the prints. Overlay a clear acetate sheet on the inked print and delineate points of reference, such as the core, delta(s), and arch top, with a red marker. Now use the marker to outline particular minutiae—**bifurcations** are good ones to use because they are easy to see and there are many of them—working out from each reference point. This “known” print can then be overlaid on other latent prints for comparison.

**bifurcations:** common minutiae, shaped like a two-pronged fork

Figure 4.12 on the next page shows an example of two fingerprints for comparison. The one on the left is the same as the one in Figure 4.8 on page 84;

### Teacher Note

This sort of algorithm is the basis of the FBI's Automated Fingerprint Identification System (AFIS). For your convenience, Figure 4.12 can be found on the TRCD as Blackline Master 4.6 and the answers as Blackline Master 4.7.



**Figure 4.12** Identification algorithm

note the red highlighted ridge characteristics. Do they match the digitized image on the right? Is the latent print on the right from the same finger?

## Other Methods

Police investigators routinely photograph fingerprint images to preserve them for further examination. Try photographing prints with a digital camera and enhance the image by computer. The latest innovation in fingerprinting is all digital—no more ink! The fingers are pressed against

a glass platen and scanned to a screen, where they can be enhanced, compared, and sent to an Automated Fingerprint Identification System (AFIS), all in a matter of a few minutes.

More sophisticated chemical methods of visualizing fingerprints use fluorescent dyes and special lighting or lasers to make the prints easier to see. Magnetic developing powder is also used in certain circumstances. Digital imaging can capture the print no matter how it has been developed. An impression is converted into a digital file that can then be manipulated to make the print easier to see. Work is being done to improve the resolution of these “e-prints.”

A digital print's ridge characteristics can be recorded in geometric patterns relative to a fixed point.

### ★ MAN PLEADS ★ GUILTY TO ★ 1979 MURDER

Ronnie Lee Bullock of Burton will serve at least 20 to 30 years in prison for the death of Vadah Warner. Warner's body was found in her Flint home on February 3, 1979. The only evidence discovered at the scene was two fingerprints.

Bullock, who was 19 at the time, was interviewed twice by police after the killing. He acknowledged knowing Warner but said he had never been in her house.

A break in the case came in 2003, when fingerprints from the crime scene were entered into the Automated Fingerprint Identification System and a match with Bullock was found. The system did not exist in 1979.

—condensed from Lansing State Journal, 2005



Taking a digital fingerprint

The resulting array may look like a drunken spider's web, yet a computer search algorithm can compare hundreds of thousands of these webs in less than a second.

Automated systems such as this one still require manual intervention of incoming data to complete a fingerprint search and identification against existing digital files.

The FBI phased in a system known as the Integrated Automated Fingerprint Identification System (IAFIS) in 1999 that completely replaces the traditional fingerprint card and operator intervention. By 2007 IAFIS had more than 55 million computerized fingerprint records for known criminals. Now, so-called Live Scan electronic fingerprint scanning devices can transmit prints at the time of arrest or booking to a central IAFIS database to provide immediate positive identification, check for a match with any suspect latent fingerprints on file, and

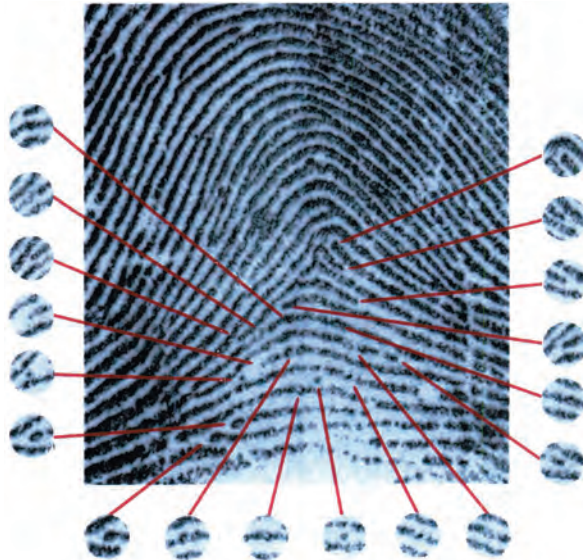
On December 17, 2002, a man was arrested for resisting arrest and obstructing an officer. As part of the booking process, his fingerprints were submitted electronically to the FBI for processing in IAFIS. Within 20 minutes, the FBI learned that the offender had used a false name at the time of arrest, had a criminal history in four states, was on parole, and had been wanted since July of 2002 for a parole violation.



Computer image of digitized prints



China's Xinhua news agency reports that the police department in Nanjing has gone beyond fingerprints and now has a data bank of smells taken from criminals and crime scenes to aid police dogs in investigations. Officials say that storing the scents at minus 18 degrees Celsius retards degradation for at least three years, and they say the bank of 500 odors has already led to the identification of 23 suspects.



Method of FBI fingerprint analysis

Brian Jeffries was arrested and charged with robbery. While in custody, officers noticed the suspect biting his fingernails—or at least that's what they thought at first. Upon closer inspection, they discovered it was not his fingernails he was biting: It was his fingertips. He was trying to chew off his own fingerprints to avoid being identified. He was restrained before he was able to complete the job.

provide a criminal history. IAFIS can also include criminal history, mug shots, photos of scars or tattoos, height, weight, hair and eye color, and aliases. With automatic scanners, inked impressions may eventually become obsolete.

Many companies now sell IAFIS-type systems for employee identification and industrial security. Search the Web to see what is available, costs, where such systems are or could be used, and how they can affect personal rights to privacy.

#### 4.1: The 1933 Hamm Kidnapping

The story begins like an old gangster flick: a gang of criminals and an unexpected kidnapping.

On a warm summer evening in 1933, William A. Hamm, Jr., president of the Theodore Hamm Brewing Company, was working at his office in St. Paul, Minnesota. He had just left the building when he was grabbed by four shadowy figures and pushed into the back of a car. He had been kidnapped by members of the Barker/Karpis gang, who demanded a ransom of more than \$100,000.

Hamm was taken to Wisconsin, where he was forced to sign four ransom notes. Then he was moved to a hideout in Bensenville, Illinois, where he was held prisoner until the kidnapers had been paid. Once the money was handed over, Hamm was released near Wyoming, Minnesota. The plan was perfect and went off without a hitch . . . almost.

### CASE STUDY



Alvin "Creepy" Karpis

At this point, the FBI Crime Lab got involved. On September 6, 1933, using what was then state-of-the-art technology, now called “latent fingerprint identification,” investigators from the lab raised incriminating fingerprints from surfaces that could not be dusted for prints. Alvin Karpis, “Doc” Barker, Charles Fitzgerald, and the other members of the gang had gotten away, but they had left their fingerprints behind—all over the ransom notes.

**CASE STUDY  
CONTINUED**

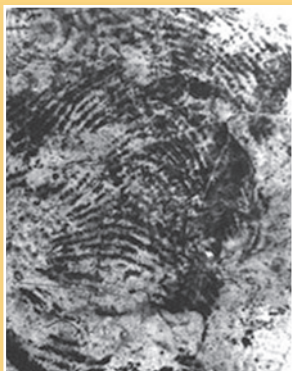
The investigation of the Hamm kidnapping was the first time the silver nitrate method was used successfully to visualize latent prints from forensic evidence. Scientists had the idea of taking advantage of the perspiration in unseen fingerprints. Perspiration is chock full of sodium chloride (common table salt). By painting the evidence, in this case the ransom notes, with a silver nitrate solution, the salty perspiration reacted chemically to form silver chloride, which is white and visible to the naked eye. There it was: hard evidence that the Karpis gang was behind the kidnapping. Case closed.

—from [www.fbi.gov/page2/sept03/kid090803.htm](http://www.fbi.gov/page2/sept03/kid090803.htm)

## 4.2: Madrid Bombings

Is fingerprint identification infallible, or do political pressures cause “mistakes”? On March 11, 2004 (911 days after 9/11), coordinated train bombings in Madrid, Spain, killed 191 people and wounded 2,050. After extensive and intrusive investigation, on May 6, 2004, the FBI arrested Brandon Mayfield, an Oregon lawyer. A bag found by Spanish police containing detonating devices had fingerprints that were identified by the FBI as belonging to Mayfield. It turned out that Mayfield’s prints were not an exact match to the ones on the bag. Two weeks later, Mayfield was released. The FBI acknowledged “serious errors” in the identification and apologized. This was not enough: Mayfield sued the U.S. government and settled for a reported 2 million dollars.

**CASE STUDY**



Latent print from the crime scene (left); known print from Mayfield (middle); known print from prime suspect (right)

## Checkpoint Questions

### Answers

1. A copy of Figure 4.13 is provided on the Teacher Resource CD as Blackline Master 4.8. Answers (below) are on Blackline Master 4.9.

A = G = S This one is interesting; there are three separate impressions of the same finger with some very unique features.

B = no match

C = no match

D = no match

E = T

F = J

H = R

I = no match

K = O

L = no match

M = P

N = Q

Note: Matching can be facilitated by digitally enlarging and comparing cropped areas, or by enlarging the image with a copier and using a transparency overlay.

Answer the following questions. Keep the answers in your notebook, to be turned in to your teacher at the end of the unit.

1. From the 20 impressions in Figure 4.13 (page 99), match the ones that are made by the same finger. In some cases, one print may appear two or three times. Some will not match. *Example:* E and T match. B does not have a match. Write your answers in your notebook as shown below.

A \_\_\_\_\_

K \_\_\_\_\_

B \_\_\_\_\_

L \_\_\_\_\_

C \_\_\_\_\_

M \_\_\_\_\_

D \_\_\_\_\_

N \_\_\_\_\_

E \_\_\_\_\_

O \_\_\_\_\_

F \_\_\_\_\_

P \_\_\_\_\_

G \_\_\_\_\_

Q \_\_\_\_\_

H \_\_\_\_\_

R \_\_\_\_\_

I \_\_\_\_\_

S \_\_\_\_\_

J \_\_\_\_\_

T \_\_\_\_\_





Figure 4.13 Match fingerprints

**Answers, continued**

2. Prepare two 10-print cards, one for the victim, the other for the suspect. Place one clear fingerprint of the suspect and/or victim on several different types of objects, such as a plastic bag, a glass, a soda can, and a piece of paper. (Be sure to wipe the objects well before depositing the prints). Have each student group develop and lift the prints. Have them characterize as many minutiae as possible and look for a match on the 10-print cards. You could work up a crime to fit the assessment or just put your students in the position of forensic scientists working in the lab.
3. The relative locations of the class characteristics make the pattern unique.
4. water, salts, organic compounds; deposited by touching or handling an object
5. Loops, whorls, and arches are patterns; the minutiae are the ridge characteristics.
6. Patterns cannot be changed.
7. loop
8. arch
9. radial loop
10. at least two
11. A latent print is invisible; it can be developed by various physical and chemical means.
12. the Integrated Automated Fingerprint Identification System (see page 95)

2. **Develop and lift any prints found on the objects submitted by your teacher. Look for a match, listing as many minutiae as possible. Evaluate your work and provide an opinion as to whose prints they are.**
3. **All fingerprints have class characteristics such as loops, whorls, arches, cores, deltas, bifurcations, ridges, spurs, and the like. Why, then, are fingerprints considered individual rather than class evidence?**
4. **What are fingerprints composed of, and how are they deposited?**
5. **What is the difference between a fingerprint pattern and a ridge characteristic?**
6. **How can fingerprint patterns be changed?**
7. **The most common type of fingerprint pattern is \_\_\_\_\_.**
8. **The least common type of fingerprint pattern is \_\_\_\_\_.**
9. **A loop pattern that opens toward the thumb is known as a \_\_\_\_\_.**
10. **All whorl patterns have \_\_\_\_\_ deltas.**
11. **What is meant by a latent print, and how can one be developed?**
12. **Explain what IAFIS is and how it is used.**

- 13.** How is the “final verification” made using the AFIS system?
- 14.** What type of fingerprint (plastic, visible, latent) would be likely to be found in, on, or by means of the following materials?
- |                  |                     |
|------------------|---------------------|
| a. blood         | h. polyethylene bag |
| b. mud           | i. fudge            |
| c. wood tabletop | j. dust             |
| d. windowpane    | k. newspaper        |
| e. Romano cheese | l. leather jacket   |
| f. chalk         | m. gun barrel       |
| g. skin          | n. snow             |
- 15.** In the crime scene presented at the beginning of the chapter, what would be the best way to develop the latent prints at each area? How would you preserve them? How would you preserve those in the putty?
- 16.** What would be the best way to visualize latent fingerprints on the following materials?
- |                     |                  |
|---------------------|------------------|
| a. matchbook cover  | e. broken bottle |
| b. Popsicle stick   | f. handkerchief  |
| c. vinyl upholstery | g. toilet seat   |
| d. cigarette butt   | h. lightbulb     |
- 17.** In Case Study 4.1, regarding the Hamm kidnapping, how were the fingerprints on the ransom note developed? Write the chemical equation. What other methods presently in use might have worked?
- 18.** From the Madrid Bombings, Case Study 4.2, what is the pattern of Mayfield’s print and that of the prime suspect? How are they similar? How are they different?

**Answers, continued**

- 13.** through examination by an expert
- 14.** a. visible; b. plastic; c. latent; d. latent; e. possibly plastic, but Romano cheese is very hard, so maybe latent; f. visible; g. latent; h. latent; i. plastic; j. visible; k. latent; l. latent; m. latent; n. plastic
- 15.** latch, windowsill—dusting; putty—photograph; bedroom—dusting and perhaps fuming particular small, portable objects that may have been picked up and examined; cheese—dusting, photography; the note—iodine and/or ninhydrin fuming; back door—dusting.
- 16.** a. ninhydrin or iodine; b. silver chloride; c. superglue and/or dusting; d. ninhydrin; e. superglue fuming; f. very difficult to visualize prints from textiles, possibly iodine; g. dusting; h. superglue fuming and/or dusting
- 17.** with  $\text{AgNO}_3$ ;  $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$  or  $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}_{(s)}$ ; other methods good for paper like ninhydrin, iodine.
- 18.** They are both loops (relatively rare). The best way to compare the two prints would be to hand out enlarged copies found on the TRCD as BLM 4.10. The students can then use the technique of designating minutiae as well as mapping bifurcations.



## Answers

2. See, for example, Kurland, Chapter 6. Also check out, for example, <http://www.crimeandclues.com/earprint.htm> and <http://technology.newscientist.com/article/dn7672.html>.



3. The boys in your class will love this one! See Chapter 9, “Trace Evidence,” for activities. Students could even write a short mystery in which lip prints aid in the solution of the crime.
5. You might ask students to review testimonial evidence in Chapter 2. Techniques that could be explored include facial features, eye scans, voice verification, ear classification, and hand recognition. The principles are related to Bertillon’s work of 100 years ago. Identity theft and terrorism have increased the importance of biometric identification. Examples abound: “keys” to unlocking computer files, airport security, etc.

## Teacher Note

Now is a good time to assess your students’ learning by having them complete Puzzle 4.1, found on the Teacher Resource CD as Blackline Master 4.11.

## Additional Projects

1. Investigate the use of “eyeprints” (retinal or iris scans) as a means of identification. Is this a valid method of identification? What are the advantages and disadvantages as compared to the use of fingerprints?
2. Are ears different enough to be a useful class of identification? How could a person devise a method of recording and classifying an individual’s ear?
3. Although not often used, lip prints can provide a means of identification because, like fingerprints, they are unique and do not change during a person’s lifetime. Transfer a lip print to a folded piece of paper by means of a dark, washable lipstick or lip gloss with subsequent powder dusting. You can then work out a method to classify the resulting prints. See Chapter 9, page 252.
4. Explore the social issues around fingerprinting and other means the government uses to confirm individual identity, considering issues such as too much government, “Big Brother” watchdog, and the like.
5. Biometrics uses biological information to verify identity. The basic idea behind biometrics is that our bodies contain unique properties that can be used to distinguish each of us from all other human beings. Discuss the latest technology in identification techniques. How are some related to historical bases?
6. Explore the role tattoos may have in identification. Look for actual examples.

### ★ EARPRINT CATCHES MURDERER ★

A man has been convicted of suffocating an elderly woman on the basis of ear print evidence. The assailant was caught after police matched him to the imprint of his ear on the victim’s window. Police believe that the thief put his ear to the window to listen for signs of anyone at home.

—abstracted from *BBC News*,  
December 15, 1998

### ★ POLICE LOVING BODY ART: TATTOOS MAKE IT EASIER TO SPOT CRIMINALS ★

Police say tattoos look great in booking photos and can be downright charming in lineups. Now, via computer networks, cops and witnesses far and wide are sharing the fashion fun.

—from a local Michigan  
newspaper, 2007

# References

## Books and Articles

- Beavan, C. *Fingerprints: The Origins of Crime Detection and the Murder Case that Launched Forensic Science*. New York: Hyperion Books, 2001.
- Evans, C. *The Casebook of Forensic Detection*. New York: John Wiley, 1966.
- Fisher, D. Chapter 5 of *Hard Evidence*. New York: Dell, 1995.
- Kurland, M. Chapter 5 of *How to Solve a Murder*. New York: MacMillan, 1995.
- Lee, H. C., and Gaensslen, R. E., eds. *Advances in Fingerprint Technology* (2nd ed.). Boca Raton, FL: CRC Press, 2001.
- Noble, D. "The Disappearing Fingerprints," *Chem Matters*, February 1997, pp. 9–12.
- Ragle, Larry. *Crime Scene*. New York: Avon Books, 2002.

## Films and Videos

- Nova Video, "Hunt for the Serial Arsonist." Suspicious fires were breaking out all over greater Los Angeles. 60 min on one DVD. <http://shop.wgbh.org/product/search?terms=serial+arsonist>

## Websites

- [www.crimelibrary.com/forensics/fingerprints](http://www.crimelibrary.com/forensics/fingerprints); the "Night Stalker" case
- [www.crimeandclues.com](http://www.crimeandclues.com); good general links
- [http://whyfiles.org/133crime\\_lab/3.html](http://whyfiles.org/133crime_lab/3.html); the criminal justice system and fingerprints
- [www.fbi.gov/hq/lab/org/systems.htm](http://www.fbi.gov/hq/lab/org/systems.htm); forensic systems, including AFIS
- [www.fbi.gov/hq/lab/fsc/backissu/jan2001/lpu.pdf](http://www.fbi.gov/hq/lab/fsc/backissu/jan2001/lpu.pdf); FBI manual on processing latent prints
- [www.fbi.gov/hq/cjisd/takingfps.html](http://www.fbi.gov/hq/cjisd/takingfps.html); a good reference for taking fingerprints
- [www.ridgesandfurrows.homestead.com/index](http://www.ridgesandfurrows.homestead.com/index); everything you ever wanted to know about fingerprints, including history, anatomy, developing, classification, and the like