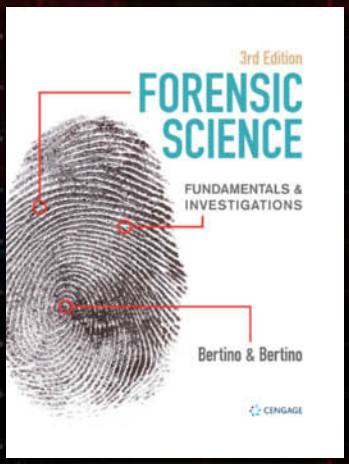
NATIONAL GEOGRAPHIC LEARNING | CENGAGE

Forensic Science: Fundamentals and Investigations

3rd Edition

REVIEWER'S GUIDE

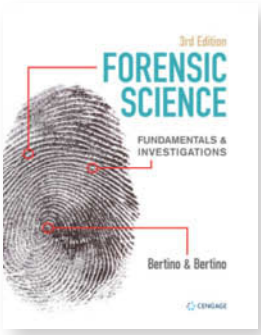


Reviewer's Guide Table of Contents

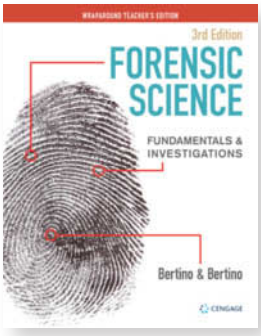
Reviewer's Guide Introduction

This guide introduces components of the Forensic Science: Fundamentals and Investigations, 3rd Edition program as they would be used in a classroom. This will show how the different components work together for completely supported instruction. This guide focuses on content from Chapter 6 - Fingerprints.

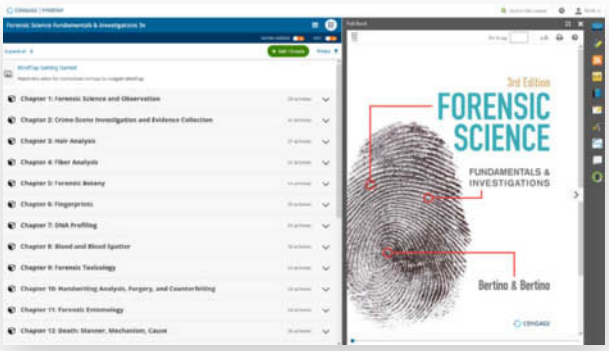
Program Components



Student Edition – includes hands-on labs, activities and Capstone Projects.



Wraparound Teacher's Edition – includes Differentiation, teacher tips, and hands-on lab support.



MindTap Digital Platform – includes a customizable interactive eBook, auto-graded assessments, chapter Interactive Labs, and the complete Virtual Lab program "The Death of Rose Cedar"

Instructor Companion Site – includes dozens of downloadable resources including student worksheets, teacher notes, PowerPoint slides, lessons plans, etc.

This guide shows a sampling of the above components for Chapter 6 to provide a better view of the variety of resources available.

To request full print book samples or digital access to MindTap, contact your sales consultant using the Rep Finder on our website.

Section I
Student Edition – Chapter 6

Features to Watch For:

Chapter Learning Objectives

Key Terms

Science-based Lessons (Biology of Fingerprints)

Visuals including images and illustrations

Chapter Summary

Case Studies

Careers in Forensics feature

Chapter Review

Hands-on Activities and Labs (7 Activities in Chapter 6)

3rd Edition

FORENSIC SCIENCE

FUNDAMENTALS & INVESTIGATIONS

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Chapter 6

Fingerprints

Technology Catches Up to Crime: FBI Latent Hit Award 2013

By September 2001, the 1999 San Bernardino, California, murder and robbery of 74-year-old Marshall Adams was a "cold case." All leads had been exhausted. But a new lead had just come to light. The San Bernardino County Sheriff's Department had submitted latent (hidden) prints from the case to the FBI's **Integrated Automated Fingerprint Identification System (IAFIS)**, a national fingerprint and criminal history database, and several possible fingerprint consistencies had been identified. One was about to lead to an arrest and guilty plea.

The crime In December 1999, a call to San Bernardino's Police Department reported an unresponsive male on the floor of a jewelry store. Detective John Munoz headed the investigation and found the victim, Marshall Adams, brutally beaten and stabbed. His wallet, along with jewelry from the store, had been taken.

Crime-scene evidence Randy Beasley, a fingerprint identification technician from the San Bernardino County Sheriff's Department, collected latent fingerprints, palm prints, and blood evidence from a knife, store doors, and a store catalog. A bloody palm print was recovered from the face of the victim.

1999 investigation In 1999, the sheriff's department searched the latent prints against their local databases without any success. All the evidence from the case was ultimately stored in their cold case unit.

2001 evidence and arrest In 2001, IAFIS returned several possible fingerprint consistencies to the latent print from the crime scene. James Nursall, a fingerprint examiner with the San Bernardino County Sheriff's Department, concluded that the print was consistent with a print taken from Jad Salem. Through IAFIS, it was discovered that Salem had been arrested and fingerprinted in Texas about two weeks after the 1999 murder. Salem was initially stopped for a traffic violation but was later arrested on a drug charge.

Detective Munoz located Salem in San Bernardino and told him about the fingerprint evidence from the 1999 murder. At first Salem denied being there. Later in the interrogation, Salem admitted being there, but only as a witness. However, after Salem was shown the bloody palm print on the victim's face, along with all the other evidence, he admitted he was the murderer. He was sentenced to 32 years in prison for the murder and robbery.

Hyoung Chang/Getty Images

A crime-scene investigator demonstrates the use of IAFIS in allowing for nationwide comparisons of prints.

LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

6.1 Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.

6.2 Describe fingerprints and how they are formed.

6.3 Describe different characteristics and types of fingerprint patterns.

6.4 Describe the proper procedures involved in collecting and documenting fingerprint evidence.

6.5 Explain how fingerprints are analyzed and the reliability of fingerprint identification.

6.6 Discuss advances in fingerprinting that have enhanced the analysis and reliability of fingerprints in identifications.

6.7 Lift a latent print using different methods to analyze the print's ridge and minutiae patterns.

6.8 Distinguish among latent, plastic, and patent fingerprints.

6.9 Prepare a ten card and analyze the ridge patterns of the prints.

6.10 Analyze a fingerprint to determine if it is consistent with a fingerprint on record.

KEY TERMS

- **arch** a fingerprint pattern in which the ridge pattern originates from one side of the print and continues to the other side
- **biometrics** uses measurements and statistical analyses of someone's physical characteristics to aid in their identification
- **core** a center of a loop
- **delta** a triangular ridge pattern created when ridge patterns diverge
- **fingerprint** an impression left on any surface that consists of patterns made by the ridges on a finger
- **Integrated Automated Fingerprint Identification System (IAFIS)** FBI-developed national database of more than 76 million criminal fingerprints and criminal histories
- **latent fingerprint** a concealed fingerprint that is made visible through the use of powders or forensic techniques
- **loop** a fingerprint pattern in which the ridge pattern flows inward and returns in the direction of the origin
- **minutiae** the combination of details in the shapes and positions of ridges in fingerprints that makes each unique; also called *ridge characteristics*
- **patent fingerprint** a visible fingerprint produced when fingers coated with blood, ink, or some other substance touch a surface and transfer their print to that surface
- **plastic fingerprint** a three-dimensional fingerprint made in soft material such as clay, soap, or putty
- **ridge count** the number of ridges between the center of a delta and the core of a loop
- **ridge pattern** the recognizable pattern of the ridges found in the end pads of fingers that form lines on the surfaces of objects in a fingerprint. They fall into three categories: arches, loops, and whorls. They are also visible on the soles of feet and bottoms of toes
- **ten print card** a form used to record and preserve a person's fingerprints
- **whorl** (plain whorl) a fingerprint pattern that resembles a bull's-eye

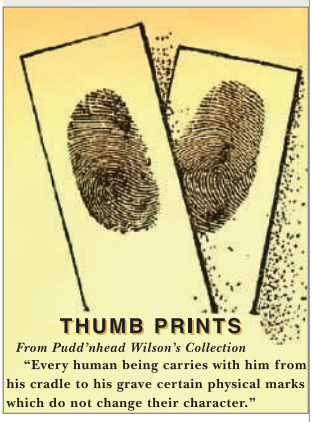
Introduction

Pudd'nhead Wilson is a lawyer created by Mark Twain in the novel of the same name, published in November 1894. In his final address to a jury, Lawyer Wilson exhibits his knowledge of the cutting-edge technology of the day:

> *Every human being carries with him from his cradle to his grave, certain physical marks which do not change their character, and by which he can always be identified—and that without shade of doubt or question. These marks are his signature, his physiological autograph, so to speak, and this autograph cannot be counterfeited, nor can he disguise it or hide it away, nor can it become illegible by the wear and mutations of time.*

No one is sure how Mark Twain learned that fingerprints made good forensic evidence, but he used them in his book to dramatically solve a case in which identical twins were falsely accused of murder. Using fingerprints as a means to identify individuals was a major breakthrough in forensic science in real life, as well as in novels, and it gave law enforcement around the world a new tool to solve crimes, clear the innocent, and convict the guilty. Fingerprint evidence also serves to identify the missing and the dead. Fingerprint cards from *Pudd'nhead Wilson* are shown in **Figure 6-1**.

FIGURE 6-1 Early, though fictional, fingerprint cards from Twain's Pudd'nhead Wilson.



Twain's Puddinhead Wilson

Analyzing fingerprint evidence today involves far more than looking at the fingerprints left at a crime scene. As technology has advanced, so has the world of fingerprint analysis. Today, programs have been initiated that allow law-enforcement officers across the country to quickly and easily submit fingerprints to a national database and obtain the identity of a suspect if their prints were entered into the database. Although fingerprints are mostly considered to be a form of individual evidence, biometrics (the measurement and statistical analysis of someone's unique physical characteristics) have improved the ability to establish one's identity.

In this chapter, you will explore the following:

- Formation of fingerprints during development
- Different types of fingerprint evidence
- How to collect, process, and analyze fingerprint evidence
- Why today fingerprint evidence may not be 100 percent unique as described in Mark Twain's novel

The History of Fingerprinting *Obj. 6.1*

For thousands of years, humans have been fascinated by the patterns found on the skin of their fingers. But exactly how long ago humans realized that these patterns could identify individuals is not clear. Several ancient cultures used fingerprints as personal markings (**Figure 6-2**). Archaeologists discovered fingerprints pressed into clay tablet contracts dating back to 1792–1750 B.C. in Babylon. In ancient China, it was a common practice to use inked fingerprints

on all official documents, such as contracts and loans. The oldest known document showing fingerprints dates from the third century B.C. Chinese historians have found fingerprints and palm prints pressed into clay writing surfaces and surmise that they were used to authenticate official seals and legal documents.

FIGURE 6-2 This ancient brick from Athens, Greece shows the builder's fingerprints embedded in the clay.

Dimitris Koskinas/Shutterstock.com

In Western culture, the earliest record of the study of the patterns on human hands comes from 1684. Dr. Nehemiah Grew wrote a paper describing the patterns that he saw on human hands under the microscope, including the presence of ridges. Johann Christoph Andreas Mayer (1788) described that "the arrangement of skin ridges is never duplicated in two persons." He was probably the first scientist to recognize this fact. In 1823, Jan Evangelist Purkinje described nine distinct fingerprint patterns, including loops, spirals, circles, and double whorls. Sir William Herschel began the collecting of fingerprints in 1856. He noted that the patterns were unique to each person and were not altered by age.

DID YOU KNOW?

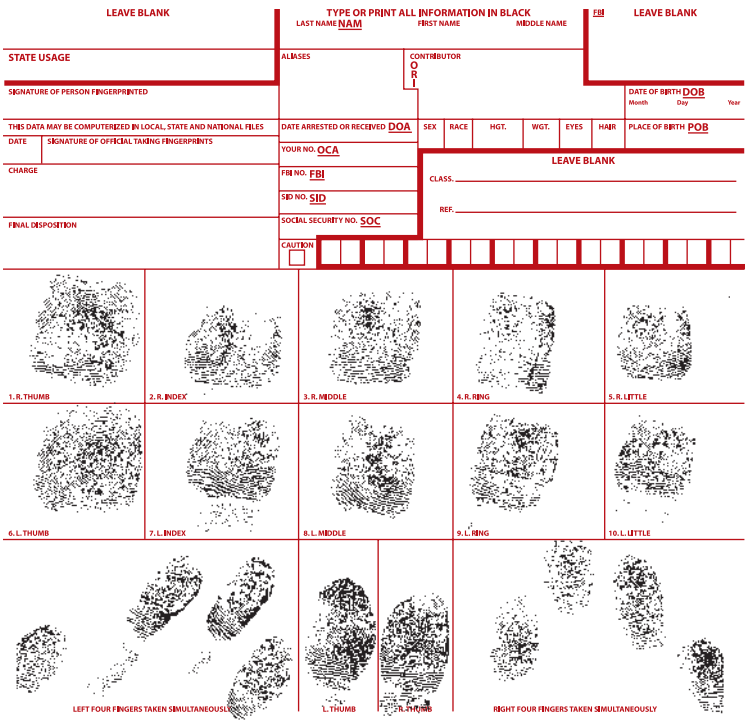
Alphonse Bertillon was the first person to document incoming prisoners with a photograph, the forerunner of the modern mug shot.

In 1879, Alphonse Bertillon, an assistant clerk in the records office at the police station in Paris, created a way to identify criminals using a list of physical measurements taken from prisoners. The system, sometimes called *bertillonage*, was first used in 1883 to identify repeat offenders. In 1902 in Argentina, Inspector Alverez, under the training of Juan Vucetich, was credited with solving the first murder using fingerprints, which replaced Bertillon measurements for identification.

Sir Francis Galton (1822–1911) verified that fingerprints do not change with age. In 1888, Galton, along with Sir Edmund Richard Henry, developed the classification system for fingerprints that is still in use today in the United States and Europe.

Beginning in 1896, Sir Edmund Richard Henry, with the help of two colleagues, created a system that divided fingerprint records into groups based on whether they have an arch, whorl, or loop pattern. Each fingerprint card in the system was imprinted with all 10 fingerprints of a person and marked with individual characteristics. This set of fingerprints has come to be called a **ten print card** (**Figure 6-3**).

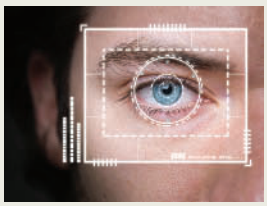
FIGURE 6-3 An example of a ten card.



Fingerprint identification systems and programs are changing to more integrated, automated systems that include biometric identification. As stated previously, **biometrics** are the use of measurements and statistical analyses of someone's physical characteristics to aid in their identification. Many of these programs are still in development. Refer to **Table 6-1** for a timeline of these developments.

Although technology has continued to improve, various state and local police agencies have not all been sufficiently funded to obtain handheld devices for rapid identification of individuals at traffic stops.

TABLE 6-1 Development of identification systems

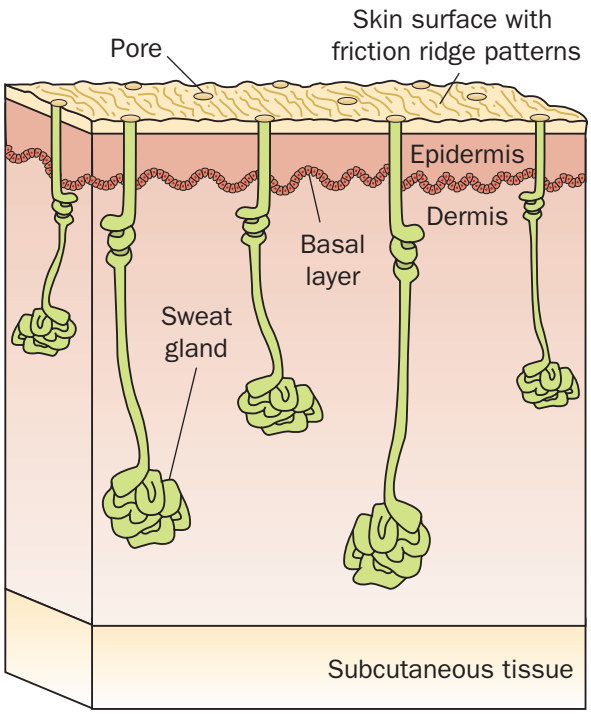
Date	Description
1980	Automated Fingerprint Identification Systems (AFIS) used by individual states.
1999	IAFIS developed by FBI replaced manual fingerprint searching with digital fingerprint images and criminal history. This system, linked to AFIS used by individual states, contains the world's largest and most efficient electronic repository of biometric (measurement and statistical analysis of someone's unique physical characteristics) and criminal history information.
2011	FBI's Next Generation Identification (NGI) incremental program is introduced and will eventually replace IAFIS. NGI uses matching algorithmic patterns in its Advanced Fingerprint Identification Technology (AFIT), increasing accuracy to 99.6%. NGI plans to gradually add biometric features to be included along with fingerprints.
2011	NGI launched Repository for Individuals of Special Concern (RISC) that enabled police officers in the field to collect and submit fingerprints and compare a suspect's fingerprints against a database of sex offenders, terrorists, and wanted individuals. (no civilian prints)
2013	NGI implemented palm and hand edge prints (little finger to the wrist) repository (20%–30% of all fingerprints are palm or edge of handprints).
2014	NGI added facial recognition using photos entered in the Interstate Photo System (IPS), a face recognition service that allows law-enforcement agencies to search photographs of criminals to assist with identifications. IPS includes photos of tattoos, scars, and marks. IPS is accessed through the Universal Face Workstations (UFW) and can search cell-phone and surveillance camera videos.  Pashkova/Shutterstock.com  ozrimoz/Shutterstock.com  metamorworks/ Shutterstock.com  Source: FBI
2014	NGI added Rap Back, a program that enables authorized entities to receive ongoing status reports of any criminal history on individuals holding positions of trust (e.g., day care workers and teachers).
2015	NGI included iris and identification examination in addition to scars, marks, and tattoos.
2018	Electronic Biometrics Transmission Specifications (EBTS) implementation. Eventually, this system will ultimately contain complete biometric and biographical profiles of the subject records in its databases.

The Science of Fingerprints *Obj. 6.2*

Look at the surface of your fingers. Are they smooth and shiny? No. All fingers, toes, feet, and palms are covered in small ridges. These are raised portions of skin, arranged in connected units called *dermal, or friction, ridges*. They help us with our grip on objects that we touch. When these ridges press against things, they leave marks. A finger leaves an impression called a **fingerprint**.

The imprint of a fingerprint consists of natural secretions of the sweat glands that are present in the friction ridge of the skin (**Figure 6-4**). These secretions are a mixture mainly of water, oils, and salts. Dirt from everyday activities is also mixed into these secretions. Anytime you touch something, you may leave behind traces of these substances in the unique pattern of your dermal ridges. Due to the uniqueness of fingerprints to an individual, this type of evidence can be considered *individual evidence*.

FIGURE 6-4 Our fingertips are covered with hundreds of microscopic sweat pores that make our fingers moist and able to grip better.



Formation of Fingerprints

The individual nature of fingerprints has been known for about 2,000 years, but scientists only recently discovered how friction ridges leading to fingerprints form in the womb. The latest information suggests that the patterns are formed at the beginning of the 10th week of gestation (time since conception). Similar ridges are formed in many other areas of the body, such as the palms and sides of the hands and the soles of the feet and toes. (Note that although identical twins have the same DNA, they do not have the same fingerprints because of alterations during gestation.) These **ridge patterns** are the ridges found in the areas such as the end pads of fingers and they form lines on the surfaces of objects in a fingerprint.

The development of ridge patterns happens in the basal layer of skin, where new skin cells are produced. As the basal layer grows, unique ridge patterns form, influenced by the environment surrounding the fetus. The pattern can be altered by damage to the dermal layer. An injury of this type may create an alteration when skin regrows, and a scar appears on the original pattern.

Characteristics of Fingerprints *Obj. 6.3*

At first glance, it may be difficult to distinguish one fingerprint from another. But by understanding the different patterns and variations of the ridge patterns, you will be able to detect differences in most fingerprints.

Types of Fingerprints

There are three types of prints that can be left at a crime scene. **Patent fingerprints**, or visible prints, are left on a smooth surface when blood, paint, grease, ink, or some

FIGURE 6-5 Latent prints made "visible" using fingerprint powders prior to being "lifted."

other material comes in contact with the hands and is transferred to that surface. **Plastic fingerprints** are actual indentations left in some soft material such as clay, putty, or wax. **Latent fingerprints**, or prints not visible to the unaided eye, are caused by the transfer of oils and other body secretions onto a surface. They can be made visible (developed) by dusting with powders and *lifting*, or by using tape or adhesive lifter (**Figure 6-5**).

Basic Ridge Patterns

Fingerprint characteristics are named for their general visual appearance (ridge pattern). Major ridge patterns are **loops**, **whorls**, and **arches** (**Figure 6-6**). About 65 percent of the total population has loops, 30 percent has whorls, and 5 percent has arches.

Arches have ridges that enter from one side of the fingerprint and leave from the other side with a rise in the center. Whorls look like a bull's-eye. Loops enter and exit from the same direction. The **core** is the center of a loop or whorl.

Some fingerprints have a triangular ridge pattern called a **delta**. A delta is where the ridge patterns diverge or change direction. Some of the ridges go above the delta and some of the ridges go below the delta. Note in Figure 6-6 that arches lack deltas, whorls have at least two deltas, and loops have one delta.

FIGURE 6-6 Three basic fingerprint patterns occur at different frequencies in humans.

Arches 5% Whorls 30% Loops 65%

FIGURE 6-7 The core is located at the center of a loop or whorl. The delta is the triangular region where the ridge pattern diverges.

Core: center of loop, shown in orange

Delta: triangular region inside red circle

Ridge count: is the number of ridges between the core and the center of the delta.

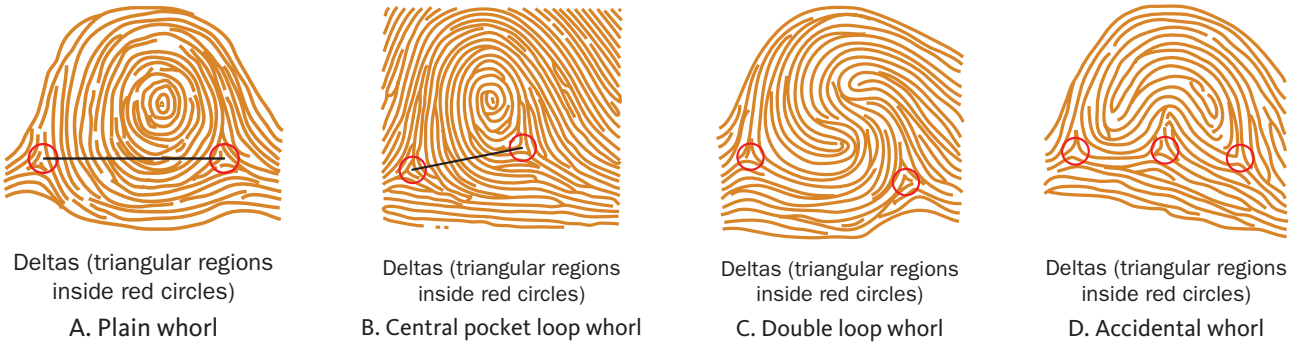
A **ridge count**, which is the number of ridges between the core and center of the delta, may help distinguish one fingerprint from another. To take a ridge count for a loop pattern, an imaginary line is drawn from the center of the core to the middle of the delta. Count the number of ridges between the core and the center of the delta. In **Figure 6-7**, the blue line shows the area used in the ridge count.

Subdivisions of Ridge Patterns

The three basic fingerprint patterns can be further subdivided. Whorl patterns with two deltas may be plain whorl (24 percent), central pocket loop whorl (2 percent),

double loop whorl (4 percent), or accidental whorl (0.01 percent) (**Figure 6-8**). The *plain whorl* (Figure 6-8A) has one or more ridges that make a complete spiral. If a line is drawn between the center of the two deltas, at least one of the concentric circles crosses that line. The *central pocket loop whorl* (Figure 6-8B) has one or more ridges that make a complete circle. If a line is drawn between the center of the two deltas, then none of the concentric circles crosses that line. The *double loop whorl* (Figure 6-8C) has two separate loop formations and two deltas. The *accidental whorl* (Figure 6-8D) has two or more deltas and is a combination of two of the other patterns (other than a plain arch).

FIGURE 6-8 Types of whorl pattern.



Deltas (triangular regions inside red circles)
A. Plain whorl

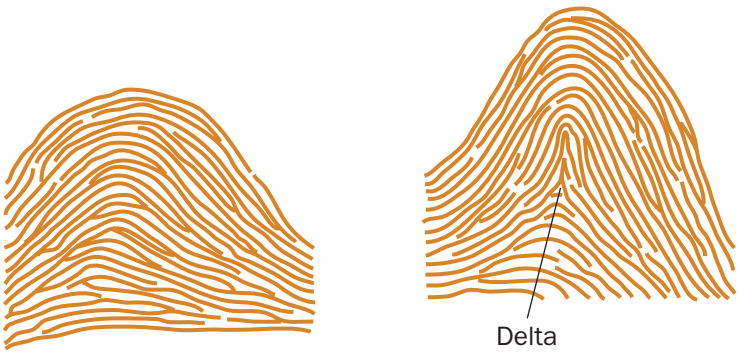
Deltas (triangular regions inside red circles)
B. Central pocket loop whorl

Deltas (triangular regions inside red circles)
C. Double loop whorl

Deltas (triangular regions inside red circles)
D. Accidental whorl

Arches may be divided into plain arches (4 percent) and tented arches (1 percent) (**Figure 6-9**). The *plain arch* (Figure 6-9A) has ridges entering one side, rising in the center, and exiting the other side. It does not have a delta. The *tented arch* (Figure 6-9B) has ridge patterns entering one side, rising in the center, and exiting out the other side. However, the ridge pattern has a sharp rise in the center of the arch.

FIGURE 6-9 Types of arch pattern.



A. Plain arch
B. Tented arch

Loops can be further classified as ulnar or radial depending on the direction of the opening of the loop. A *radial loop* opens toward the thumb (toward the radius bone), and an *ulnar loop* opens toward the little finger (toward the ulna bone).

DID YOU KNOW?

Fingerprints can be taken from dead bodies by chemically treating the fingertips to help them puff out. Another method involves removing the finger skin and placing it like a glove onto the (gloved) finger of someone else, who can then roll the print.

Minutiae and Fingerprint Identification

While looking at the basic fingerprint patterns can quickly help exclude a suspect, in order to consider a print found at a crime scene consistent with that of an individual, more information is needed. An examiner needs to know if he is viewing a partial print, multiple prints, or prints from a right or left hand. (Left and right fingerprints are not mirror images.) Every individual, including identical twins, has unique ridge characteristic details called **minutiae** (because the details are so small). Recognizing minutiae, their relative number, and their location on a specific fingerprint is called *fingerprint identification*. There are about 150 individual ridge characteristics on the average full fingerprint. When forensic examiners identify a fingerprint, they are, in theory, identifying the unique signature of a person.

Refer to **Figure 6-10**, to see descriptions of fingerprint minutiae patterns. Keep in mind that most prints recovered from a crime scene are only partial prints. Identification of minutiae patterns can be done without having a full fingerprint. In the lab activities, you will practice the techniques necessary to identify and compare fingerprints, including analyzing these ridge characteristics.

FIGURE 6-10 Some minutiae patterns used to analyze fingerprints.

Name	Visual Appearance
1. Ridge ending (including broken ridge)	
2. Fork (or bifurcation)	
3. Island ridge (or short ridge)	
4. Dot (or very short ridge)	
5. Bridge	
6. Spur (or hook)	
7. Eye (enclosure or island)	
8. Double bifurcation	
9. Delta	
10. Trifurcation	

Collection and Documentation of Fingerprints *Obj. 6.4*

When collecting and documenting evidence, it is important to follow the proper procedures (as described in Chapter 2). Because fingerprints are difficult to see, all crime-scene investigators (CSIs) need to be specially trained in

- where to look for fingerprint evidence;
- how to identify different types of fingerprints;
- what type of lighting, powders, or chemicals should be used to enhance the fingerprint; and
- how to photograph and document each fingerprint.

Photographing Fingerprints

Because not all fingerprints are visible, it takes a trained CSI to know where to recover possible fingerprints. Crime-scene investigators often use alternative light sources such as lasers or LED devices that emit a particular wavelet of light or use filters on the light source to help identify fingerprints. Once located, all fingerprints should be photographed *in situ* before any attempt to enhance the fingerprint or to lift the fingerprint (**Figure 6-11**). Close-up photos as well as photos that show where the fingerprint was found in relationship to the crime scene should be taken. After the fingerprint is enhanced, another photo should be taken of the fingerprint with the powder or chemical enhancer. All photos and fingerprint evidence are logged as evidence.

FIGURE 6-11 A crime-scene specialist photographing a print *in situ*.

Couperfield/Shutterstock.com

Methods of Collection

All fingerprint evidence should be documented in the evidence log. Chain of custody labels should be completed for each fingerprint. The method of collection differs depending on the type of fingerprint.

Collecting Latent Fingerprints

As mentioned earlier, latent fingerprints are not easily visible, but techniques can enhance them. To enhance the latent print, dusting smooth, nonporous surfaces such as drinking glasses, the faucets on sinks, telephones, and the like with a fine carbon powder can make a fingerprint more visible. Magnetic powders may also be used and are easier to clean than dusting powders. Fluorescent dye stains or powders aided with a laser or light source are also used. Tape is used to lift and preserve the fingerprint. Latent prints are fragile and can be easily affected by environmental factors; therefore, fingerprints should be processed as soon as possible. The side of the tape with the fingerprint is placed on an evidence card

with a contrasting background. The date, time, location, and collector of the print are logged on the evidence card.

To recover a print from a porous surface that is not smooth and hard requires the use of different chemicals to enhance the image. When the fingerprint residue combines with these chemicals, the fingerprint image becomes visible. **Table 6-2** summarizes common chemicals used to recover a latent print.

TABLE 6-2 Other methods used for visualizing latent fingerprints

Chemical	Uses	Application	Safety	Chemical Reaction	Latent Print
Ninhydrin	Paper	Object is dipped or sprayed in ninhydrin; wait for 24 hours	Do not inhale or get on your skin	Reacts with amino acids (from proteins) found in sweat	Purplish-blue print
Cyanoacrylate vapor (super glue)	Household items: plastic, metal, glass; skin	Cyanoacrylate is heated in a vapor tent or fuming wand is used	Do not inhale or get on your skin: irritating to mucous membranes	Reacts with amino acids, proteins, fatty acids	White print
Silver nitrate	Wood; styrofoam	Object is dipped or sprayed in silver nitrate	Wear gloves to avoid contact with skin	Chloride from salt in perspiration on the print combines with silver nitrate to form silver chloride	Black or reddish-brown print under UV light
Iodine fuming	Paper; cardboard; unpainted surfaces	In a vapor tent, heat solid iodine crystals	Toxic to inhale or ingest	Iodine combines with carbohydrates in latent print	Brownish print fades quickly; must be photographed or sprayed with a starch solution

Collecting Patent Prints

Patent or visible prints found in blood or ink are immediately photographed. If the patent print is on a surface, such as a shirt or piece of paper, the item is dried and then bagged in a paper bag. The blood or liquid that was found in the print could be further analyzed in the lab for additional evidence.

Collecting Plastic Prints

Plastic prints that appear as indentations on soft items are first photographed. They usually do not require any enhancement. The item with the plastic print can be collected and may be casted if necessary. Oblique lighting may help enhance images.

Collecting Suspect Prints

Fingerprints of suspects are taken by rolling each of the 10 fingers in ink and then rolling them onto a ten print card that presents the 10 fingerprints in a standard format. In Activity 6-4, you will learn how to take your own ten card fingerprints. In most labs today, however, fingerprints are taken digitally.

Forensic Analysis of Fingerprinting *Obj. 6.5*

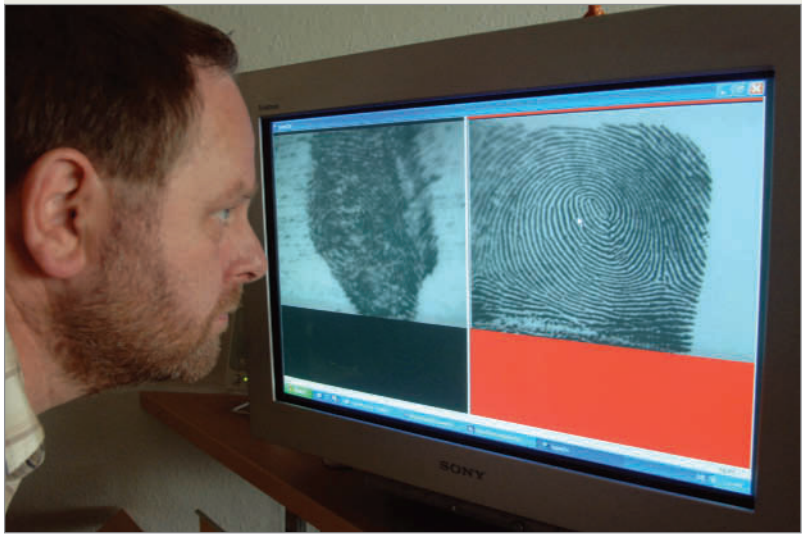
Fingerprint analysis and fingerprint storage of data have changed dramatically since the turn of the century, when individual experts analyzed, copied, and stored fingerprints on paper. Today, fingerprints are taken digitally, stored on huge computer databases shared both nationally and internationally, and easily accessed from mobile police units. The initial and final fingerprint assessments are completed by a person. However, most of the analyses are done electronically on computers resulting in more objective, reliable, and valid results.

How Are Fingerprints Analyzed?

Contrary to what we see on television, fingerprint comparisons and identifications are not carried out by a computer in a matter of seconds. To complicate the analysis, most fingerprints left at crime scene are often partial, smudged, or altered. Before analyzing a fingerprint, an assessment is made by a fingerprint expert to determine if the fingerprint has adequate quality and quantity of features. By 1987, when most fingerprints were being analyzed by people and not computers, the FBI had 23 million criminal fingerprint cards on file, and getting a comparison with a fingerprint found at a crime scene with one stored on file required manual searching. It could take as long as three months to do a thorough search.

In 1999, IAFIS (**Figure 6-12**) provided digital, automated fingerprint searches, latent print searches, electronic storage of fingerprint photo files, and electronic exchange of fingerprints and test results that greatly improved the ability to analyze and compare fingerprints. IAFIS operated 24 hours a day, 365 days a year. The FBI's NGI, launched in 2011, is enhancing and ultimately replacing IAFIS. Since the NGI system was introduced, it has improved automated fingerprint and latent search capabilities, mobile fingerprint identification, and electronic image storage as well as incorporating new means of biometric identification, including facial recognition, iris scans, and palm and hand edge prints. Personal identification information can be easily and quickly stored, accessed, and shared both nationally and internationally.

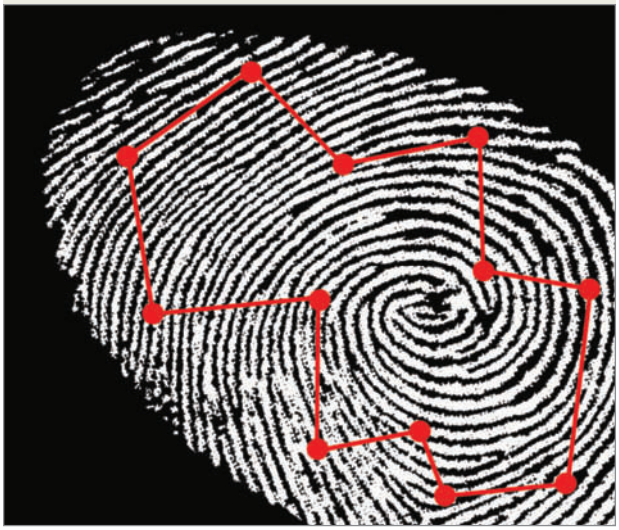
FIGURE 6-12 A technician compares fingerprints in the IAFIS system.



Peter Foerester/picture-alliance/dpa/AP Images

In early 2019, the NGI databases contained 65 million sets of civilian fingerprints, 77 million sets of criminal fingerprints, and 5 million sets of RISC fingerprints, or fingerprints in the Repository for Individuals of Special Concern. Over 24,000 law-enforcement agencies at the local, state, federal, tribal, and international law-enforcement groups submitted fingerprints and other identify information to NGI. With advancements in portable scanning units and the use of digital fingerprints, speed in identification of fingerprints has increased dramatically. If a police officer makes a routine traffic stop and needs to check the

FIGURE 6-13 Computer analysis of fingerprints examines patterns formed from ridge patterns and minutiae.



Mehau Kalyk/Science Source

identification of the driver, he can scan the driver's fingerprints and electronically submit the fingerprints to NGI. Those fingerprints are checked within minutes with the NGI databases and can help dictate a possible course of action for that officer.

Today, most fingerprints are compared using technology first, with the final comparison made by an expert. Using image enhancement algorithms, fingerprint quality and clarity can be improved and marked. Scanners are used to identify and mark minutiae points. Software calculates the distances and angles between key minutiae points and defines a unique pattern, known as an *algorithm* (**Figure 6-13**). Instead of examining individual ridges and minutiae, the computer searches for the pattern formed from the minutiae and ridges. A computer rapidly searches the databases for fingerprints that are consistent with the algorithm or unique pattern formed by the ridges and minutiae patterns. The computer search for that pattern or algorithm is not only much faster, but it can also significantly reduce the search to a smaller number of individuals.

Most fingerprints recovered from a crime scene are often partial prints and often smudged. New studies show that the initial analysis of the fingerprint to determine if it is a usable print having sufficient quantity and quality can now be done objectively by a machine and not a person. "Matching scores" of the comparison of the evidence fingerprint with a suspect's fingerprint is electronically assigned, removing the subjective analysis of a fingerprint examiner. However, the final fingerprint identification is still confirmed by a fingerprint examiner.

Fingerprint Reliability and Validity

Fingerprint evidence, once believed to be infallible, is now under scrutiny for its validity and reliability. In 1995, 156 fingerprint examiners were given a test. One in five examiners made at least one false identification. In 2004, the FBI arrested and jailed Oregon lawyer Brandon Mayfield based on fingerprint evidence that linked him to the Madrid train bombings, which killed 170 people. Mayfield, who had not traveled out of the United States for 10 years, claimed the fingerprint was inconsistent with his. Mayfield was held in custody for two weeks, until the Spanish authorities told the FBI that the fingerprint was, in fact, that of an Algerian citizen.

In 2009, a report from the National Academy of Sciences found that results are not necessarily repeatable (not reliable) from examiner to examiner and that even experienced examiners might disagree with their own past conclusions when they reexamine the same prints at a later date. The tragedy of erroneous results is that innocent people are being wrongly accused and guilty people are free to commit more crimes.

The problem of fingerprint evidence analysis in the past was due to the subjectivity of the examiner. The lack of scientific objectivity led many scientists to question the validity of fingerprint analysis. The National Academy of Sciences requested a federal board to research and access reliable methods used in

DID YOU KNOW?

Digital fingerprint images can be enhanced. Characteristics like ridge endings and bifurcations are assigned coded mathematical values. Corrupted regions on the fingerprint file can be blended with distinct regions to produce an enhanced composite print.

forensics. This resulted in the creation of Scientific Working Groups (SWGs) to ensure high standards of evidence evaluation. In 2014, the SWG became known as the Organization of Scientific Area Committees (OSAC).

Among the recommendations made by SWG and OSAC were that results need to be double-checked to prevent false identifications. In 2018, the Department of Justice (DOJ) standardized the language used in reporting information about fingerprints at trial. Experts are to report such items as a suspect's ridge and sweat pore patterns and compare their consistency with evidence. The experts should explain their procedures without using such terms as "scientific certainty" or "individualization." The examiner cannot assert a "100 percent certainty" or a "zero-percent error rate." The examiner should not use the number of cases worked on during a career as a measure of accuracy, rather only as a measure of past experience. The examiner can make only one of three conclusions for source identification: exclusive, inclusive, or inconclusive.

Today, with NGI and the use of computer algorithms, there has been a 90 percent reduction in the number of manual fingerprint reviews, resulting in less subjective evaluation of fingerprints and much improved evidence reliability.

Can Fingerprints Be Altered or Disguised?

As soon as fingerprints were discovered to be a means of identification, criminals began to devise ways to alter them so that they could avoid being identified. American Public Enemy Number One in the 1930s, John Dillinger put acid on his fingertips to change their appearance, something he likely learned from stories of workers in the pineapple fields in Cuba who did not have readily visible fingerprints. This is because chemical substances found in the pineapple plant, when combined with the pressure of handling the plants, dissolved the workers' fingertip skin. What Dillinger did not learn is that when these workers ended their contact with the pineapples, their fingerprints grew back! Fingerprints taken from Dillinger's body in the morgue were compared to known examples he left behind during his life of crime. Despite his efforts to destroy his fingerprints, they still allowed him to be identified. Sometimes, the scars formed by trying to remove fingerprints even make fingerprint identification easier!

DID YOU KNOW?

Pineapple juice contains an enzyme that digests protein. The protein fingerprint ridges in the skin are temporarily removed when exposed to pineapple juice and result in poor fingerprints.

Advances in Fingerprinting *Obj. 6.6*

Fingerprinting is as much a part of the future of forensics as it has been a part of its past. New technology has significantly improved the speed, accuracy, and reliability of fingerprint analysis. In an attempt to reduce the subjective human errors made in preliminary fingerprint screening, scientists at the Michigan State University (2017) have developed an algorithm that automates and standardizes the key first step of assessing if a fingerprint's quality and quantity is usable for analysis. Human experts develop the algorithm for the computer to recognize and identify minutiae patterns. Large databases must be used to help refine the machine learning process. In controlled testing, the machines outscored the human examiners and were much faster at identifying similarities. With new scanning technology and digital systems of identifying patterns, fingerprints can be scanned at a

DID YOU KNOW?

Biometric finger and hand scanners can use fingerprint ridge patterns, the length of your fingers, and your body temperature to help identify you. Biometrics are used in Singapore's border security checkpoints. It takes on average 12 seconds to pass through an unmanned security station using a fingerprint scanner and a passport.

FIGURE 6-14 This high-resolution fingerprint is a digital image that shows the sweat pores along the ridges, which appear as bumps in the print.

resolution of 500–1,000 dots per inch. This provides an image that reveals minute pore patterns on the fingerprint ridges, allowing for more precise pattern comparisons. Nanoparticles have now been added to fingerprint powders, making pore patterns appear even sharper (**Figure 6-14**).

Entirely new uses for fingerprints are also being developed. Trace amounts of DNA have been recovered from fingerprints that may help identify suspects at a crime scene. Fingerprints contain sweat that can be chemically analyzed using mass spectrophotometry to reveal information about what we touched or consumed. Using infrared spectromicroscopy, minute particles found in fingerprints are analyzed for color, shape, and size to determine if someone was exposed to or handled explosives (or other chemicals), which could help identify terrorists. Samples obtained from fingerprints are compared with existing databases for identification.

Technology is under development to provide a molecular fingerprint from a fingerprint sample that might someday tell us much more about the lives of the fingerprint donors than just their identities.

Search the Internet for "FBI-Latent Print of the Year 2012" and read how a cold case was solved using IAFIS.

SUMMARY

- Humans have noticed the patterns on their hands for thousands of years, but it was not until 1684 that these patterns were described in detail. In the mid-1800s, the idea of a fingerprint's uniqueness was studied, and the application of fingerprints to an identification system began. By the late 1800s, two effective systems were being used to identify criminals, and fingerprints were being collected as evidence in crimes. In the past 20 years, improvements in technology have improved fingerprint analysis and reliability.
- The elevated regions in the skin of the finger are called friction ridges formed early in development between two layers of skin. Unique to individuals, their shape does not change during their lifetime.
- Fingerprints left on an object are created by the naturally occurring ridges in the skin of fingertips and secretions from sweat glands that leave small amounts of oils and salts when the ridges are pressed against an object. The residues leave a reproduction of the ridges found on the finger of the donor.
- Fingerprints found at a crime scene are latent, not easily seen without the addition of powders or chemical; plastic prints are found embedded in soft materials; patent prints are formed when fingers come in contact with a material and are transferred to a surface.

- Fingerprint patterns are classified as loops, whorls, and arches. A core is the center of a loop or whorl. A delta is a triangular region where the ridges diverge. Ridge counts, measured from the center of the delta to the center of a core, provide distinguishing characteristics of fingerprints. The three basic patterns of fingerprints can be further subdivided into more specific subcategories.
- Minutiae patterns are small distinguishing features used to analyze fingerprints. Prior to advancements in scanners, fingerprint analysis was a very slow process undertaken by a fingerprint expert that was not always reliable.
- Criminals have sought to alter their fingerprints with chemicals, surgery, and superficial destruction. Some fingerprints can temporarily be altered by long-term contact with rough surfaces. Attempts at permanent fingerprint alteration have been painful, leaving mutilated, deformed, and even more recognizable fingerprints than the original fingerprints.
- Fingerprints must be properly collected and documented to be an acceptable evidence. Both the SWG and OSAC have developed standards and protocols to improve fingerprint evidence reliability and validity.
- Fingerprint collection and documentation may involve dusting with specialized powders or chemicals, casting of plastic prints, and photographing the print.
- Today, much of fingerprint analysis is automated. Fingerprints of suspects can be quickly scanned and compared to a national FBI database of over 149 million fingerprints.
- Mobile handheld scanners obtain fingerprints of suspects, forward them to the national database. Within minutes, the police officer knows if the suspect has an open warrant for arrest, is on a terrorist or sex offender list, or has previously committed crimes.
- New technology continues to improve fingerprint analysis through machine learning to access usability of prints and improved scanning technologies using nanoparticles for pore analysis.
- New uses of fingerprints include DNA analysis and chemical analysis of the sweat found in prints using infrared spectromicroscopy to detect evidence of what donor touched or consumed.
- Fingerprint analysis has become less subjective, faster, and more reliable with advances in technology. AFIT's use of algorithms and NGI's inclusion of palm prints, rapid ID in the field, and biometrics have improved both reliability and validity of fingerprint analysis.

Case STUDIES

Francisca Rojas (1892)

On June 29, 1892, in the village of Necochea, Argentina, two children, Ponciano Carballo Rojas, age 6, and his sister Teresa, age 4, were found murdered in their home. Their mother, Francisca, age 27, was found with a superficial knife wound to the throat.

Francisca told police that her neighbor, Pedro Ramón Velásquez, had committed the crime. Velásquez, a one-time boyfriend of Francisca, did not confess, even after being tortured.

Inspector Commissioner Alvárez went to the crime scene to reexamine it, searching for any trace evidence that might have been overlooked. He spotted bloody fingerprints on the doorpost of the house. Because Francisca had denied touching the bodies of her children, Alvárez believed he had found an important clue.

He took the bloody doorpost and fingerprint samples of Pedro Velásquez to Juan Vucetich, who in late 1891 had opened the first fingerprint bureau in South America in Buenos Aires. Vucetich examined the fingerprints and found they were not consistent with those of Velásquez. Alvárez became suspicious of Francisca, who had been so insistent that Velásquez had committed the crime. He took a sample of her fingerprints and discovered that they were consistent with the bloody prints found on the doorpost of the house.

When Francisca was confronted with the evidence against her, she confessed. She had murdered her own children, faked an attack on herself, and cast blame on an innocent man, intending him to die for the crime. Her reasons for the murder and for blaming Velásquez were that he had interfered in a romance between her and another man, and she felt she would be more appealing to the other man if she did not have children. Francisca Rojas was the first person in the Americas to be convicted of a crime based on fingerprint evidence.

Stephen Cowans (1997)

On the afternoon of May 30, 1997, Boston police officer Gregory Gallagher was shot with his own gun in a backyard in Roxbury, Massachusetts. Still carrying the gun, the assailant ran to a nearby residence, where he received a glass of water and wiped off the gun. Investigators found a print on the glass used by the assailant. The print was found to be consistent with the prints of Stephen Cowans by two fingerprint examiners from the Boston Police Department. Cowans maintained his innocence. With the compelling fingerprint evidence, Cowans was convicted of the shooting and sentenced to 30–45 years in the state prison.

In 2004, Cowan's defense team requested DNA testing of the glass and a baseball cap dropped at the scene of the shooting. Neither DNA sample was consistent with Cowan's DNA. The original verdict was overturned. As Suffolk County reexamined the fingerprints in preparing to retry Cowans, the assistant district attorney discovered "conclusively and unequivocally that … the purported match was a mistake." Cowans was released from prison after 6-1/2 years. As a result, Boston police and the Suffolk County District Attorney's office established new guidelines for identification and evidence handling.

Routine Traffic Stop Identifies Murderer Using RISC
(1997)

During a routine traffic stop in Ormond Beach, Florida, Officer Rickie Zigler smelled marijuana and became suspicious. When the driver showed officer Ziegler his driver's license, the officer noticed that the driver's license and a bank card had different names. Officer Zigler used a handheld, live scan rapid capture device to scan and digitize the driver's fingerprints. The scanned prints were sent to the Florida state AFIS and the RISC. Within 45 seconds the RISC site returned an eight-year-old outstanding warrant for aggravated assault and murder. The driver was arrested. In 2011, the RISC system became fully operational as a part of NGI.

Anne Kitzman/Shutterstock.com

Think CRITICALLY

"To get a conviction, I would rather have one good fingerprint than a pound of hair and fiber evidence." Do you agree or disagree? Support your answer.

Careers IN FORENSICS

Peter Paul Biro

ART CONSERVATOR

A Hungarian immigrant, currently living and working in Canada, Peter Paul Biro is an art conservator who, in 1984, was the first to study the fingerprints left behind on paintings by artists. After years of careful study, he began using these marks as a means of identifying artists.

Biro's job is to discover, by the use of fingerprint comparison, who painted a work of art and to support the claim with strong evidence. No two fingerprints are alike, so Biro's evidence is extremely valuable to those who buy and sell art because a painting that can be attributed to a specific artist rises in value.

Biro only uses fingerprints on artworks that were clearly made during the original creation of the work. These include imprints left in the paint while it was still wet, or prints left as a result of the use of a fingertip to apply paint (Leonardo da Vinci often used his fingertips as paintbrushes), or a palm print that might have resulted from applying varnish by hand. The print used for comparison should come from an unquestioned work of art by the artist.

In 1993, Biro examined a painting discovered in the early 1980s entitled *Landscape with Rainbow* that was thought to be painted by J. M. W. Turner. During the restoration of this painting, fingerprints were discovered in the paint. Even though fingerprints on *Landscape with Rainbow* and fingerprints photographed on another Turner painting, *Chichester Canal*, were consistent, art experts and scholars alike discounted the evidence. Turner, who was known to work alone with no assistants, had used his fingertip on both paintings to model the still-wet paint and was the only possible donor for both prints. When an independent fingerprint examination by John Manners of the West Yorkshire Police confirmed the conclusions that the fingerprints on both paintings were consistent, the unbelievers changed their minds. This case was the first successful use of fingerprints to authenticate artwork. The newly authenticated Turner painting sold for much more money than it would have otherwise.

Artists unwittingly leave their fingerprints in their artwork. Patent fingerprints such as this left in oil paint have been used to help authenticate artwork.

Chapter 6 REVIEW

TRUE OR FALSE

1. Fingerprint impressions left on a smooth surface consist of natural secretions of the sweat pores found in the friction ridge of the skin. *Obj. 6.2*
2. Fingerprints are generally considered to be a form of class evidence. *Obj. 6.2*
3. It is necessary to obtain a full print from a suspect in order to compare his fingerprint with a fingerprint found at the crime scene. *Obj. 6.3*
4. Plastic prints must be dusted or treated in order to identify the ridge patterns. *Obj. 6.3, 6.4*
5. It is important to always photograph a fingerprint before you attempt to lift it. *Obj. 6.4*
6. Fingerprints are formed deep within the dermis layer of the skin. *Obj. 6.2*
7. NGI improves the speed and accuracy of fingerprint searches because it electronically accesses fingerprints from local, state, and national agencies. *Obj. 6.5*
8. The type of powder used to dust prints will vary depending upon the weather conditions when the print is lifted. *Obj. 6.4*
9. Fingerprints of the left hand are mirror images of the fingerprints on the right hand. *Obj. 6.2*
10. Similar print or ridge patterns can also be found on the toes. *Obj. 6.2*

MULTIPLE CHOICE

11. Fingerprints are formed *Obj. 6.2*
    a) shortly after birth.
    b) at about two years of age.
    c) at 10 weeks' gestation (pregnancy).
    d) at conception.
12. Fingerprints that are actual indentations left in some soft material such as clay or putty are referred to as *Obj. 6.3*
    a) plastic fingerprints.
    b) patent fingerprints.
    c) latent fingerprints.
    d) indented fingerprints.

13. The use of fingerprints in identification is not perfect because *Obj. 6.5, 6.6*

a) the current technology depends on humans to analyze the information, and humans make mistakes.

b) many people have the same exact fingerprints.

c) people can easily change their fingerprints.

d) all of the above

14. The presence of two deltas in a fingerprint indicates *Obj. 6.3*

a) scar tissue.

b) that a print is a whorl pattern.

c) that a print is a loop pattern.

d) that a print has a core.

SHORT ANSWER

15. Outline the steps in taking a ridge count from a fingerprint. *Obj. 6.3*

16. Summarize how fingerprints are formed. *Obj. 6.2*

17. Is it possible to alter fingerprints? Defend your opinion, citing evidence from the chapter. *Obj. 6.5*

18. Another way to make prints visible is to apply certain chemicals. What component of a fingerprint chemically reacts with each of the following? *Obj. 6.4*

a) Ninhydrin

b) Cyanoacrylate

c) Silver nitrate

d) Iodine fuming

19. Refer to the scenario at the beginning of the chapter entitled Technology Catches Up to Crime and answer the following questions: *Obj. 6.1, 6.3, 6.6*

a) List the evidence recovered from the December 1999 murder case.

b) Describe the patent fingerprints found at the crime scene. Define *patent fingerprints* in your answer.

c) Several investigators were involved with the May 1999 murder case. List each investigator's name, the name of his agency, and the description of his role in the investigation.

d) Compare and contrast fingerprint searches today using IAFIS with fingerprint searches that might have occurred 25 years ago.

e) When the San Bernardino County Sheriff's Department submitted the latent print recovered at the 1999 murder scene to IAFIS, it was compared to Jad Salem's prints, which were already in the IAFIS system. Describe the circumstances that resulted in Salem's fingerprints being entered into IAFIS.

f) What is the significance of the title Technology Catches Up to Crime?

20. Discuss how identification of individuals today is faster and more reliable as a result of technology. Consider the following in your response: *Obj. 6.6*

a) Mobile scanning fingerprint devices

b) NGI biometric measurement

c) Infrared spectromicroscopy

d) Computer analysis of minutiae patterns

21. Refer to the following two prints. The first print is taken from the FBI files of a suspect. The second print has been lifted off a glass taken from a crime scene. Determine if the prints are consistent with those of the suspect. Justify your answer. *Obj. 6.4, 6.5*

- Identify the type of ridge pattern found in both prints.
- Describe similarities or differences.

GOING FURTHER

1. Do you agree or disagree with the following statement? "At birth, all children should be fingerprinted and photographed so that in the future it will be easier to identify them." Explain your reasoning.

2. Design a procedure to demonstrate how to produce a plastic fingerprint impression of one of your fingers. Follow your procedure to make the plastic fingerprint impression. Prepare an inked fingerprint or a graphite fingerprint of the same finger. Which of the two fingerprint impressions do you think produces a better image of the fingerprint ridge patterns? Compare the plastic fingerprint with an inked or graphite impression of the same fingerprint.

a) List the materials you will need.

b) Describe how to

i. make a plastic fingerprint impression of one of your fingertips.

ii. take a digital image of the plastic fingerprint.

iii. make an inked or graphite fingerprint impression of the same fingertip.

iv. compare both images of the plastic fingerprint with the inked or graphite fingertip impression. Cite evidence that demonstrates that the two fingerprints are consistent.

v. contrast your plastic fingerprint impression with your partner's inked or graphite fingerprint impression. Defend your claim citing evidence from the two impressions that the two fingerprints are not consistent.

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Internet Resources

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Crime Scene Investigator, https://www.crime-scene-investigator.net/prints.html
Cutting Edge Fingerprint Identification, Border Security, https://www.nec.com
http://www.fbi.gov/about-us/cjis/fingerprints_biometrics/ngi
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Scientists Automate Key Step in Forensic Fingerprint Analysis, https://www.forensicmag.com
Velders, M.J.M. (Theo), "Visualization of Latent Fingerprints on Vinyl and Latex Gloves Using Gellifters"
https://www.crime-scene-investigator.net/visualization-of-latent-fingerprints-on-used-vinyl-and-latex-gloves-using-gellifters.html

YouTube

"Future of Fingerprints", https://www.youtube.com/watch?v=N8YEHr_3tus (13:40 minutes)
"NEC Biometric Clearance System for Immigration"
https://www.youtube.com/watch?v=tZMZ2Hr3ALk (3:25 minutes)
Simona Francese, " Your Fingerprints Reveal More Than You Think"
https://www.ted.com/talks/simona_francese_your_fingerprints_reveal_more_than_you_think? (9:58 minutes)
Video FBI Latent Hit of the Year. 2013, https://www.fbi.gov (10:43 minutes)

ACTIVITY
6–1

Study Your Fingerprints *Obj. 6.2, 6.3, 6.7*

Objectives:

By the end of this activity, you will be able to:

1. Lift your fingerprint using tape and a graphite pencil.
2. Identify the ridge pattern of your finger.
3. Compare and contrast your fingerprints to your classmates' fingerprints.
4. Find two other students with the same basic ridge pattern as your own.
5. Calculate the percentage of students having each of the three different ridge patterns.

Time Required to Complete Activity:

40 minutes

Materials:

Act 6-1 WKST *Data Table*
Clear, adhesive tape 3/4 inch in width or wider (not "transparent" tape)
Pencil
Two 3 × 5-inch cards
Magnifying glass

SAFETY PRECAUTIONS:

None

Procedure:

1. On a lined 3 × 5-inch card, rub the end of a graphite pencil in a back-and-forth motion, creating a dark patch of graphite.
2. Rub your right index finger across the graphite patch so that the fingertip becomes coated with graphite from the first joint in the finger to the tip, and from fingernail edge to fingernail edge.
3. Tear off a piece of clear adhesive tape about 2 inches long. Carefully press the sticky side of the tape onto your finger pad from the edge of your fingernail across your finger pad to the other side of your fingernail.
4. Gently peel off the tape.
5. Press the tape, sticky side down, on the clean 3 × 5-inch card.
6. Examine your fingerprint using a magnifying glass.
7. Compare your fingerprint to the pictured samples.
8. Identify whether your fingerprint pattern is a loop, arch, or whorl.
9. Find two other students who have a similar ridge pattern as yours and record your answer on the worksheet.
10. Find two other students who have the other two types of ridge patterns.
11. Calculate the percentage of loops, whorls, and arches found in your class.

Arches 5%

Whorls 30%

Loops 65%

12. Record the number of students showing each of the three types of fingerprint patterns, place those numbers in the data table in your worksheet, and then complete the rest of the data table.

Data Table

Data Collection From Classmates	Loop	Whorl	Arch
Number of students showing trait			
Total number of students in the class (*This will be the same total for each column.*)			
Percentage of class showing the trait (*Divide the number of students with the trait by the total number in the class, and then multiply by 100.*)			
National averages	65%	30%	5%

Questions:

1. Did the class percentage agree with the national averages? Support your claim using data from your data table.
2. Describe how to improve this data-collecting activity so that your results are more reliable.

Going Further:

Research chi-squared statistical analyses. Then run chi-squared statistical analyses to determine if the differences between your data and the national averages were significant.

ACTIVITY
6–2

Giant Balloon Fingerprint *Obj. 6.3, 6.7*

Objectives:

By the end of this activity, you will be able to:

1. Create a giant balloon fingerprint for use in studying various ridge patterns.
2. Identify the three basic ridge patterns among your classmates' fingerprints.

Time Required to Complete Activity:

20 minutes

Materials:

Act 6-2 WKST *Data Table*
1 large white balloon
Fingerprinting inkpad
Hand soap or moist wipes
Paper towels
Ballpoint pen and felt tip permanent marker

What you will need to do this experiment: a white balloon and an inkpad.

SAFETY PRECAUTIONS:

Before doing this activity, if you are allergic to latex, notify your teacher immediately.

Introduction:

Ridge patterns on fingerprints are unique and identifiable. In this activity, you will be comparing and contrasting your own thumbprint and those of your classmates to identify these patterns.

Procedure:

1. Slightly inflate a large balloon.
2. Ink your thumb from thumbnail to thumbnail and past the first joint.
3. Position your thumb so that your print will be about a quarter of the way from the top of the balloon and two-thirds of the way from the bottom. Gently press your thumb into the semi-inflated balloon. Do not roll your thumb. Pull your thumb from the balloon.
4. Fully inflate the balloon and examine your thumbprint.
5. Identify your thumb pattern as a loop, whorl, or arch on the data table in the accompanying worksheet.
6. Examine the balloons of your classmates and identify the ridge types.
7. Deflate your balloon and save it, unless you plan to do the following Going Further activity.

Data Table

Student Name for Fingerprint	Loop	Whorl	Arch
Your name:			
Name:			
Name:			
Name:			
Name:			

Going Further:

Refer to **Figure 6-10**, which describes minutiae patterns. Use a felt-tipped permanent marker to identify and circle the minutiae patterns on the balloon. Then deflate your balloon and save it.

ACTIVITY
6–3

Studying Latent and Plastic Fingerprints

Obj. 6.3, 6.4, 6.8

Objectives:

By the end of this activity, you will be able to:

1. Distinguish between a latent and plastic fingerprint.
2. Summarize how to dust and lift a latent fingerprint.
3. Lift latent fingerprints from a glass surface.
4. Design an experiment to demonstrate plastic fingerprint impressions.
5. Identify ridge patterns from lifted and plastic fingerprints.

Time Required to Complete Activity:

Part A: 40 minutes; Part B: 40 minutes

Materials:

Act 6-3 WKST *Latent Print*
Act 6-3 WKST *Plastic Prints*
Newspaper
Black dusting powder or brush and magnetic powder
Adhesive tape 3/4 inch wide
Dusting brush
Cloth
Magnifying glass
Drinking glass, glass petri dish, beaker, other pieces of glass or Plexiglas®
Soap or moist hand wipes
Paper towels
3 × 5-inch card per student
Digital camera (for plastic print procedure)

SAFETY PRECAUTIONS:

Cover the work area with newspapers.
Remember that the dusting powder can be very messy.

Introduction:

Every person has a unique set of fingerprints, even an identical twin. Whenever you touch a surface without gloves or other protection, you leave behind an invisible (latent) fingerprint. Law-enforcement agencies use various fingerprint powders and chemicals to help visualize these telltale prints. Plastic fingerprints are the impressions left in soft material, such as wax.

Procedure:

PART A: LATENT FINGERPRINTS

1. Cover the worktable with newspaper.
2. Wipe off your glass or Plexiglas® with a clean cloth.
3. Take your thumb and run it along the side of your nose or the back of your neck. These areas of your body are rich in oils and will help lubricate the ridges of the thumb to produce a clearer print.
4. Choose an area on the glass object and touch the glass with your thumb. Use a paper towel or other type of cloth in your other hand to prevent leaving other fingerprints. Avoid placing any other fingerprints in this area.
5. Dip the dusting brush lightly into the fingerprint powder. Place the brush between your hands and gently twist the brush back and forth, so that the bristles spin off excess powder near the surface of the object you are dusting. A latent (hidden) fingerprint should begin to appear. Continue to dust lightly, touching the surface until you have exposed as much of the latent print as possible. Gently blow off the excess powder. (Be prepared for dust to settle on everything in the area.)
6. Tear off a 3-inch piece of adhesive tape and place it over the fingerprint and press down.
7. Peel off the tape and place it on a 3 × 5-inch card. This process is called lifting the print.
8. On the 3 × 5-inch card or on the ACT 6-3 WKST *Latent Print*, identify and record the ridge pattern.

Loop

Arch

Whorl

PART B: PLASTIC FINGERPRINTS

1. Design an experiment to demonstrate how plastic fingerprint impressions are formed. Include the following in your design:
   a. Materials list
   b. Procedure
2. Have another student create a plastic fingerprint impression using your procedure.

3. Take a digital image of the plastic fingerprint and attach to or digitally embed the photo within your Act 6-3 WKST *Plastic Prints*.
4. Discuss with your partner ways to improve your procedure and record your suggestions on Act 6-3 WKST *Plastic Prints*.
5. (*Optional*) Create a PowerPoint presentation of the digital images of the class's plastic fingerprint impressions. Ask students in the class to identify the ridge patterns seen in the presentations.

Going Further:

1. If time permits, clean the glass and place additional fingerprints on the surface and repeat the technique; then exchange your glass for a classmate's. Dust, lift, and identify their fingerprint pattern.
2. Fingerprints are not the only latent prints left at a crime scene. Sometimes, if someone is trying to look into a window from the outside, they will cup their hands around their eyes to shield the light and lean against a window this way. Try creating and lifting a latent print from side of your hand (nearest the little finger). Can you identify ridge patterns in the latent print?
3. Research the National Palm Print System (NPPS). When was it formed? How many law-enforcement agencies use NPPS?

ACTIVITY
6–4

How to Print a Ten Card *Obj. 6.1, 6.9*

Objectives:

By the end of this activity, you will be able to:

1. Properly ink a finger for a fingerprint impression.
2. Roll a fingerprint for a thumb and a fingers.
3. Prepare a ten card.
4. Analyze fingerprints to diagnose errors in the fingerprinting process.

Time Required to Complete Activity:

45 minutes

Materials:

Act 6-4 WKST *Ten Card*
Blank ten print card
Inking strips and inkpad or nonink pads and paper
Magnifying glass
Moist cleansing wipes, soap, and paper towels

SAFETY PRECAUTIONS:

None

Introduction:

Law-enforcement officials prepare and use fingerprint cards, or ten print cards, to identify criminals, security workers, teachers, bus drivers, and individuals licensed to carry firearms, as well as to register children's personal identification for parents. Today, most police departments prepare digital scanned fingerprints. In this activity, you will prepare and ink a ten card.

Today, more and more fingerprinting is done digitally.

Background:

In this activity, you should produce a ten card of your fingerprints. Label it with an identifiable code but not your name. At the end of the activity, take your ten card home.

Procedure:

PART A: PRACTICE BEFORE USING INK

Prior to inking the fingers, you should practice the technique of how to ink a finger and how to roll a finger to get good fingerprint impressions.

1. How to ink a finger:
   - Hold up your right index finger. Bend the finger. The ink should be applied below the first joint.
   - Look at the edges of the fingernail. Ink should be applied from one nail edge to the pad of the finger to the other nail edge. If properly inked and rolled, the fingerprint should appear square.
2. How to roll a print:
   a. Stand sideways to the fingerprinting table (right side closest to the table to roll the right fingers).
   b. Extend one arm so that their fingers extend over the table. If you are too close to the table, your own body and elbow will get in the way of rolling a print.
   c. Relax your arms and shoulders.
   d. The direction that a finger is rolled depends on whether you are rolling a thumb or a finger.
      - Think of the expression ***TIFO*** (*thumbs inside, fingers outside*).
      - *Thumbs* roll toward the *inside* of the body.
      - *Fingers* roll toward the *outside* of the body.
3. Practice rolling the right index finger.

   Once in the correct body position, extend your right index finger above the table:
   - Turn the finger so that the left side edge of the finger is just above the table. Remember that you roll nail edge to nail edge!
   - Hold fingers, hand, and wrist parallel to the table.
   - Extend the arm fully with relaxed shoulders and arm.
   - Once in the proper position, practice rolling the finger from nail edge to nail edge by placing the finger onto the table and rolling the finger using a smooth, continuous motion. Do not hesitate or reverse direction. Remember fingers roll toward the outside of the body (TIFO).
   - You may find that taking a step forward or backward might be more comfortable when rolling your fingers to get a print.
   - Repeat the practice maneuver using different fingers.
   - Repeat the practice using your thumb (remember the thumb will roll to the inside of your body [TIFO]). Place the right edge of the right thumb onto the table and roll the thumb toward the center of the body.
4. Repeat Step 3 using your left hand.

PART B: INKING AND ROLLING A TEN CARD

1. Align the card so that the right-hand fingerprints on the card are located on the edge of the fingerprint table.
2. Ink the right index finger and roll the finger from nail edge to nail edge.
3. Continue inking and rolling each fingerprint, one at a time.
4. After completing the right hand, turn the fingerprint card so that the left side prints are closest to the table edge.
5. Repeat the process for the left hand.
6. Re-ink the fingers of the right hand and press them gently into the box labeled "first four" for the right hand. Do not roll the fingers.
7. Re-ink the right thumb, placing the print in the box labeled "Right thumb."
8. Repeat the process for the left hand.
9. Using a magnifying lens, examine each fingerprint, labeling each as a loop, whorl, or arch. You can also use your cell phone to take a photo and enlarge the image for viewing.
10. Examine other students' ten cards. Provide suggestions to them on how to improve upon their technique based on their ten card fingerprint impressions.

Questions:

It takes practice to be able to roll good fingerprints. Review the following list to see if you or your classmates produced any of these fingerprint errors. If so, diagnose what may have occurred while inking and rolling.

1. Looked more like a circle than a square
2. Appeared very faint
3. Appeared too dark
4. Had a smudge in the middle of the print
5. Had a smudge at the end of the print
6. Had a square edge only on one side
7. Were totally smudged
8. Contained gaps or spaces within the fingerprint

ACTIVITY
6–5

Minutiae Patterns *Obj. 6.3, 6.10*

Objectives:

By the end of this activity, you will be able to:

1. Describe different types of fingerprint minutiae patterns.
2. Identify different minutiae patterns found in fingerprints.

Time Required to Complete Activity:

15 minutes

Materials:

Act 6-5 WKST *Minutiae Patterns*
Red pen
Ruler or straight edge
Magnifying glasses

SAFETY PRECAUTIONS:

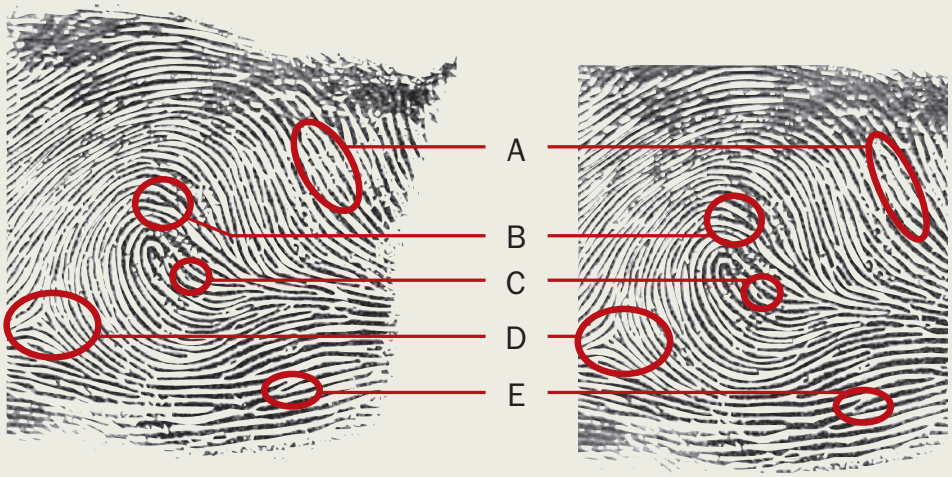
None

Introduction:

Latent fingerprints found at crime scenes are usually incomplete (partial) prints. Investigators need to examine the characteristics of a fingerprint very carefully. The simple identification of a whorl, loop, or arch is not sufficient. Other markers (minutiae) are used in distinguishing one fingerprint from another.

Procedure:

1. Study the following picture. It shows fingerprints obtained from a suspect (left) and a fingerprint lifted from the crime scene (right). Notice how the investigator has labeled the points of comparison with the same letter on the rolled ink print and the latent print from the crime scene. Use the table of minutiae



Suspect print Latent print from crime scene

patterns (**Figure 6-10**) to identify the specific types of minutiae. Record your answers for A–E on your Act 6-5 WKST *Minutiae Patterns*.

A. _____
B. _____
C. _____
D. _____
E. _____

2. Examine each of the following fingerprints. On your student worksheet, using a red pen and referring to **Figure 6-10**, circle the minutiae pattern and then label it with the appropriate number.

Arthur

1. Bifurcation
2. Island ridge
3. Ridge ending

Doris

4. Eye
5. Spur or hook
6. Ridge ending

Alice

7. Double bifurcation
8. Island ridge

Joe

9. Bridge
10. Delta
11. Bifurcation
12. Dot

ACTIVITY
6–6

Fingerprint Analysis *Obj. 6.3, 6.10*

Objectives:

By the end of this activity, you will be able to:

1. Analyze the fingerprints to determine if any of the suspects' prints are consistent with the crime-scene print.
2. Support your claim by identifying the ridge pattern and fingerprint minutiae found in both the crime-scene print and the suspect's fingerprint.
3. Circle common minutiae on the crime scene and suspect's fingerprints.

Time Required to Complete Activity:

45 minutes

Materials:

Act 6-6 WKST *Include or Exclude?*

Act 6-6 WKST *Comparing Suspects' Prints*

Red pencil

SAFETY PRECAUTIONS:

None

Procedure:

PART A: DETERMINE IF TWO SETS OF FINGERPRINTS ARE CONSISTENT OR NOT CONSISTENT

Refer to the following two sets of fingerprint examples. The print on the left is from a suspect. The fingerprint on the right is latent print recovered from the crime scene.

Example 1: Suspect print

Example 1: Crime-scene print

Example 2: Suspect print

Example 2: Crime-scene print

Determine if they are consistent or not. Using a red pencil, circle and identify as many minutiae reference points as you can that support your claim. (Images are enlarged on Act 6-6 WKST *Include or Exclude?*)

PART B: DETERMINE IF ANY SUSPECT PRINTS ARE CONSISTENT OR NOT CONSISTENT WITH CRIME-SCENE PRINT

Refer to Act WKST 6-6 *Comparing Suspects' Prints*. Analyze the prints and determine if the crime-scene print is consistent with any of the suspects. Using a red pen, circle and identify as many minutiae reference points as you can that are shared by the crime-scene fingerprint and the suspects' fingerprints. Support your claim using evidence from the fingerprints.

Crime-scene print

Suspect A

Suspect B

Suspect C

Suspect D

Suspect E

Suspect F

Suspect G

Suspect H

Final Analysis:

Prepare a written report, PowerPoint, or poster presentation to support your claim that a suspect's print(s) are, or are not, consistent with the crime-scene print. Include as evidence ridge patterns, minutiae, any deltas or ridge count, and any scars.

ACTIVITY
6–7

Using Cyanoacrylate to Recover Latent Fingerprints *Obj. 6.3, 6.4, 6.7*

Objectives:

1. Outline the procedure for using cyanoacrylate (Super Glue®) on a latent fingerprint to produce a visible print.
2. Given a latent fingerprint, use cyanoacrylate on the fingerprint to produce a visible fingerprint.
3. Photograph the cyanoacrylate fingerprint and print a copy of the digital image.
4. Identify the ridge pattern and minutiae patterns on the latent print.

Time Required to Complete Activity:

Part A: 45 minutes; Part B: 1 hour

Materials:

Act 6-7 WKST *Cyanoacrylate Protocol Redesign*
Resealable plastic bags (quart- or gallon-sized)
Glass slide
Fume hood if performed inside
Camera, phone, or computer tablet that takes high-quality photos
Plastic beverage-bottle caps
Cyanoacrylate (Super Glue)
Desk lamps, drying lamps, or other nonfluorescent light sources
3 × 5-inch cards (not white; darkest cards possible)
Safety goggles
Nitrile or latex gloves

SAFETY PRECAUTIONS:

Because cyanoacrylate and its fumes are toxic, this experiment should be done inside a fume hood or outdoors. Students should wear safety goggles and gloves when handling cyanoacrylate. Students wearing contact lenses should not be exposed to cyanoacrylate or its fumes.

Introduction:

This procedure is an inexpensive method of developing a fingerprint using cyanoacrylate. The chemical bonds to the fatty acids, amino acids, and proteins in a fingerprint and produces a permanent white product of that chemical reaction on the ridges of the print. Factors that affect how quickly the product forms include the amount of heat and water vapor. You will do a basic experiment using cyanoacrylate to reveal a print on a glass side. Then your group will redesign the procedure by altering variables in an effort to produce more reliable results.

Procedure:

PART A: USING CYANOACRYLATE TO RECOVER LATENT FINGERPRINTS

1. Work with the glue should only be done in a fume hood or outdoors on a flat surface.
2. Fold a 3 × 5-inch card in half by folding the top down to the bottom (creating a 1-1/2 × 5-inch folded card).
3. Rub your finger on your nose or the back of your neck to pick up additional skin oil on your fingertip. Use this finger to leave a latent fingerprint on a clean glass slide.
4. Insert the slide with the latent fingerprint into your folded 3 × 5-inch card. Be sure that the fingerprint is on the top of the slide in the folded 3 × 5-inch card.
5. Insert the folded 3 × 5-inch card with the latent fingerprint into an opened, resealable plastic bag. The folded card will prevent the plastic bag from touching the latent fingerprint.
6. Blow into the bag to add moisture and seal the bag.
7. Place three to five drops of cyanoacrylate into the beverage cap. (Be sure you are working under a fume hood or outdoors.)
8. Unseal the bag and quickly slide the bottle cap containing the cyanoacrylate into the plastic bag so that it is positioned next to the microscope slide. Quickly reseal the bag.
9. Position a lamp above the fingerprint to provide warmth to vaporize the cyanoacrylate.
10. Examine the slide approximately every five minutes until a fingerprint is clearly visible.
11. Open the plastic bag (inside a fume hood or outdoors). Remove the 3 × 5-inch folded card containing the slide from the bag.
12. Photograph the cyanoacrylate fingerprint. Print a copy of the fingerprint photo. (You may want to enlarge the image prior to printing to make for easier viewing. If the fingerprint is difficult to see, you can dust the fingerprint with fingerprint powder.)
13. Identify the ridge pattern and minutiae patterns on the fingerprint.
14. Instead of using a glass slide, try working with other objects such as a soda can, paper, or plastic items such as a water bottle.

PART B: CYANOACRYLATE PROTOCOL REDESIGN

1. Discuss the different variables that affect the development of latent cyanoacrylate fingerprints and record the information on Act 6-7 WKST *Cyanoacrylate Protocol Design*.
2. Working in small collaborative groups, develop a more reliable procedure for developing cyanoacrylate fingerprints. Each team will work with changing *one* of the variables, observing the results, and subsequently revising the lab

procedures. Each team should demonstrate its results showing a cyanoacrylate fingerprint made using the original protocol (control group) and a cyanoacrylate fingerprint produced after altering one variable (experimental group). The class will evaluate which procedural change(s) improved the quality of the print.

Questions:

1. List the different variables that affect the development of latent cyanoacrylate fingerprints.
2. State which variable your team will alter to try to produce better cyanoacrylate fingerprints.
3. Describe how you will alter this variable compared to the original lab protocol.

Final Analysis:

1. Compare and contrast the cyanoacrylate fingerprint made using the original protocol (control group) with the cyanoacrylate fingerprint made using your revised protocol (experimental group).
2. What claims can you make regarding which procedure is more reliable: the original (control group) or your revised protocol (experimental group)? Cite evidence from your experiments to support your claim.
3. Review the experiments of your classmates. What changes made to the original protocol by your classmates seemed to have the greatest effect on the quality of the cyanoacrylate fingerprints? Justify your claim citing evidence from their presentations.

Going Further:

1. Investigate other methods of revealing latent prints, such as iodine fuming and ninhydrin. Prepare a table comparing cyanoacrylate fuming, iodine fuming, and ninhydrin. Include the following:
   - Procedure for each method
   - What the chemical is reacting to in the fingerprint
   - Advantages of each method
   - Disadvantages of each method, including safety concerns (if any)
2. Research why cyanoacrylate bonds to a fingerprint. Describe the chemical reactions that result in formation of the white precipitate.
3. Research how cyanoacrylate fuming became a method used to reveal a latent fingerprint.

Section II
Wraparound Teacher's Edition Sample – Excerpts from Chapter 6

Features to Watch For:

Chapter Overview

Academic Connections to other disciplines

Differentiated Learning boxes for multiple levels of learners

"Teach" headers with helpful teaching tips

Suggestions for using the chapter Activities at specific points in the chapter

"Enrich" activities

Hands-on Activity tips and advice for success

WRAPAROUND TEACHER'S EDITION

3rd Edition

FORENSIC SCIENCE

FUNDAMENTALS & INVESTIGATIONS

Bertino & Bertino

CENGAGE

Preface

Transform Your Course and Engage Your Students with

FORENSIC SCIENCE

Fundamentals and Investigations, 3e

Forensic Science: Fundamentals and Investigations 3e is student- *and* teacher-friendly. Students benefit from a practical approach to forensics with photographs sourced from the field, descriptive illustrations and tables, current case studies, and hands-on activities and projects, while teachers enjoy the extra support of measurable outcomes, validated teaching advice, and additional activities for differentiating learning.

AT A GLANCE

Forensic Science: Fundamentals and Investigations 3e reveals the science used in forensic science techniques. It provides a chapter-by-chapter description of specific types of evidence and the techniques to collect, analyze, and evaluate the evidence. As students progress through the course, they refine the techniques and apply them to other areas of study. As teachers guide their students through the course, essential teaching support enables them to deliver technical content and conduct hands-on activities in a focused and engaging way.

Forensic Science: Fundamentals and Investigations 3e is comprised of the following learning and teaching tools:

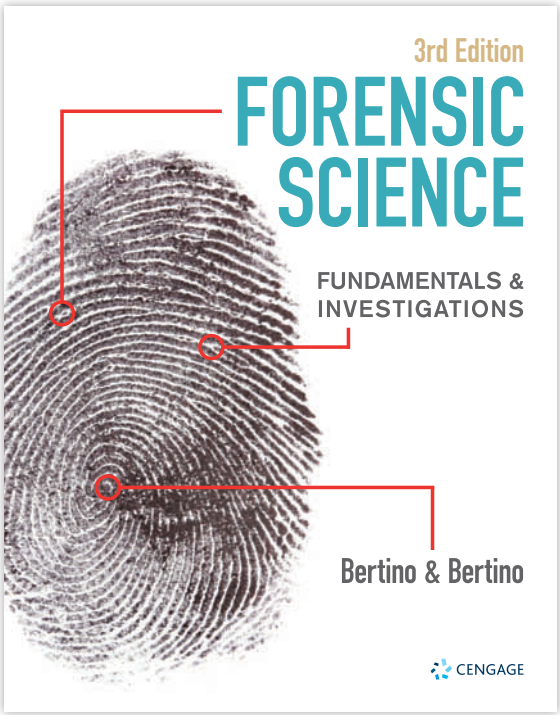
Student Edition (PRINT)

The 18 chapters are designed to both inform and motivate students while developing problem-solving skills. Each chapter features engaging opening scenarios, photographs and illustrations, and case studies that bring relevancy to the content. Forensic topics covered in the chapters include:

- Crime scene investigation
- The collection, handling, and analysis of trace evidence such as hair, fibers, soil, pollen, and fingerprints

- Blood and blood-spatter examination
- Forensic analysis of DNA, insects, drugs, glass, handwriting, and tool marks and impressions
- Firearms and ballistics
- Forensic anthropology
- The determination of the manner, mechanism, and cause of death
- The estimation of postmortem interval

Each chapter is accompanied by hands-on activities that allow students to explore these topics, and the text concludes with 10 Capstone Projects that integrate several forensic techniques into a single activity.



NEW TO THIS EDITION

- Aligned to current national standards, including Next Generation Science Standards (NGSS)
- Validated Learning Objectives streamline and align technical content with the end-of-lesson chapter questions, in addition to all supplementary assessments, to provide a clear pathway for learning
- New Chapter Scenarios and Case Studies reflect current events and methodologies in forensic investigation and include supporting questions to develop analytical skills
- Emphasizes the collaboration of various forensic investigators and experts in solving crimes
- Enhanced sections in history, evidence collection, and documentation and analysis provide context and facilitate understanding of forensic processes
- Current statistics reflect trends that affect forensic investigation and analysis
- New photographs and graphics engage and enhance the learning experience
- Current references to additional resources, including books and journals, tutorials, videos, and animations, promote further exploration and learning
- New sections in each chapter focus on advances in forensic science, including new technologies and techniques related to forensic investigation and analysis
- Includes over 100 hands-on activities, including 14 new activities for this edition
- Combined Glossary and Glosario provides additional support for English-Language Learners (ELLs)

CHAPTER REVISIONS

Specifically, revisions include some of the following new and enhanced topics:

- Formation and alteration of memory and its influence on eyewitness accounts
- Interrogation techniques for interviewing suspects
- Fingerprint analysis using algorithms
- Handheld devices to collect drug samples and fingerprints
- DNA single-nucleotide polymorphism (SNP) analysis
- DNA phenotyping and digital facial reconstruction
- Forensic genealogy
- Forensic microbiology and postmortem interval (PMI)
- Next Generation Identification (NGI)
- N-tracing used in handwriting analysis
- Art forgeries
- Online credit card fraud and counterfeiting of merchandise
- Expanded coverage in soil analysis, including worldwide sand shortage and theft
- Improved spectrometers and instrumentation to analyze evidence
- Claim-Evidence-Reasoning format in activity analysis

Wraparound Teacher's Edition (PRINT)

This version includes the SE pages with the addition of teaching tips, correlations to Activities and Capstone Projects, additional activities for differentiating learning, and cross-curricular information.

NEW TO THIS EDITION

- New tips on how to present information, set-up and deliver activities, and engage students
- New advice on how to support and encourage students at different levels of learning to inclusively support the heterogeneous nature of a forensics classroom

Companion Site (DIGITAL)

Providing support for both students and teachers, this site includes supporting worksheets and teacher notes for the Activities and Capstone Projects, lesson plans, PowerPoint® presentations, test banks, and additional Activities.

NEW TO THIS EDITION

- Site design facilitates the teaching process with practical resources
- All-new Lesson Plans correlating to teacher and student resources
- Thoroughly revised question banks to reflect new content, provide feedback, accurately assess students, and provide additional learning opportunities
- New lab activities enrich learning and reinforce chapter concepts

Forensic Science: Fundamentals and Investigations 3e, MindTap (DIGITAL)

This all-encompassing digital course includes the e-book, auto-graded quizzing, PowerPoint® presentations, activities and projects, and interactive virtual simulations.

NEW TO THIS EDITION

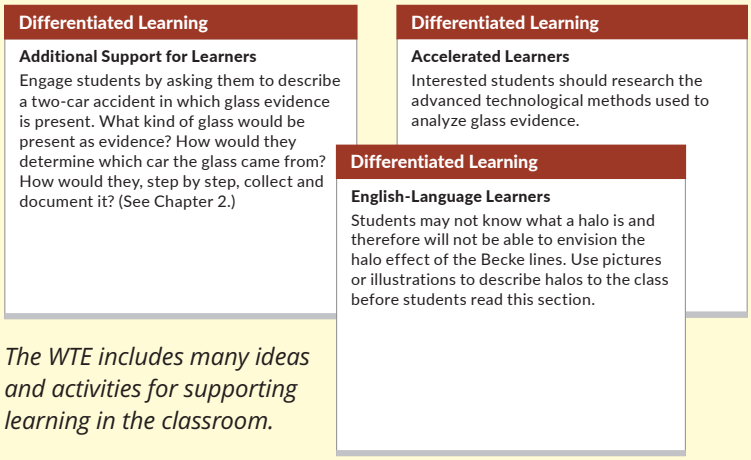
- Learning path design facilitates the learning process, with each chapter building knowledge and skills through different levels of assessments and authentic activities.
- Chapter activities are offered in an interactive format and include all Activities from both the student edition and companion site.
- Assessments align to learning objectives and provide feedback, including rationale, to support learning.

Refer to page xii to explore the teacher offerings further.

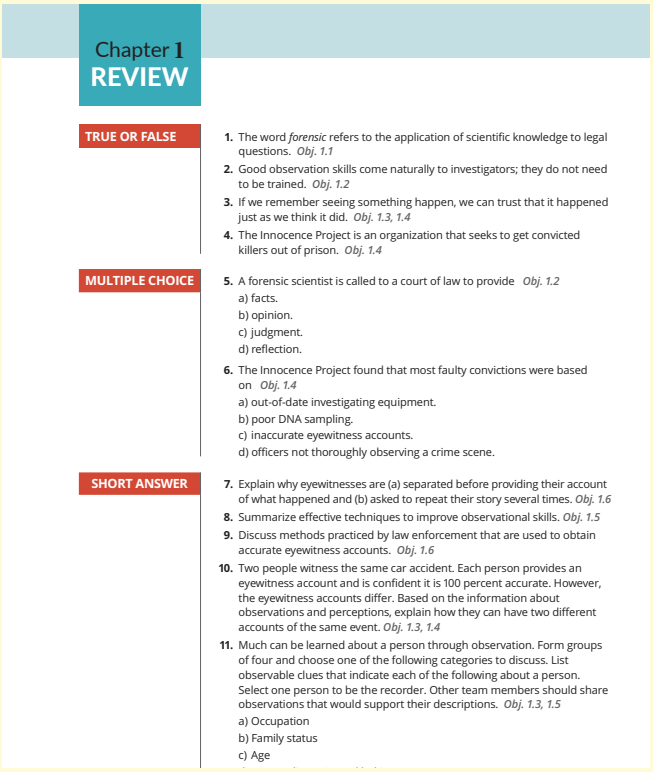
TRANSFORM YOUR COURSE WITH MEASURABLE OUTCOMES

A focus on learning design ensures that technical content and pedagogy clearly support, and assessments accurately measure, the learning objectives to bolster student success.

- Validated learning objectives align technical content with the end-of-chapter questions, in addition to the supplementary assessments, to provide a clear pathway for learning.
- Concepts build from simple to more complex to increase student comprehension and support learning.
- Differentiated Learning is recognized with various activities and advice on how to reach and engage students of varying levels of abilities.



The WTE includes many ideas and activities for supporting learning in the classroom.



LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

1.1 Describe the purpose of forensic science.
1.2 Explain the role and responsibilities of a forensic scientist.
1.3 Distinguish between observation and perception.
1.4 Distinguish between fact and opinion as they relate to eyewitness testimony.
1.5 Describe ways to improve observation skills.
1.6 Describe effective techniques that result in an accurate eyewitness interview.
1.7 Develop your observational skills and ability to assess the validity of eyewitness accounts of a crime.
1.8 Design an experiment that demonstrates how different factors influence our observational abilities.

Learning Objectives are identified at the point of introduction, throughout the chapter and end-of-chapter questions. Chapter Review questions scaffold from simple to more complex to build and accurately evaluate student comprehension.

TRANSFORM YOUR COURSE WITH CROSS-CURRICULAR INTEGRATION

Teachers can conduct a full-year study of forensics or select topics that can be incorporated into a half-year course. As another option, teachers can use the topics to motivate students in all science classes by using forensics to teach basic science concepts. For this purpose, technical content is correlated to the NGSS. Additionally, opportunities for integrating connections to other disciplines are interwoven throughout the chapters. Each chapter integrates history, science, mathematics, literacy, technology, and political science along with writing and presentation skills using real-life applications to provide complete flexibility for any science program.

Academic icons help students make connections between forensic science and other areas of study.

Academic Connections

BIOLOGY:
collecting biological evidence such as pollen, blood, semen, and DNA

EARTH SCIENCES:
identifying soil evidence

MATHEMATICS:
laying out crime scene perimeters, determination of angle using a compass, and using statistical values of evidence

CHEMISTRY:
laboratory analysis of evidence

TECHNOLOGY:
New devices that map out crime scenes

LITERACY:
further exploration of crime scene investigation and analysis, synthesize information from various sources

Academic references provide insight into how teachers can help students make those cross-curriculum connections.

ENGAGE YOUR STUDENTS WITH CURRENT AND RELEVANT CONTENT

Thoughtfully designed content in each chapter promotes learning in the classroom and encourages further exploration.

- Chapters open with a **case scenario** pulled directly from headlines and features both pivotal historical and current ***Case Studies*** at the end, offering high-interest topics for critical thinking, writing, and class discussion.
- ***Did You Know?*** notes provide additional interesting facts and information to pique students' interest.
- ***Digging Deeper*** identifies additional topics relevant to the chapter for students to explore.
- ***Careers in Forensics*** highlight prolific forensic scientists, describing a forensic occupation related to the chapter.

DNA Profiling

Who Are You? Cold Cases Solved Using Forensic Genealogy

In April 1981, the body of a young girl with red, braided hair wearing a buckskin jacket (known as the "Buckskin Girl") was found murdered by the side of an Ohio road. Detailed fingerprint analysis; dental record comparisons; hair, pollen, and isotope analysis; and facial reconstructions completed by the National Center for Missing and Exploited Children (NCMEC) network failed to identify the young woman until 2018. At that time, a volunteer group known as John and Jane Doe Project used the stored 37-year-old blood sample with its degraded DNA to compare the unidentified person's DNA with the DNA found in public genealogical databases (GEDmatch provides tools for DNA and genealogical analyses). Based on that search, relatives were identified from the public genealogical database, family trees were viewed, interviews were conducted by detectives, and ultimately, the "Buckskin Girl" was identified as 21-year-old Marcia L. King from Arkansas.

This was one of the many cold cases solved by using public genealogical databases and SNPs (single nucleotide polymorphisms) to analyze DNA. You may have heard of genealogy searches through Ancestry.com and 23andMe. As of 2019, over 26 million people have submitted their DNA to undergo this genetic screening. To collect an individual's DNA, the mouth is swabbed, and then the sample is mailed to the company for analysis. They analyze the DNA to trace ancestry and help locate relatives. This same amazing technology is being used to solve many cold case crimes because SNP analyses use shorter DNA fragments. Degraded or damaged DNA evidence, once thought to be useless, can now be reevaluated and used to identify perpetrators of crime who have eluded capture. It can also be used to identify the remains of unknown deceased individuals such as the "Buckskin Girl."

National Center for Missing and Exploited Children

Artist sketch of the unidentified murder victim known as the "Buckskin Girl."

Courtesy of Marcia King's Mother

Marcia Lenore King's remains were identified 37 years after her murder using public genealogy databases.

Case STUDIES

Lamar Johnson (2005)

In 2005, Lamar Johnson pleaded not guilty to killing Carlos Sawyer, who was shot and killed outside an elementary school in East Baltimore. Based on eyewitness testimony that Lamar Johnson resembled the killer, Lamar Johnson was sentenced to life in prison.

Lawyers from the Innocence Project discovered three other witnesses who independently confirmed that Johnson was not the gunman. One man said he saw the shooter and it was not Johnson. Another told investigators that he heard a different person confess to the killing. The third witness, a woman, said that the gunman ran past her after the shooting and it was not Lamar Johnson. Asked why they did not come forward earlier, they said they were afraid to testify.

The attorneys presented their evidence to Baltimore prosecutors. Together, both offices asked the court to free Lamar Johnson. After more than 13 years, Johnson was a free man. Police have reopened the investigation to find Sawyer's killer.

Courtesy of Mid-Atlantic Innocence Project

Lamar Johnson exonerated by the Innocence Project after 13 years in prison.

Careers IN FORENSICS

Dr. Michael Baden

FORENSIC PATHOLOGIST

Dr. Michael M. Baden is an internationally known and respected board-certified forensic pathologist. In his long, fascinating career, he has performed more than 20,000 autopsies. After earning a Bachelor of Science degree from the City College of New York, he attended New York University School of Medicine and was

- ***Activities*** provide hands-on experiences with the opportunity to perform forensic science techniques and develop problem-solving skills. Each activity has clear instructions, including a list of materials, important safety information, step-by-step directions to guide students through the activity, questions for analysis, reflection and class discussion, and opportunities for further exploration beyond the activity to provide enrichment for student learning. For teachers, they offer easy, quick preparation, and minimal expense for materials.
- ***Capstone Projects*** build upon the activities in the chapters and combine concepts from different chapters as well as focus on specific forensic science techniques or skills.

CAPSTONE PROJECT 7

Forensic Science Career Exploration

LEARNING OBJECTIVES:

By the end of this project, you will be able to:

1. Identify different types of careers in forensic science.
2. Discuss the education requirements, job skills, job training, salary ranges, and so on of different careers in forensic science.
3. Present your research to the class.

Time Required

Varies depending on if research is done during class time or outside of class.

Materials

- CP-7 WKST *Careers in Forensic Science Sign-up Form*
- CP-7 WKST *Career Research Questions*
- Computer with Internet access (*Optional*)

Safety Precautions

None

Introduction

Thinking of pursuing a career in forensic science? In this project, you explore various career opportunities in forensic science. Research what type of training is needed, what the day-to-day work experiences are, and what type of income and job opportunities are associated with this career. You will present and share your findings with your classmates.

ACTIVITY 6–5

Minutiae Patterns *Obj. 6.3, 6.10*

Objectives:

By the end of this activity, you will be able to:

1. Describe different types of fingerprint minutiae patterns.
2. Identify different minutiae patterns found in fingerprints.

Time Required to Complete Activity:

15 minutes

Materials:

Act 6-5 WKST *Minutiae Patterns*
Red pen
Ruler or straight edge
Magnifying glasses

SAFETY PRECAUTIONS:

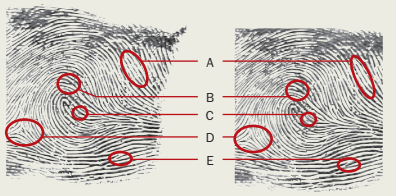
None

Introduction:

Latent fingerprints found at crime scenes are usually incomplete (partial) prints. Investigators need to examine the characteristics of a fingerprint very carefully. The simple identification of a whorl, loop, or arch is not sufficient. Other markers (minutiae) are used in distinguishing one fingerprint from another.

Procedure:

1. Study the following picture. It shows fingerprints obtained from a suspect (left) and a fingerprint lifted from the crime scene (right). Notice how the investigator has labeled the points of comparison with the same letter on the rolled ink print and the latent print from the crime scene. Use the table of minutiae



Suspect print Latent print from crime scene

TRANSFORM YOUR COURSE WITH TEACHING SOLUTIONS

WRAPAROUND TEACHER'S EDITION

The **Wraparound Teacher's Edition** (WTE) contains teaching strategies to support and engage students. The WTE provides clarification of science content and forensic science procedures, ideas to help stimulate students, evaluation opportunities, additional questions, and suggestions for further exploration and research. Additional support for offering differentiating learning in the classroom is also included.

Chapter Overview: introduces chapter and topics of discussion

The Big Ideas: highlight the main points of the chapter

Scenario: provides questions for opening class discussion based on the case presented at the beginning of the chapter

Academic Connections: provide relevant information connecting to other discipline areas, including math, science, chemistry, biology, earth sciences, technology, and literary references

Differentiated Learning: presents teaching strategies for delivering content to students who need additional support, as well as those seeking additional enrichment

Activities: point out appropriate points in the lesson to introduce a lab activity

Capstone Projects: point out appropriate points in the lesson to introduce a project

Teach: tips for teachers to highlight the main points of the lesson, guide students, and prepare for activities

Engage: advice for engaging students in an interactive way with the content

Explore: opportunities for further research on relevant topics

Chapter Overview

Soil is more than just dirt or rock. It is the medium that supports plant growth. Soil is primarily made up of weathered rock, but it also contains air, water, and organic matter. Soil has three different textures that differ in size from coarsest to finest: sand, clay, and silt. Soil samples also differ in shape, color, mineral composition, and organic composition. Each sample of soil has unique chemical and physical characteristics. Forensic scientists use soil's distinguishing traits to help solve crimes. Soil and sand can be examined for its general texture and appearance and then further analyzed for its mineral and chemical composition.

The Big Ideas

Soil scientists agree that no two places on Earth have precisely the same soil. Soil recovered from a crime scene, a victim, or a suspect can be analyzed for consistencies that can link the suspect to the crime scene or victim. Soil is part of the top layer of the earth's crust and contains minerals, decaying organisms, water, and air in uniquely varying amounts in each location. Soil is classified by its texture or grain size. Soils form in horizons, or layers, and each horizon has characteristic properties that differ. The horizons unique to an area make up its soil profile. Being able to recognize alterations to soil in an area can help forensic scientists locate a burial site. Proper collection and documentation of soil evidence are required. While soil evidence has been used in many cases, its reliability has been questioned in the courts.

ACTIVITY

Consider introducing Activity 13-9 ACT: *Sand Theft*, including the accompanying podcast, at this point in the lesson. It is located on the Companion Site.

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Chapter 13

Soil Evidence

Sand Theft and Worldwide Sand Shortage

In 2008, the pure white sand of an entire Jamaican beach disappeared overnight. An eyewitness reported the theft, relaying that most of the sand was removed using heavy equipment. The prime suspects included the owners of the exclusive Jamaican beachfront resorts, who were known to steal or purchase white sand to replenish sand continually lost due to tides and hurricanes. Because Jamaica is a commonwealth of Great Britain, the Queen of England was involved in the investigation. The search for the stolen sand involved helicopters, police warrants, death threats, police corruption, and an early and abrupt judge retirement. The case was never resolved.

Overcrowded countries such as Singapore and Dubai are reclaiming land by importing massive amounts of sand to extend their borders. Entire islands, some purchased and some stolen, have provided sand to countries seeking to increase landmass. In India and Morocco, a corrupt sand "mafia" was organized to steal entire beaches!

In the United States, the Army Corps of Engineers continues to replace sand washed away by storms at beach resorts in Miami and other high tourism areas. Despite efforts to restore the coastline, tidal erosion continues to deplete coastal waterfronts.

Sand is essential to the infrastructure of a country; it is used in the construction of concrete buildings, roads, bridges, dams, highways, technology, and in the manufacture of glass. Human use of sand in 2019 is estimated to be 50 billion metric tons a year. Dr. Pascal Peduzzi of the United Nations has declared a worldwide sand shortage and has stated that the sand shortage is a major sustainability challenge of the 21st century.

Sand and other types of soils are analyzed to combat the worldwide sand shortage problems and the associated sand thefts. The analysis of sand and soils provides physical evidence that links a person or an object to a specific crime scene.

This sea wall is being build in St. Patrick, Grenada, after tons of sand was stolen from the beach, opening the area to erosion.

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Scenario

After reading the scenario in class, have students consider the following:

1. How many have heard of the worldwide sand shortage?
2. Why is sand in such high demand? How is sand being used?
3. What is your opinion about replacing beach sand lost due to erosion?
4. Discuss some of the effects of reclaiming land on the ecosystem.
5. What is the relationship between crime and the worldwide sand shortage?
6. Brainstorm ideas on how sand or soils can be analyzed to determine if two different samples of sand or soil came from the same location.

Enrich: ideas for bringing experts from the field to the classroom and extending learning beyond the activities and projects presented in the chapter

Reteach: presents ways to revisit previously learned content

Assess: prompts teachers to review the learning objectives and key terms with students

Close: revisits the main points of the chapter

COMPANION SITE

The **Companion Site** includes the following resources in addition to other valuable references to enhance the teaching and learning experience:

Lesson Plans provide an outline of the key topics in each chapter and correlate topics to the learning objectives, activities, projects, and the accompanying PowerPoint® presentations.

PowerPoint® presentations align with the Lesson Plans and learning objectives and include photographs and illustrations to visually reinforce the key points in each chapter. Additional PowerPoint® presentations are provided by the authors and highlight specific topics in the chapters.

Student Learning Objectives (SLOs) support the chapter learning objectives and provide a method for learning and assessing students' comprehension of specific concepts within a topic. They also can be used for group work to encourage students to work together to achieve comprehension of forensic knowledge and techniques.

Chapter Activities and Capstone Project Worksheets support the chapter activities and Capstone Projects included in the text. Teacher Notes (TNs) are also available to provide direction on setting up and conducting the activity or project, as well as assessing student progress.

Testing Powered by Cognero, a flexible online system, provides chapter-by-chapter quizzes and enables teachers to

- author, edit, and manage test bank content from multiple sources.
- create multiple test versions in an instant.
- deliver tests from teacher/school-specific learning management system (LMS) or classrooms.

Additional Activities and Resources include lab activities based on specific chapters and provide alternatives for the activities in the text or an opportunity for enrichment.

The list of additional Activities found on the Companion Site include:

Chapter 6: Fingerprints

- Act 6-8 ACT Print Variations

Chapter 7: DNA Profiling

- Act 7-6 ACT Design and Build a Human DNA Structure (NEW)

Chapter 8: Blood and Blood Spatter

- Act 8-8 ACT Antigens and Antibodies Kinesthetic Activity

Chapter 9: Forensic Toxicology

- Act 9-4 ACT Urine Prescription Drug Test
- Act 9-5 ACT Drug Research and Presentation
- Act 9-6 ACT Drug Residue on Money
- Act 9-7 ACT Drug Testing Debate
- Act 9-8 ACT Toxin Case Study
- Act 9-9 ACT Pre-Testing, Evidence Reliability and Validity (NEW)

Chapter 10: Handwriting Analysis, Forgery, and Counterfeiting

- Act 10-4 ACT Landmark Handwriting Cases
- Act 10-5 ACT President's Signature Activity

Chapter 11: Forensic Entomology

- Act 11-5 ACT Processing a Crime Scene for Forensic Insect Evidence
- Act 11-6 ACT Jigsaw Research
- Act 11-7 ACT Calculating Accumulated Degree Hours (ADH)
- Act 11-8 ACT Forensic Entomology Case Study (NEW)

Chapter 12: Death: Manner, Mechanism, Cause

- Act 12-5 ACT Chicken Decomposition (NEW)
- Act 12-6 ACT Student Projects (NEW)

Chapter 13: Soil Evidence

- Act 13-7 ACT Grain Size and Velocity (NEW)
- Act 13-8 Japanese Fire Balloon Podcast (NEW)
- Act 13-9 Sand Theft Podcast (NEW)

Chapter 15: Glass Evidence

- Act 15-5 ACT Case Study Using Conchoidal Fractures (NEW)

Chapter 18: Firearms and Ballistics

- Act 18-5 ACT Sectional Density of Rifle Bullets
- Act 18-6 ACT Kinetic Energy of a Projectile

Also included are forensic books of interest for further exploration and links to other resources offered by the authors on their website.

National and State Standard Correlations illustrate how content in *Forensic Science: Fundamentals and Investigations 3e* align to the **NGSS** and several current state standards.

Visit ngl.cengage.com or contact your sales consultant for access to the NGLSync teacher dashboard.

MINDTAP FOR FORENSIC SCIENCE: FUNDAMENTALS AND INVESTIGATIONS 3E

The MindTap for *Forensic Science: Fundamentals and Investigations 3e* features an integrated course offering a complete digital experience for the student and teacher. This MindTap is highly customizable and combines the enhanced e-book along with interactivities, lab activities, auto-graded quizzing, and virtual simulations to enable students to directly analyze and apply what they are learning and allow teachers to measure skills and outcomes with ease.

- A Guide: Relevant interactivities combined with prescribed readings, featured multimedia, and quizzing to evaluate progress will guide students from basic knowledge and comprehension to analysis and application.
- Personalized Teaching: Teachers are able to control course content—hiding, rearranging existing content, or adding and creating own content to meet the needs of their specific program.
- Promote Better Outcomes: Through relevant and engaging content, assignments, and activities, students are able to build the confidence they need to ultimately lead them to success. Likewise, teachers are able to view analytics and reports that provide a snapshot of class progress, time in course, engagement, and completion rates.

Enhanced e-book includes highlighting and note-taking features, read-speaker, both English and Spanish definitions at point of reference and hyperlinked figures and tables to increase comprehension.

Interactivities include chapter PowerPoint® presentations, flashcards with select images, and other apps to enhance the learning experience.

Lab Activities and Capstone Projects are provided in an interactive format, allowing students to enter data directly online or print and upload files to their instructor for grading. The activities here include all those in the print student edition text, as well as those posted to the *Companion Site*.

Auto-graded quizzing comprised of various question types is integrated throughout the chapters, including matching, true-false, multiple-choice, and scenario-based questions.

Virtual Lab Simulations are integrated into the chapters as well as a final project at the end of the learning path. Interactive labs in the chapters reinforce chapter concepts while *The Death of Rose Cedar* Virtual Lab can be used as a final assessment for the course. As students work through individual lab activities included in the virtual case, they will record their findings within an auto-graded assignment. After they are completed and have recorded the data, there is a post-assessment covering the topics and techniques used within the virtual lab.

Each lab activity included within *The Death of Rose Cedar* Virtual Lab includes the following:

- Background information
- Clear instructions
- Three-dimensional crime scenes
- Toolkit
- Lab assessments
- Critical-thinking questions
- Research activities

ABOUT THE AUTHORS

Anthony (Bud) Bertino taught high school and community college science to students for over 40 years. He has taught biology, chemistry, physical science, ecology, and AP Biology and has served as a science supervisor at Canandaigua Academy. His awards include Outstanding Biology Teacher (NY, NABT), Woodrow Wilson Fellowship Award, Tandy Scholars' Award, and Outstanding Teaching Award from the University of Rochester. He has served as an AP Biology reader, consultant, and trainer for the College Board presenting week-long workshops around the country. Bud has presented week-long coursework for John Hopkins Center for Talented Youth (CTY) program and has served as an adjunct professor at Finger Lakes Community College and as a clinical supervisor for both the University of Albany (NY) Graduate School of Education and the College of St. Rose. Bud has been an attendee, curriculum developer, and presenter for the Cornell Institute for Biology Teachers (CIBT) and the Howard Hughes Medical Institute (HHMI). He is co-author of "Where's the CAT," and author of "The Cookie Jar Mystery" (forensic activities for elementary and after-school programs). His activities on money-saving techniques have been published in *The Science Teacher* (NSTA publication) and *The Forensic Teacher* magazine.

Patricia Nolan Bertino taught high school science for over 34 years at Scotia-Glenville High School. She developed curricula and taught high school biology and forensic science biology. Her awards include Outstanding Biology Teacher (NY, NABT), Woodrow Wilson Fellowship Award, and the Tandy Scholars' Award. She served as a scientific consultant for Video Discovery, Neo Sci, Prentice Hall Biology Review books, and several other publishers. Patricia has had numerous articles published in magazines including the *NSTA Reports, STANYS Science Bulletin, The Forensic Teacher*, and *Women in Engineering*. Patricia attended, developed curricula, and was a frequent presenter for the Cornell Institute of Biology Teachers (CIBT) and the Howard Hughes Medical Institute (HHMI).

Patricia's professional involvement includes memberships in numerous professional organizations. She served as a corresponding secretary for her local teacher's union and served as the Subject Area Representative in Biology for the Eastern section of Science Teachers Association of New York State (STANYS).

The Bertinos have been and continue to be actively involved in professional development for teachers including the following:

- Presenting and developing curricula for the HHMI (14 years)
- Serving as co-directors and instructors of the Bertino Forensic Summer Institute (15 years) and the AP Summer Institute at Rensselaerville, NY (7 years)
- Co-presenting at over 300 workshops sessions in forensic science, AP biology, and biology at national, state, and regional conferences.

The Bertinos reside near Schenectady, NY.

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Chapter Overview

If a standard DNA analysis were done on identical twins, it would show that they have identical DNA. How would a forensic investigator determine which of the twins committed a crime? Today, forensic science depends heavily on DNA analysis. However, in the case of twins, the forensic investigation team might need to use a technique that began in the mid-1800s to identify the suspect—fingerprinting. Every individual, even an identical twin, has a unique fingerprint made up of whorls, loops, or arches. Today, fingerprint analysis using scanners and computers allows examiners to quickly search interconnected local, state, and national databases. This automated system improves speed, accuracy, and efficiency of fingerprint identification, helping to solve both current and cold cases.

The Big Ideas

Fingerprinting has a long history of forensic use. A person's fingerprints develop long before birth. The ridges on our fingers in the shapes of loops, arches, and whorls are different from anyone else's. Fingerprint examiners look for unique characteristics, such as a core and deltas. Computer algorithms based on location of minutiae help to quickly sort fingerprints. There are three types of prints that might be found at a crime scene: patent, plastic, or latent. The Integrated Automated Fingerprint Identification System (IAFIS) database, developed by the Federal Bureau of Investigation (FBI), is used to compare prints. Fingerprints can be collected by using tape, powders, or other chemicals, or they can be photographed and compared with criminal fingerprint cards on file.

Chapter 6

Fingerprints

Technology Catches Up to Crime: FBI Latent Hit Award 2013

By September 2001, the 1999 San Bernardino, California, murder and robbery of 74-year-old Marshall Adams was a "cold case." All leads had been exhausted. But a new lead had just come to light. The San Bernardino County Sheriff's Department had submitted latent (hidden) prints from the case to the FBI's Integrated Automated Fingerprint Identification System (IAFIS), a national fingerprint and criminal history database, and several possible fingerprint consistencies had been identified. One was about to lead to an arrest and guilty plea.

The crime In December 1999, a call to San Bernardino's Police Department reported an unresponsive male on the floor of a jewelry store. Detective John Munoz headed the investigation and found the victim, Marshall Adams, brutally beaten and stabbed. His wallet, along with jewelry from the store, had been taken.

Crime-scene evidence Randy Beasley, a fingerprint identification technician from the San Bernardino County Sheriff's Department, collected latent fingerprints, palm prints, and blood evidence from a knife, store doors, and a store catalog. A bloody palm print was recovered from the face of the victim.

1999 investigation In 1999, the sheriff's department searched the latent prints against their local databases without any success. All the evidence from the case was ultimately stored in their cold case unit.

2001 evidence and arrest In 2001, IAFIS returned several possible fingerprint consistencies to the latent print from the crime scene. James Nursall, a fingerprint examiner with the San Bernardino County Sheriff's Department, concluded that the print was consistent with a print taken from Jad Salem. Through IAFIS, it was discovered that Salem had been arrested and fingerprinted in Texas about two weeks after the 1999 murder. Salem was initially stopped for a traffic violation but was later arrested on a drug charge.

Detective Munoz located Salem in San Bernardino and told him about the fingerprint evidence from the 1999 murder. At first Salem denied being there. Later in the interrogation, Salem admitted being there, but only as a witness. However, after Salem was shown the bloody palm print on the victim's face, along with all the other evidence, he admitted he was the murderer. He was sentenced to 32 years in prison for the murder and robbery.

Hyoung Chang/Getty Images

A crime-scene investigator demonstrates the use of IAFIS in allowing for nationwide comparisons of prints.

Scenario

After reading the scenario in class, have students consider the following:

1. Use the case in the scenario to introduce fingerprinting in a class discussion.
2. Discuss the crime and the type of evidence left at the crime scene.
3. Have students describe the role played by each of the various crime scene investigators.
4. Discuss the collaboration required among different law enforcement agencies in one area and among agencies.
5. Discuss the changes in fingerprint technology over the past 20 years.
6. Describe how IAFIS helped solve the case.
7. The FBI also has an excellent video on fingerprinting that will prompt class discussion. Search "FBI Latent Hit Award 2013 video" for this online video.

LEARNING OBJECTIVES

By the end of this chapter, you will be able to:

6.1 Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.

6.2 Describe fingerprints and how they are formed.

6.3 Describe different characteristics and types of fingerprint patterns.

6.4 Describe the proper procedures involved in collecting and documenting fingerprint evidence.

6.5 Explain how fingerprints are analyzed and the reliability of fingerprint identification.

6.6 Discuss advances in fingerprinting that have enhanced the analysis and reliability of fingerprints in identifications.

6.7 Lift a latent print using different methods to analyze the print's ridge and minutiae patterns.

6.8 Distinguish among latent, plastic, and patent fingerprints.

6.9 Prepare a ten card and analyze the ridge patterns of the prints.

6.10 Analyze a fingerprint to determine if it is consistent with a fingerprint on record.

BIOLOGY
CHEMISTRY
EARTH SCIENCES
PHYSICS
LITERACY
MATHEMATICS
TECHNOLOGY

KEY TERMS

- **arch** a fingerprint pattern in which the ridge pattern originates from one side of the print and continues to the other side
- **biometrics** uses measurements and statistical analyses of someone's physical characteristics to aid in their identification
- **core** a center of a loop
- **delta** a triangular ridge pattern created when ridge patterns diverge
- **fingerprint** an impression left on any surface that consists of patterns made by the ridges on a finger
- **Integrated Automated Fingerprint Identification System (IAFIS)** FBI-developed national database of more than 76 million criminal fingerprints and criminal histories
- **latent fingerprint** a concealed fingerprint that is made visible through the use of powders or forensic techniques
- **loop** a fingerprint pattern in which the ridge pattern flows inward and returns in the direction of the origin
- **minutiae** the combination of details in the shapes and positions of ridges in fingerprints that makes each unique; also called *ridge characteristics*
- **patent fingerprint** a visible fingerprint produced when fingers coated with blood, ink, or some other substance touch a surface and transfer their print to that surface
- **plastic fingerprint** a three-dimensional fingerprint made in soft material such as clay, soap, or putty
- **ridge count** the number of ridges between the center of a delta and the core of a loop
- **ridge pattern** the recognizable pattern of the ridges found in the end pads of fingers that form lines on the surfaces of objects in a fingerprint. They fall into three categories: arches, loops, and whorls. They are also visible on the soles of feet and bottoms of toes
- **ten print card** a form used to record and preserve a person's fingerprints
- **whorl** (plain whorl) a fingerprint pattern that resembles a bull's-eye

Academic Connections

BIOLOGY:
the skin; fingerprints are formed in utero; fingerprints are different in identical twins

CHEMISTRY:
powders and other chemicals used to recover fingerprints; skin oil can leave a fingerprint on a surface; chemical reactions can help lift latent fingerprints; chemical analysis of fingerprint impressions

PHYSICS:
nanoparticles; facial recognition programs; relating minutiae patterns to algorithms

LITERACY:
read case studies that used fingerprint analysis to help solve the crime

MATHEMATICS:
measurement of angles and distances of minutiae patterns; biometric measurements of facial recognition patterns

TECHNOLOGY:
scanners and computers are used to collect and sort fingerprints; biometric technology

Teach

Prior to beginning this topic, ask students the following questions:

1. How can an individual person be identified?
2. After listing ways to identify a person, ask students if that identification is based on scientific evidence or subjective evidence.
3. Ask students if they can provide other methods of biometric identification other than fingerprinting.
4. Ask students how technology has improved the ability to quickly and more reliably identify a person.

COMPANION SITE

The Companion Site includes the following resources to enhance the teaching and learning experience, in addition to other valuable references to expand learning beyond the classroom:

- Lesson Plans
- PowerPoint Presentations
- Student Learning Objectives (SLOs)
- Chapter Activity and Capstone Project Worksheets
- Testing Powered by Cognero
- National and State Standard Correlations
- Additional Activities and Resources

Visit ngl.cengage.com or contact your sales consultant for access to the NGLSync teacher dashboard.

Engage

Ask students to brainstorm what they know about fingerprints and fingerprint evidence. Discuss their responses and correct misconceptions.

Teach

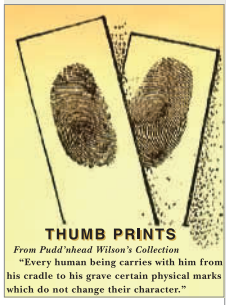
Ask students if they are aware of what jobs require fingerprinting as a requirement for employment. (The list varies by state but always includes jobs that involve care of the elderly, children, and the disabled.) Tell students that today all members of the military, school bus drivers, and teachers are required to be fingerprinted. Ask students if they think all individuals for any job should be fingerprinted as a requirement for employment.

Introduction

Pudd'nhead Wilson is a lawyer created by Mark Twain in the novel of the same name, published in November 1894. In his final address to a jury, Lawyer Wilson exhibits his knowledge of the cutting-edge technology of the day:

> *Every human being carries with him from his cradle to his grave, certain physical marks which do not change their character, and by which he can always be identified—and that without shade of doubt or question. These marks are his signature, his physiological autograph, so to speak, and this autograph cannot be counterfeited, nor can he disguise it or hide it away, nor can it become illegible by the wear and mutations of time.*

FIGURE 6-1 Early, though fictional, fingerprint cards from Twain's Pudd'nhead Wilson.



Twain's Puddinhead Wilson

No one is sure how Mark Twain learned that fingerprints made good forensic evidence, but he used them in his book to dramatically solve a case in which identical twins were falsely accused of murder. Using fingerprints as a means to identify individuals was a major breakthrough in forensic science in real life, as well as in novels, and it gave law enforcement around the world a new tool to solve crimes, clear the innocent, and convict the guilty. Fingerprint evidence also serves to identify the missing and the dead. Fingerprint cards from *Pudd'nhead Wilson* are shown in **Figure 6-1**.

Analyzing fingerprint evidence today involves far more than looking at the fingerprints left at a crime scene. As technology has advanced, so has the world of fingerprint analysis. Today, programs have been initiated that allow law-enforcement officers across the country to quickly and easily submit fingerprints to a national database and obtain the identity of a suspect if their prints were entered into the database. Although fingerprints are mostly considered to be a form of individual evidence, biometrics (the measurement and statistical analysis of someone's unique physical characteristics) have improved the ability to establish one's identity.

In this chapter, you will explore the following:

- Formation of fingerprints during development
- Different types of fingerprint evidence
- How to collect, process, and analyze fingerprint evidence
- Why today fingerprint evidence may not be 100 percent unique as described in Mark Twain's novel

The History of Fingerprinting *Obj. 6.1*

For thousands of years, humans have been fascinated by the patterns found on the skin of their fingers. But exactly how long ago humans realized that these patterns could identify individuals is not clear. Several ancient cultures used fingerprints as personal markings (**Figure 6-2**). Archaeologists discovered fingerprints pressed into clay tablet contracts dating back to 1792–1750 B.C. in Babylon. In ancient China, it was a common practice to use inked fingerprints

Differentiated Learning

Additional Support for Learners

During classroom discussions, encourage all students to share prior knowledge. Tell students that when a classmate is sharing, they should listen carefully, then write down a follow up question. When the classroom discussion is complete, encourage students to research the answers to their follow up questions. This strategy is particularly useful for discussing the topic of fingerprinting as a requirement for employment.

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on all official documents, such as contracts and loans. The oldest known document showing fingerprints dates from the third century B.C. Chinese historians have found fingerprints and palm prints pressed into clay writing surfaces and surmise that they were used to authenticate official seals and legal documents.

In Western culture, the earliest record of the study of the patterns on human hands comes from 1684. Dr. Nehemiah Grew wrote a paper describing the patterns that he saw on human hands under the microscope, including the presence of ridges. Johann Christoph Andreas Mayer (1788) described that "the arrangement of skin ridges is never duplicated in two persons." He was probably the first scientist to recognize this fact. In 1823, Jan Evangelist Purkinje described nine distinct fingerprint patterns, including loops, spirals, circles, and double whorls. Sir William Herschel began the collecting of fingerprints in 1856. He noted that the patterns were unique to each person and were not altered by age.

FIGURE 6-2 This ancient brick from Athens, Greece shows the builder's fingerprints embedded in the clay.

Dimitris Koskinas/Shutterstock.com

DID YOU KNOW?

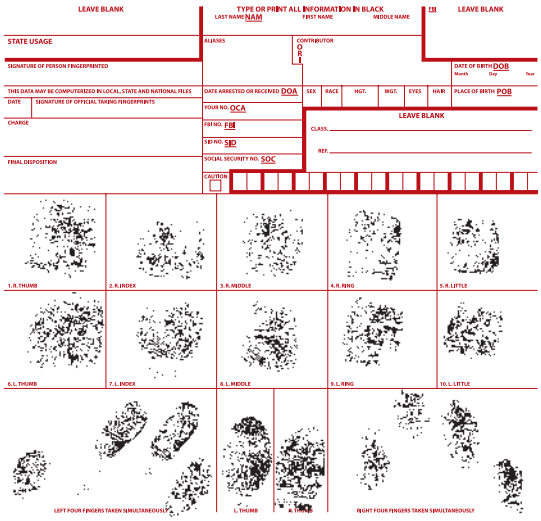
Alphonse Bertillon was the first person to document incoming prisoners with a photograph, the forerunner of the modern mug shot.

In 1879, Alphonse Bertillon, an assistant clerk in the records office at the police station in Paris, created a way to identify criminals using a list of physical measurements taken from prisoners. The system, sometimes called *bertillonage*, was first used in 1883 to identify repeat offenders. In 1902 in Argentina, Inspector Alverez, under the training of Juan Vucetich, was credited with solving the first murder using fingerprints, which replaced Bertillon measurements for identification.

Sir Francis Galton (1822–1911) verified that fingerprints do not change with age. In 1888, Galton, along with Sir Edmund Richard Henry, developed the classification system for fingerprints that is still in use today in the United States and Europe.

Beginning in 1896, Sir Edmund Richard Henry, with the help of two colleagues, created a system that divided fingerprint records into groups based on whether they have an arch, whorl, or loop pattern. Each fingerprint card in the system was imprinted with all 10 fingerprints of a person and marked with individual characteristics. This set of fingerprints has come to be called a **ten print card** (**Figure 6-3**).

FIGURE 6-3 An example of a ten card.



Engage

Before discussing fingerprint patterns, ask students to study fingerprints and have them devise their own method of classification.

Explore

Have students research the relevant work of Jan Evangelista Purkinje, who was a professor of physiology and pathology at the University of Prague. In 1823, the professor recognized fingerprints as a way of making identifications.

Explore

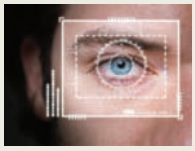
Alphonse Bertillon created anthropometry, which records the measurements of humans. Anthropometry was the first scientific system police used to help solve crimes. Have interested students research what bodily measurements were taken and why fingerprints were considered to be a more accurate means to identify someone.

Fingerprints 193

Fingerprint identification systems and programs are changing to more integrated, automated systems that include biometric identification. As stated previously, **biometrics** are the use of measurements and statistical analyses of someone's physical characteristics to aid in their identification. Many of these programs are still in development. Refer to **Table 6-1** for a timeline of these developments.

Although technology has continued to improve, various state and local police agencies have not all been sufficiently funded to obtain handheld devices for rapid identification of individuals at traffic stops.

TABLE 6-1 Development of identification systems

Date	Description
1980	Automated Fingerprint Identification Systems (AFIS) used by individual states.
1999	IAFIS developed by FBI replaced manual fingerprint searching with digital fingerprint images and criminal history. This system, linked to AFIS used by individual states, contains the world's largest and most efficient electronic repository of biometric (measurement and statistical analysis of someone's unique physical characteristics) and criminal history information.
2011	FBI's Next Generation Identification (NGI) incremental program is introduced and will eventually replace IAFIS. NGI uses matching algorithmic patterns in its Advanced Fingerprint Identification Technology (AFIT), increasing accuracy to 99.6%. NGI plans to gradually add biometric features to be included along with fingerprints.
2011	NGI launched Repository for Individuals of Special Concern (RISC) that enabled police officers in the field to collect and submit fingerprints and compare a suspect's fingerprints against a database of sex offenders, terrorists, and wanted individuals. (no civilian prints)
2013	NGI implemented palm and hand edge prints (little finger to the wrist) repository (20%–30% of all fingerprints are palm or edge of handprints).
2014	NGI added facial recognition using photos entered in the Interstate Photo System (IPS), a face recognition service that allows law-enforcement agencies to search photographs of criminals to assist with identifications. IPS includes photos of tattoos, scars, and marks. IPS is accessed through the Universal Face Workstations (UFW) and can search cell-phone and surveillance camera videos.  Pashkova/Shutterstock.com  ozrimoz/Shutterstock.com  metamorworks/ Shutterstock.com  Source: FBI
2014	NGI added Rap Back, a program that enables authorized entities to receive ongoing status reports of any criminal history on individuals holding positions of trust (e.g., day care workers and teachers).
2015	NGI included iris and identification examination in addition to scars, marks, and tattoos.
2018	Electronic Biometrics Transmission Specifications (EBTS) implementation. Eventually, this system will ultimately contain complete biometric and biographical profiles of the subject records in its databases.

Teach

The Criminal Justice Information System (CJIS) is the division within the FBI that provides management of Next Generation Identification (NGI) as well as providing the central repository of all the information.

Engage

Have students prepare inked palm print impressions. Discuss what additional information about a person's identity could be known by analyzing a palm print versus analyzing a fingerprint.

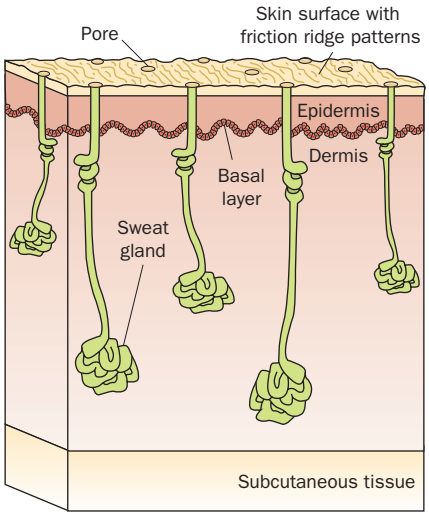
194 Chapter 6

The Science of Fingerprints *Obj. 6.2*

Look at the surface of your fingers. Are they smooth and shiny? No. All fingers, toes, feet, and palms are covered in small ridges. These are raised portions of skin, arranged in connected units called *dermal, or friction, ridges*. They help us with our grip on objects that we touch. When these ridges press against things, they leave marks. A finger leaves an impression called a **fingerprint**.

The imprint of a fingerprint consists of natural secretions of the sweat glands that are present in the friction ridge of the skin (**Figure 6-4**). These secretions are a mixture mainly of water, oils, and salts. Dirt from everyday activities is also mixed into these secretions. Anytime you touch something, you may leave behind traces of these substances in the unique pattern of your dermal ridges. Due to the uniqueness of fingerprints to an individual, this type of evidence can be considered *individual evidence*.

FIGURE 6-4 Our fingertips are covered with hundreds of microscopic sweat pores that make our fingers moist and able to grip better.



Formation of Fingerprints

The individual nature of fingerprints has been known for about 2,000 years, but scientists only recently discovered how friction ridges leading to fingerprints form in the womb. The latest information suggests that the patterns are formed at the beginning of the 10th week of gestation (time since conception). Similar ridges are formed in many other areas of the body, such as the palms and sides of the hands and the soles of the feet and toes. (Note that although identical twins have the same DNA, they do not have the same fingerprints because of alterations during gestation.) These **ridge patterns** are the ridges found in the areas such as the end pads of fingers and they form lines on the surfaces of objects in a fingerprint.

The development of ridge patterns happens in the basal layer of skin, where new skin cells are produced. As the basal layer grows, unique ridge patterns form, influenced by the environment surrounding the fetus. The pattern can be altered by damage to the dermal layer. An injury of this type may create an alteration when skin regrows, and a scar appears on the original pattern.

Characteristics of Fingerprints *Obj. 6.3*

At first glance, it may be difficult to distinguish one fingerprint from another. But by understanding the different patterns and variations of the ridge patterns, you will be able to detect differences in most fingerprints.

Types of Fingerprints

There are three types of prints that can be left at a crime scene. **Patent fingerprints**, or visible prints, are left on a smooth surface when blood, paint, grease, ink, or some

Explore

Have students research Internet photographs of finger pads on apes and chimpanzees and compare them to human fingerprint patterns.

Academic Connections

BIOLOGY

The skin has three layers, each with different functions. The surface of the skin is called the *epidermis*. The epidermis is a relatively thin layer where the outermost cells are shed. The newer cells grow from the lowest layer of the epidermis, called the *basal layer*. The epidermis, when undamaged, is mostly waterproof; prevents bacteria and viruses from entering the body; and contains melanin that filters out ultraviolet (UV) rays from the sun. The next layer is called the *dermis*. This layer provides the skin with strength and flexibility and contains nerve endings, sweat glands, oil glands, hair follicles, and blood vessels. The *subcutaneous layer* is the most internal layer of the skin. This layer provides the body with insulation from the cold and heat, offers protective padding, and stores energy.

Differentiated Learning

Accelerated Learners

Have students write a short story or draw a short graphic feature involving a crime committed by one of two identical twins. Which twin committed the crime? Eyewitnesses in the story should provide a detailed description of the suspect. The conclusion should explain how the case was solved through the use of fingerprinting. Students may wish to research actual cases where one of the identical twins committed a crime and fingerprints were used to solve the crime.

Differentiated Learning

Accelerated Learners

Have interested students research the relative uniqueness of footprints. Is a database of footprints in use today? Have students who performed research share what they learned about footprints and lead a class discussion on why or why not a footprint database would be useful for CSIs.

Teach

Plastic prints found at a crime scene can be preserved by taking photographs of the prints. Plastic fingerprints can be made in poster putty and then dusted with fingerprint powder before photographing. A ruler should be included in the photograph to show relative size of the print.

Teach

Point out that arches do not have deltas. The entire basis for declaring an arch, whorl, or loop is due to the presence or absence of deltas, and the number thereof. For example, you can have a print that looks like an arch, but if a delta is present, it would be classified as a loop. A loop has a single delta and ridge lines that originate and exit on the same side. A whorl has at least two deltas.

Engage

Read students the following scenario and then ask them to suggest where fingerprints may be found and identify what prints are patent, plastic, or latent: a local pottery studio was robbed while the potter was out. The thieves broke a window on the studio's front door and then reached inside, turning the doorknob to get in. (Patent and latent prints might be left on the doorknob as well as on whatever was used to break the window.) Designs (latent print) the potter had drawn were strewn about the room. A fresh clay platter (plastic print) was broken in half. A cash register (a possible latent print on the register or whatever tool was used to force the drawer) was forcibly opened, and all of the cash (partial latent prints on individual slots) was taken. The criminals left by opening the back door (latent print on the knob; could be patent if they had dirty, sweaty, or bloody hands).

ACTIVITY

Consider introducing Activity 6-1: *Study Your Fingerprints* at this point in the lesson.

FIGURE 6-5 Latent prints made "visible" using fingerprint powders prior to being "lifted."

other material comes in contact with the hands and is transferred to that surface. **Plastic fingerprints** are actual indentations left in some soft material such as clay, putty, or wax. **Latent fingerprints**, or prints not visible to the unaided eye, are caused by the transfer of oils and other body secretions onto a surface. They can be made visible (developed) by dusting with powders and *lifting*, or by using tape or adhesive lifter (**Figure 6-5**).

Basic Ridge Patterns

Fingerprint characteristics are named for their general visual appearance (ridge pattern). Major ridge patterns are **loops**, **whorls**, and **arches** (**Figure 6-6**). About 65 percent of the total population has loops, 30 percent has whorls, and 5 percent has arches.

Arches have ridges that enter from one side of the fingerprint and leave from the other side with a rise in the center. Whorls look like a bull's-eye. Loops enter and exit from the same direction. The **core** is the center of a loop or whorl.

Some fingerprints have a triangular ridge pattern called a **delta**. A delta is where the ridge patterns diverge or change direction. Some of the ridges go above the delta and some of the ridges go below the delta. Note in Figure 6-6 that arches lack deltas, whorls have at least two deltas, and loops have one delta.

FIGURE 6-6 Three basic fingerprint patterns occur at different frequencies in humans.

Arches 5% Whorls 30% Loops 65%

FIGURE 6-7 The core is located at the center of a loop or whorl. The delta is the triangular region where the ridge pattern diverges.

Core: center of loop, shown in orange

Delta: triangular region inside red circle

Ridge count: is the number of ridges between the core and the center of the delta.

A **ridge count**, which is the number of ridges between the core and center of the delta, may help distinguish one fingerprint from another. To take a ridge count for a loop pattern, an imaginary line is drawn from the center of the core to the middle of the delta. Count the number of ridges between the core and the center of the delta. In **Figure 6-7**, the blue line shows the area used in the ridge count.

Subdivisions of Ridge Patterns

The three basic fingerprint patterns can be further subdivided. Whorl patterns with two deltas may be plain whorl (24 percent), central pocket loop whorl (2 percent),

Teach

Activity 6-1: *Study Your Fingerprints* is a simple and inexpensive activity to help students master the three types of ridge patterns and the concepts of deltas and cores.

- The graphite pencil method of making fingerprints yields very clear, distinct ridge patterns. Enlarge the graphite prints on a copy machine to provide easy-to-see fingerprints.
- Ask students to perform ridge counts on the enlarged fingerprints. As students view each other's fingerprints, ask them to identify prints that do not fit into the basic three categories. Use this discussion as a lead-in to a discussion on the variations of the three ridge patterns.

Differentiated Learning

English-Language Learners

Students may have difficulty distinguishing between the terms *latent* and *patent* because they only differ by one letter. Try to come up with a clever way for them to remember these terms. For example, because latent begins with an L, that L could refer to investigators having to LOOK for these kinds of prints. Latent prints are invisible prints.

double loop whorl (4 percent), or accidental whorl (0.01 percent) (**Figure 6-8**). The *plain whorl* (Figure 6-8A) has one or more ridges that make a complete spiral. If a line is drawn between the center of the two deltas, at least one of the concentric circles crosses that line. The *central pocket loop whorl* (Figure 6-8B) has one or more ridges that make a complete circle. If a line is drawn between the center of the two deltas, then none of the concentric circles crosses that line. The *double loop whorl* (Figure 6-8C) has two separate loop formations and two deltas. The *accidental whorl* (Figure 6-8D) has two or more deltas and is a combination of two of the other patterns (other than a plain arch).

FIGURE 6-8 Types of whorl pattern.

Deltas (triangular regions inside red circles)
A. Plain whorl

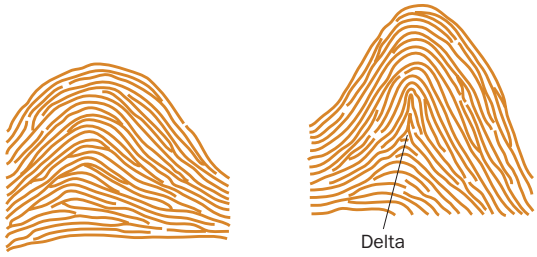
Deltas (triangular regions inside red circles)
B. Central pocket loop whorl

Deltas (triangular regions inside red circles)
C. Double loop whorl

Deltas (triangular regions inside red circles)
D. Accidental whorl

Arches may be divided into plain arches (4 percent) and tented arches (1 percent) (**Figure 6-9**). The *plain arch* (Figure 6-9A) has ridges entering one side, rising in the center, and exiting the other side. It does not have a delta. The *tented arch* (Figure 6-9B) has ridge patterns entering one side, rising in the center, and exiting out the other side. However, the ridge pattern has a sharp rise in the center of the arch.

FIGURE 6-9 Types of arch pattern.



A. Plain arch
B. Tented arch

Loops can be further classified as ulnar or radial depending on the direction of the opening of the loop. A *radial loop* opens toward the thumb (toward the radius bone), and an *ulnar loop* opens toward the little finger (toward the ulna bone).

Teach

Point out that fingerprint classification is also useful for excluding possible suspects. For example, if a thumbprint on an object is clearly a whorl and your suspect has two loops on their thumbprints, there is no need to proceed further to minutiae analysis.

Teach

Have students master the three types of ridge patterns before reviewing their variations.

ACTIVITY

Consider introducing Activity 6-8 ACT: *Print Variations* at this point in the lesson. This additional activity is located on the Companion Site.

Teach

Students can easily get confused when trying to distinguish a plain whorl from a central pocket loop whorl. Emphasize that they need to draw a line between the two deltas. If the line crosses any of the concentric circles, then it is a plain whorl. Also point out that the central pocket loop whorl is actually both a whorl and a loop pattern.

Teach

Project photos of enlarged fingerprints. Have students practice identifying deltas, loops, whorls, and arches. Emphasize that whorls need two deltas and a loop only has one, and arches have no deltas. Don't introduce minutiae patterns until students master identifying the type of fingerprint. If students provide the wrong answer, show them what to view in the fingerprint to determine the type of print.

Teach

Enlarge fingerprints to ensure all students are able to see minutiae patterns.

1. Use a copy machine to greatly enlarge a fingerprint and distribute copies to all students.
2. Have students circle different minutiae patterns on their copies. They should use different colored pencils when circling minutiae patterns.
3. Take digital photographs of fingerprints and enlarge or project their images for the class, pointing out minutiae patterns.

ACTIVITY

Consider introducing the following activities at this point in the lesson:

- Activity 6-5: *Minutiae Patterns*
- Activity 6-2: *Giant Balloon Fingerprint*

DID YOU KNOW?

Fingerprints can be taken from dead bodies by chemically treating the fingertips to help them puff out. Another method involves removing the finger skin and placing it like a glove onto the (gloved) finger of someone else, who can then roll the print.

Minutiae and Fingerprint Identification

While looking at the basic fingerprint patterns can quickly help exclude a suspect, in order to consider a print found at a crime scene consistent with that of an individual, more information is needed. An examiner needs to know if he is viewing a partial print, multiple prints, or prints from a right or left hand. (Left and right fingerprints are not mirror images.) Every individual, including identical twins, has unique ridge characteristic details called **minutiae** (because the details are so small). Recognizing minutiae, their relative number, and their location on a specific fingerprint is called *fingerprint identification*. There are about 150 individual ridge characteristics on the average full fingerprint. When forensic examiners identify a fingerprint, they are, in theory, identifying the unique signature of a person.

Refer to **Figure 6-10**, to see descriptions of fingerprint minutiae patterns. Keep in mind that most prints recovered from a crime scene are only partial prints. Identification of minutiae patterns can be done without having a full fingerprint. In the lab activities, you will practice the techniques necessary to identify and compare fingerprints, including analyzing these ridge characteristics.

FIGURE 6-10 Some minutiae patterns used to analyze fingerprints.

Name	Visual Appearance
1. Ridge ending (including broken ridge)	
2. Fork (or bifurcation)	
3. Island ridge (or short ridge)	
4. Dot (or very short ridge)	
5. Bridge	
6. Spur (or hook)	
7. Eye (enclosure or island)	
8. Double bifurcation	
9. Delta	
10. Trifurcation	

Differentiated Learning

Accelerated Learners

Show students images of different minutiae types from **Figure 6-10** without including the names. Ask them what names they would give these images just based on what they see. Students often end up with the same or similar names. This helps break the ice when learning new terms like *bifurcation* and *spur*.

Differentiated Learning

English-Language Learners

To help students understand minutiae terms, explain to students:

- bi = means 2
- tri = means 3
- furcation is similar to a fork
- eye is the same shape as their eyes

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Collection and Documentation of Fingerprints *Obj. 6.4*

When collecting and documenting evidence, it is important to follow the proper procedures (as described in Chapter 2). Because fingerprints are difficult to see, all crime-scene investigators (CSIs) need to be specially trained in

- where to look for fingerprint evidence;
- how to identify different types of fingerprints;
- what type of lighting, powders, or chemicals should be used to enhance the fingerprint; and
- how to photograph and document each fingerprint.

Photographing Fingerprints

Because not all fingerprints are visible, it takes a trained CSI to know where to recover possible fingerprints. Crime-scene investigators often use alternative light sources such as lasers or LED devices that emit a particular wavelet of light or use filters on the light source to help identify fingerprints. Once located, all fingerprints should be photographed *in situ* before any attempt to enhance the fingerprint or to lift the fingerprint (**Figure 6-11**). Close-up photos as well as photos that show where the fingerprint was found in relationship to the crime scene should be taken. After the fingerprint is enhanced, another photo should be taken of the fingerprint with the powder or chemical enhancer. All photos and fingerprint evidence are logged as evidence.

FIGURE 6-11 A crime-scene specialist photographing a print *in situ*.

Couperfield/Shutterstock.com

Methods of Collection

All fingerprint evidence should be documented in the evidence log. Chain of custody labels should be completed for each fingerprint. The method of collection differs depending on the type of fingerprint.

Collecting Latent Fingerprints

As mentioned earlier, latent fingerprints are not easily visible, but techniques can enhance them. To enhance the latent print, dusting smooth, nonporous surfaces such as drinking glasses, the faucets on sinks, telephones, and the like with a fine carbon powder can make a fingerprint more visible. Magnetic powders may also be used and are easier to clean than dusting powders. Fluorescent dye stains or powders aided with a laser or light source are also used. Tape is used to lift and preserve the fingerprint. Latent prints are fragile and can be easily affected by environmental factors; therefore, fingerprints should be processed as soon as possible. The side of the tape with the fingerprint is placed on an evidence card

Explore

Have students research the use of color-changing fluorescent film and micro-X-ray fluorescence (MXRF), a noninvasive method of detecting salt impressions.

ACTIVITY

Consider introducing the following activities at this point in the lesson:

- Activity 6-3: *Studying Latent and Plastic Fingerprints*

Academic Connections

CHEMISTRY

When crime scene investigators work with metal dusting powders, they typically use a Magna Brush. The Magna Brush is a specially designed magnet that picks up finely divided metal powder. This method is far less messy, and the metal powder can be swept up and reused.

ACTIVITY

Consider introducing Activity 6-7: *Using Cyanoacrylate to Recover Latent Fingerprints* at this point in the lesson.

Engage

Help students learn the information in **Table 6-2** by enlarging the table and making several copies of it. Then, cut out the squares of information and place each set of pieces into a separate envelope. Working in groups of two, have students recreate the table from the pieces. Make this exercise into a game by assigning a point value for each piece placed in the correct position.

Teach

Tell students that cyanoacrylate is Super Glue®.

Academic Connections

CHEMISTRY

Collecting latent fingerprints requires chemicals that will help investigators see and remove the prints for analysis without damaging them. The method used depends on the surface material. For example, ninhydrin reacts with traces of amino acids left on porous surfaces. Cyanoacrylate fumes adhere to latent prints on nonporous surfaces, such as plastic bags or electrical tape.

Teach

Explain how the prints on a ten card are made. For the upper ten impressions, each digit is individually rolled nail edge to nail edge on the card. This is done to obtain all available ridge detail. The prints at the bottom of the ten card are taken simultaneously without rolling. All of the fingers of each hand—except the thumb, which is printed separately—are set down at a 45-degree angle. These are referred to as plain or flat impressions. The bottom prints are taken in this manner to verify the sequence and accuracy of the rolled impressions at the top of the card.

with a contrasting background. The date, time, location, and collector of the print are logged on the evidence card.

To recover a print from a porous surface that is not smooth and hard requires the use of different chemicals to enhance the image. When the fingerprint residue combines with these chemicals, the fingerprint image becomes visible. **Table 6-2** summarizes common chemicals used to recover a latent print.

TABLE 6-2 Other methods used for visualizing latent fingerprints

Chemical	Uses	Application	Safety	Chemical Reaction	Latent Print
Ninhydrin	Paper	Object is dipped or sprayed in ninhydrin; wait for 24 hours	Do not inhale or get on your skin	Reacts with amino acids (from proteins) found in sweat	Purplish-blue print
Cyanoacrylate vapor (super glue)	Household items: plastic, metal, glass; skin	Cyanoacrylate is heated in a vapor tent or fuming wand is used	Do not inhale or get on your skin: irritating to mucous membranes	Reacts with amino acids, proteins, fatty acids	White print
Silver nitrate	Wood; styrofoam	Object is dipped or sprayed in silver nitrate	Wear gloves to avoid contact with skin	Chloride from salt in perspiration on the print combines with silver nitrate to form silver chloride	Black or reddish-brown print under UV light
Iodine fuming	Paper; cardboard; unpainted surfaces	In a vapor tent, heat solid iodine crystals	Toxic to inhale or ingest	Iodine combines with carbohydrates in latent print	Brownish print fades quickly; must be photographed or sprayed with a starch solution

Collecting Patent Prints

Patent or visible prints found in blood or ink are immediately photographed. If the patent print is on a surface, such as a shirt or piece of paper, the item is dried and then bagged in a paper bag. The blood or liquid that was found in the print could be further analyzed in the lab for additional evidence.

Collecting Plastic Prints

Plastic prints that appear as indentations on soft items are first photographed. They usually do not require any enhancement. The item with the plastic print can be collected and may be casted if necessary. Oblique lighting may help enhance images.

Collecting Suspect Prints

Fingerprints of suspects are taken by rolling each of the 10 fingers in ink and then rolling them onto a ten print card that presents the 10 fingerprints in a standard format. In Activity 6-4, you will learn how to take your own ten card fingerprints. In most labs today, however, fingerprints are taken digitally.

Enrich

Ask a fingerprint technician to visit your class and demonstrate the correct procedure in preparing a ten card.

ACTIVITY

Consider introducing Activity 6-4 *How to Print a Ten Card* at this point in the lesson.

Differentiated Learning

Accelerated Learners

Have students research (1) the chemical reactions involved in fingerprint recovery using ninhydrin and cyanoacrylate and (2) how additional hidden data can be identified from fingerprints, including traces of drugs, blood, foods, cosmetics, medicines, explosives, and environmental hazards.

Forensic Analysis of Fingerprinting *Obj. 6.5*

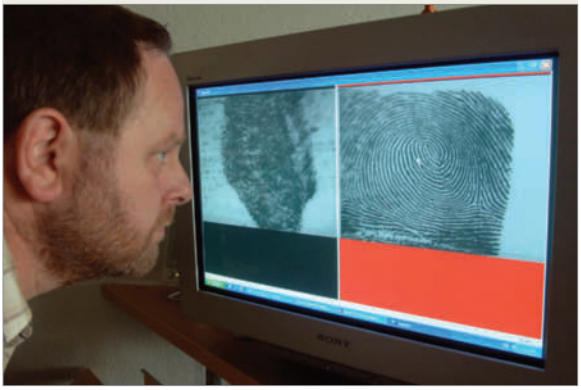
Fingerprint analysis and fingerprint storage of data have changed dramatically since the turn of the century, when individual experts analyzed, copied, and stored fingerprints on paper. Today, fingerprints are taken digitally, stored on huge computer databases shared both nationally and internationally, and easily accessed from mobile police units. The initial and final fingerprint assessments are completed by a person. However, most of the analyses are done electronically on computers resulting in more objective, reliable, and valid results.

How Are Fingerprints Analyzed?

Contrary to what we see on television, fingerprint comparisons and identifications are not carried out by a computer in a matter of seconds. To complicate the analysis, most fingerprints left at crime scene are often partial, smudged, or altered. Before analyzing a fingerprint, an assessment is made by a fingerprint expert to determine if the fingerprint has adequate quality and quantity of features. By 1987, when most fingerprints were being analyzed by people and not computers, the FBI had 23 million criminal fingerprint cards on file, and getting a comparison with a fingerprint found at a crime scene with one stored on file required manual searching. It could take as long as three months to do a thorough search.

In 1999, IAFIS (**Figure 6-12**) provided digital, automated fingerprint searches, latent print searches, electronic storage of fingerprint photo files, and electronic exchange of fingerprints and test results that greatly improved the ability to analyze and compare fingerprints. IAFIS operated 24 hours a day, 365 days a year. The FBI's NGI, launched in 2011, is enhancing and ultimately replacing IAFIS. Since the NGI system was introduced, it has improved automated fingerprint and latent search capabilities, mobile fingerprint identification, and electronic image storage as well as incorporating new means of biometric identification, including facial recognition, iris scans, and palm and hand edge prints. Personal identification information can be easily and quickly stored, accessed, and shared both nationally and internationally.

FIGURE 6-12 A technician compares fingerprints in the IAFIS system.



Peter Foerester/picture-alliance/dpa/AP Images

In early 2019, the NGI databases contained 65 million sets of civilian fingerprints, 77 million sets of criminal fingerprints, and 5 million sets of RISC fingerprints, or fingerprints in the Repository for Individuals of Special Concern. Over 24,000 law-enforcement agencies at the local, state, federal, tribal, and international law-enforcement groups submitted fingerprints and other identify information to NGI. With advancements in portable scanning units and the use of digital fingerprints, speed in identification of fingerprints has increased dramatically. If a police officer makes a routine traffic stop and needs to check the

Teach

IAFIS uses an algorithm to compare fingerprints that improved accuracy from 92 percent to 99.6 percent.

ACTIVITY

Consider introducing Activity 6-6: *Fingerprint Analysis* at this point in the lesson.

Enrich

Invite a law-enforcement officer to your class to discuss the role of fingerprints in investigations. Have students prepare questions in advance of the visit. Ask the officer to cite specific case studies in which fingerprints played an important role in solving the crime.

Engage

To help students understand that computers don't examine individual minutiae patterns, that an algorithm or pattern does, provide each student with a full-sized enlarged fingerprint. Ask students to circle the distinctive minutiae patterns then connect the minutiae encircled patterns to create an "algorithm" or unique shape. Make a transparency of the "algorithm" to show how its shape can identify the print if the pattern is consistent (aligns) with the minutiae patterns in the fingerprint.

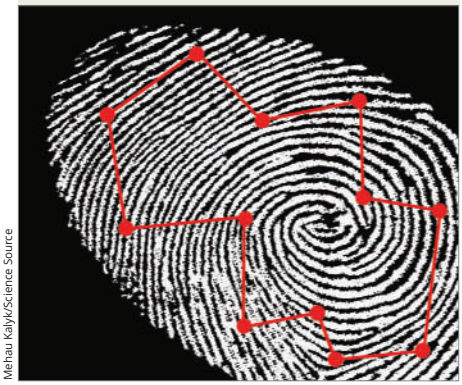
CAPSTONE PROJECT

Consider introducing **Capstone Project 3:** *How Reliable Is the Evidence?* at this point in the lesson.

Enrich

Ask students to design a method of lifting a fingerprint from a light bulb. The standard methods of dusting and lifting the print are challenging due to the shape of the light bulb. (*Options could include using Play-Doh to lift the print or using Mikrosil, a type of puddy available from forensic suppliers.*)

FIGURE 6-13 Computer analysis of fingerprints examines patterns formed from ridge patterns and minutiae.



Mehau Kulyk/Science Source

identification of the driver, he can scan the driver's fingerprints and electronically submit the fingerprints to NGI. Those fingerprints are checked within minutes with the NGI databases and can help dictate a possible course of action for that officer.

Today, most fingerprints are compared using technology first, with the final comparison made by an expert. Using image enhancement algorithms, fingerprint quality and clarity can be improved and marked. Scanners are used to identify and mark minutiae points. Software calculates the distances and angles between key minutiae points and defines a unique pattern, known as an *algorithm* (**Figure 6-13**). Instead of examining individual ridges and minutiae, the computer searches for the pattern formed from the minutiae and ridges. A computer rapidly searches the databases for fingerprints that are consistent with the algorithm or unique pattern formed by the ridges and minutiae patterns. The computer search for that pattern or algorithm is not only much faster, but it can also significantly reduce the search to a smaller number of individuals.

Most fingerprints recovered from a crime scene are often partial prints and often smudged. New studies show that the initial analysis of the fingerprint to determine if it is a usable print having sufficient quantity and quality can now be done objectively by a machine and not a person. "Matching scores" of the comparison of the evidence fingerprint with a suspect's fingerprint is electronically assigned, removing the subjective analysis of a fingerprint examiner. However, the final fingerprint identification is still confirmed by a fingerprint examiner.

DID YOU KNOW?

Digital fingerprint images can be enhanced. Characteristics like ridge endings and bifurcations are assigned coded mathematical values. Corrupted regions on the fingerprint file can be blended with distinct regions to produce an enhanced composite print.

Fingerprint Reliability and Validity

Fingerprint evidence, once believed to be infallible, is now under scrutiny for its validity and reliability. In 1995, 156 fingerprint examiners were given a test. One in five examiners made at least one false identification. In 2004, the FBI arrested and jailed Oregon lawyer Brandon Mayfield based on fingerprint evidence that linked him to the Madrid train bombings, which killed 170 people. Mayfield, who had not traveled out of the United States for 10 years, claimed the fingerprint was inconsistent with his. Mayfield was held in custody for two weeks, until the Spanish authorities told the FBI that the fingerprint was, in fact, that of an Algerian citizen.

In 2009, a report from the National Academy of Sciences found that results are not necessarily repeatable (not reliable) from examiner to examiner and that even experienced examiners might disagree with their own past conclusions when they reexamine the same prints at a later date. The tragedy of erroneous results is that innocent people are being wrongly accused and guilty people are free to commit more crimes.

The problem of fingerprint evidence analysis in the past was due to the subjectivity of the examiner. The lack of scientific objectivity led many scientists to question the validity of fingerprint analysis. The National Academy of Sciences requested a federal board to research and access reliable methods used in

Differentiated Learning

Accelerated Learners

Ask students to research the following:

1. Court cases thrown out due to faulty identification of fingerprints
2. Acceptance of fingerprint evidence by courts
3. Newest methods of fingerprint identification including prints from metal objects, the use of color-changing fluorescent films, and noninvasive techniques

Differentiated Learning

Additional Support for Learners

Ask students if it's possible to estimate an individual's age by examining their fingerprints. Have them design an experiment to obtain fingerprint data and make a claim based on their data. Then, ask students to alter their design to improve the evidence reliability and validity. Students should consider variables that can affect the appearance of someone's fingerprints (e.g., *scars, calluses, dry skin, working with different chemicals*).

forensics. This resulted in the creation of Scientific Working Groups (SWGs) to ensure high standards of evidence evaluation. In 2014, the SWG became known as the Organization of Scientific Area Committees (OSAC).

Among the recommendations made by SWG and OSAC were that results need to be double-checked to prevent false identifications. In 2018, the Department of Justice (DOJ) standardized the language used in reporting information about fingerprints at trial. Experts are to report such items as a suspect's ridge and sweat pore patterns and compare their consistency with evidence. The experts should explain their procedures without using such terms as "scientific certainty" or "individualization." The examiner cannot assert a "100 percent certainty" or a "zero-percent error rate." The examiner should not use the number of cases worked on during a career as a measure of accuracy, rather only as a measure of past experience. The examiner can make only one of three conclusions for source identification: exclusive, inclusive, or inconclusive.

Today, with NGI and the use of computer algorithms, there has been a 90 percent reduction in the number of manual fingerprint reviews, resulting in less subjective evaluation of fingerprints and much improved evidence reliability.

Can Fingerprints Be Altered or Disguised?

As soon as fingerprints were discovered to be a means of identification, criminals began to devise ways to alter them so that they could avoid being identified. American Public Enemy Number One in the 1930s, John Dillinger put acid on his fingertips to change their appearance, something he likely learned from stories of workers in the pineapple fields in Cuba who did not have readily visible fingerprints. This is because chemical substances found in the pineapple plant, when combined with the pressure of handling the plants, dissolved the workers' fingertip skin. What Dillinger did not learn is that when these workers ended their contact with the pineapples, their fingerprints grew back! Fingerprints taken from Dillinger's body in the morgue were compared to known examples he left behind during his life of crime. Despite his efforts to destroy his fingerprints, they still allowed him to be identified. Sometimes, the scars formed by trying to remove fingerprints even make fingerprint identification easier!

DID YOU KNOW?

Pineapple juice contains an enzyme that digests protein. The protein fingerprint ridges in the skin are temporarily removed when exposed to pineapple juice and result in poor fingerprints.

DID YOU KNOW?

Biometric finger and hand scanners can use fingerprint ridge patterns, the length of your fingers, and your body temperature to help identify you. Biometrics are used in Singapore's border security checkpoints. It takes on average 12 seconds to pass through an unmanned security station using a fingerprint scanner and a passport.

Advances in Fingerprinting *Obj. 6.6*

Fingerprinting is as much a part of the future of forensics as it has been a part of its past. New technology has significantly improved the speed, accuracy, and reliability of fingerprint analysis. In an attempt to reduce the subjective human errors made in preliminary fingerprint screening, scientists at the Michigan State University (2017) have developed an algorithm that automates and standardizes the key first step of assessing if a fingerprint's quality and quantity is usable for analysis. Human experts develop the algorithm for the computer to recognize and identify minutiae patterns. Large databases must be used to help refine the machine learning process. In controlled testing, the machines outscored the human examiners and were much faster at identifying similarities. With new scanning technology and digital systems of identifying patterns, fingerprints can be scanned at a

Explore

Have students research the following programs and report on how they are used to help identify immigrants and why some people believe they violate their First Amendment Rights:

- Automated Biometric Identification System (IDENT) database, headed by US Immigration and Customs Enforcement, prevents illegal entry into the U.S. by storing over 200 million identities.
- Homeland Advanced Recognition Technology (HART) to replace IDENT in the future with the ability to store biometrics for 500 million identities at a faster speed.

Explore

Have students research the Organization of Scientific Area Committees (OSAC) to learn about the new standards and guidelines being developed to help improve the accuracy and reliability of fingerprint analysis.

Explore

Have students search the Internet for Uniform Language for Testimony and Reports for Latent Prints (justice.gov). There are guidelines for expert witness testimony of fingerprint identification.

Teach

Point out to students that Dillinger not only failed to remove his fingerprints but also made his fingerprints more distinctive by damaging his skin. Fingerprint patterns will not change on their own. If a trauma that produces a scar is deep enough to damage the underlying dermal papillae of the skin, then it will alter the friction ridges on the surface.

Teach

Point out to students that fingerprint biometric technologies are being developed or in use with ATMs, firearms, computers, and security systems. (You may have the option to use a biometric finger scanner on your laptop or smartphone in lieu of a password.) Large theme parks, such as Disney World, also use biometric fingerprint technology to decrease fraud.

Explore

Have students research how iris and retinal scans are also being used as a form of biometric identification. These scans test the pattern of the blood vessels of the eye.

FIGURE 6-14 This high-resolution fingerprint is a digital image that shows the sweat pores along the ridges, which appear as bumps in the print.

resolution of 500–1,000 dots per inch. This provides an image that reveals minute pore patterns on the fingerprint ridges, allowing for more precise pattern comparisons. Nanoparticles have now been added to fingerprint powders, making pore patterns appear even sharper (**Figure 6-14**).

Entirely new uses for fingerprints are also being developed. Trace amounts of DNA have been recovered from fingerprints that may help identify suspects at a crime scene. Fingerprints contain sweat that can be chemically analyzed using mass spectrophotometry to reveal information about what we touched or consumed. Using infrared spectromicroscopy, minute particles found in fingerprints are analyzed for color, shape, and size to determine if someone was exposed to or handled explosives (or other chemicals), which could help identify terrorists. Samples obtained from fingerprints are compared with existing databases for identification.

Technology is under development to provide a molecular fingerprint from a fingerprint sample that might someday tell us much more about the lives of the fingerprint donors than just their identities.

SUMMARY

Search the Internet for "FBI-Latent Print of the Year 2012" and read how a cold case was solved using IAFIS.

- Humans have noticed the patterns on their hands for thousands of years, but it was not until 1684 that these patterns were described in detail. In the mid-1800s, the idea of a fingerprint's uniqueness was studied, and the application of fingerprints to an identification system began. By the late 1800s, two effective systems were being used to identify criminals, and fingerprints were being collected as evidence in crimes. In the past 20 years, improvements in technology have improved fingerprint analysis and reliability.
- The elevated regions in the skin of the finger are called friction ridges formed early in development between two layers of skin. Unique to individuals, their shape does not change during their lifetime.
- Fingerprints left on an object are created by the naturally occurring ridges in the skin of fingertips and secretions from sweat glands that leave small amounts of oils and salts when the ridges are pressed against an object. The residues leave a reproduction of the ridges found on the finger of the donor.
- Fingerprints found at a crime scene are latent, not easily seen without the addition of powders or chemical; plastic prints are found embedded in soft materials; patent prints are formed when fingers come in contact with a material and are transferred to a surface.

Close

Point out to students that they have learned many technical terms in the chapter. Ask them to call out key words from the chapter. As you introduce each word, have them tell you what it means and why it is significant.

Assess

Review the learning objectives and key terms at the beginning of the chapter. Have students work in small collaborative groups to discuss and respond orally or in writing to each objective stated as a question.

Differentiated Learning

Additional Support for Learners

Ask students to prepare a thumb fingerprint using a graphite pencil (Act 6-1). Students should enlarge the fingerprint using a copy machine, or take a digital photo with a cell phone and enlarge the image. Ask students if they can see sweat pores in the enlarged image.

Differentiated Learning

Accelerated Learners

Ask students to prepare a digital image of a graphite thumbprint and work with a software program to enhance the image and make sweat pore patterns more visible.

ACTIVITY
6–1

Study Your Fingerprints *Obj. 6.2, 6.3, 6.7*

Objectives:

By the end of this activity, you will be able to:

1. Lift your fingerprint using tape and a graphite pencil.
2. Identify the ridge pattern of your finger.
3. Compare and contrast your fingerprints to your classmates' fingerprints.
4. Find two other students with the same basic ridge pattern as your own.
5. Calculate the percentage of students having each of the three different ridge patterns.

Time Required to Complete Activity:

40 minutes

Materials:

Act 6-1 WKST *Data Table*
Clear, adhesive tape 3/4 inch in width or wider (not "transparent" tape)
Pencil
Two 3 × 5-inch cards
Magnifying glass

SAFETY PRECAUTIONS:

None

Procedure:

1. On a lined 3 × 5-inch card, rub the end of a graphite pencil in a back-and-forth motion, creating a dark patch of graphite.
2. Rub your right index finger across the graphite patch so that the fingertip becomes coated with graphite from the first joint in the finger to the tip, and from fingernail edge to fingernail edge.
3. Tear off a piece of clear adhesive tape about 2 inches long. Carefully press the sticky side of the tape onto your finger pad from the edge of your fingernail across your finger pad to the other side of your fingernail.
4. Gently peel off the tape.
5. Press the tape, sticky side down, on the clean 3 × 5-inch card.
6. Examine your fingerprint using a magnifying glass.
7. Compare your fingerprint to the pictured samples.
8. Identify whether your fingerprint pattern is a loop, arch, or whorl.
9. Find two other students who have a similar ridge pattern as yours and record your answer on the worksheet.
10. Find two other students who have the other two types of ridge patterns.
11. Calculate the percentage of loops, whorls, and arches found in your class.

Differentiated Learning

Additional Support for Learners

Students with reduced visual acuity can use a magnifying glass to enlarge the fingerprint, or they can take a digital image of the print and enlarge the photograph for viewing.

Activity 6-1

BACKGROUND

This activity gives students an opportunity to examine their own fingerprints and compare them with their classmates' prints. Students use tape to make an impression of their fingerprints and determine what type of pattern they have.

SAFETY PRECAUTIONS

Students should wash their hands after using the graphite pencils.

PROCEDURE

1. Print, copy, and distribute Act 6-1 WKST *Data Table* from the Companion Site.
2. Clear, ¾"-wide adhesive tape will not be wide enough for a thumbprint. If you take a thumbprint, use a wider tape.
3. Reminder: Students should not roll their fingers across the graphite on their 3 × 5 card; they should vigorously rub their fingers across the graphite card, being sure to get graphite below the first digit and from nail edge across fingertip to the other nail edge.

Teach

Demonstrate how to cover a fingertip with graphite. The graphite should extend from nail to nail across the pad of the finger. The graphite should cover the crease of the first joint.

Teach

If the fingerprint impression does not look like a square (or rectangle), it is likely that the student did not spread graphite from nail edge to nail edge as directed.

Arches 5%

Whorls 30%

Loops 65%

12. Record the number of students showing each of the three types of fingerprint patterns, place those numbers in the data table in your worksheet, and then complete the rest of the data table.

Data Table

Data Collection From Classmates	Loop	Whorl	Arch
Number of students showing trait			
Total number of students in the class (*This will be the same total for each column.*)			
Percentage of class showing the trait (*Divide the number of students with the trait by the total number in the class, and then multiply by 100.*)			
National averages	65%	30%	5%

Questions:

1. Did the class percentage agree with the national averages? Support your claim using data from your data table.
2. Describe how to improve this data-collecting activity so that your results are more reliable.

Going Further:

Research chi-squared statistical analyses. Then run chi-squared statistical analyses to determine if the differences between your data and the national averages were significant.

ANSWERS

Data Tables

Check students' data tables.

Questions

1. Answers will vary. Tips: Be prepared to address averages that greatly deviate from the percentages given by the experts (small sample size). Pool the data with other class periods, and save them from year to year so students can see the power of having more data when drawing conclusions.
2. Possible answer: The larger your sample size, the closer to the national averages the data will be.

Enrich

In this activity, students examine one of their fingerprints. If time permits, have students make prints of each of their fingers and describe the pattern of each. They can also compare and contrast their right and left index fingers or their two thumbs. Have them identify other classmates' fingerprints for more practice.

ACTIVITY
6–2

Giant Balloon Fingerprint *Obj. 6.3, 6.7*

Objectives:

By the end of this activity, you will be able to:

1. Create a giant balloon fingerprint for use in studying various ridge patterns.
2. Identify the three basic ridge patterns among your classmates' fingerprints.

Time Required to Complete Activity:

20 minutes

Materials:

Act 6-2 WKST *Data Table*
1 large white balloon
Fingerprinting inkpad
Hand soap or moist wipes
Paper towels
Ballpoint pen and felt tip permanent marker

What you will need to do this experiment: a white balloon and an inkpad.

SAFETY PRECAUTIONS:

Before doing this activity, if you are allergic to latex, notify your teacher immediately.

Introduction:

Ridge patterns on fingerprints are unique and identifiable. In this activity, you will be comparing and contrasting your own thumbprint and those of your classmates to identify these patterns.

Procedure:

1. Slightly inflate a large balloon.
2. Ink your thumb from thumbnail to thumbnail and past the first joint.
3. Position your thumb so that your print will be about a quarter of the way from the top of the balloon and two-thirds of the way from the bottom. Gently press your thumb into the semi-inflated balloon. Do not roll your thumb. Pull your thumb from the balloon.
4. Fully inflate the balloon and examine your thumbprint.
5. Identify your thumb pattern as a loop, whorl, or arch on the data table in the accompanying worksheet.
6. Examine the balloons of your classmates and identify the ridge types.
7. Deflate your balloon and save it, unless you plan to do the following Going Further activity.

Engage

Students can also use permanent markers to circle minutiae patterns on the balloons.

Activity 6-2

BACKGROUND

In this activity, students use a balloon to enlarge their thumbprint so the ridge lines will be easier to see and identify. Instead of looking under a microscope, students enlarge the image of their fingerprint by semi-inflating the balloon.

SAFETY PRECAUTIONS

Some students may be allergic to latex. You may want to have students sign a waiver stating that they are not allergic to latex. Check with the school nurse to inquire if anyone in the class has a latex allergy. Some students may be highly allergic. Local hospitals or clinics might be willing to donate latex-free gloves.

PROCEDURE

1. Print and distribute Act 6-2 WKST *Data Table* from the Companion Site.
2. Placement of the print on the balloon is critical to enlarging the print. It should be placed about one-quarter of the way from the top and two-thirds of the way from the bottom of the balloon for optimal results.
3. Semi-inflate the balloon to about one-third capacity before applying the fingerprint. Then inflate it fully to magnify the fingerprint.
4. Allow students to experiment with placement of the print on the balloon.
5. At the end of this activity, collect all balloons from the students. Students should staple a piece of paper to the end of the balloon before turning it in. The piece of paper should have their name, which finger they printed, the fingerprint pattern, and any other identifying marks. Turning in the balloon will allow the teacher time to enter grades for this activity based on completeness and participation. Balloons should be cut up after grading for privacy protection.

ACTIVITY 6–2 CONTINUED

Data Table

Student Name for Fingerprint	Loop	Whorl	Arch
Your name:			
Name:			
Name:			
Name:			
Name:			

Going Further:

Refer to **Figure 6-10**, which describes minutiae patterns. Use a felt-tipped permanent marker to identify and circle the minutiae patterns on the balloon. Then deflate your balloon and save it.

ANSWERS

Data Tables

Check students' data tables.

Enrich

This activity does not take much time. To extend the activity, ask each student to examine the balloons of every student in the class. Remind students to write their initials on their balloon to keep track of the balloons. Give students two minutes to observe a balloon print. For each print they examine, they should record the fingerprint pattern and the initials written on the balloon. After two minutes, have students switch balloons until all students have examined every balloon. Compile the class data and determine the percentage of students with arches, whorls, or loops.

ACTIVITY
6–3

Studying Latent and Plastic Fingerprints

Obj. 6.3, 6.4, 6.8

Objectives:

By the end of this activity, you will be able to:

1. Distinguish between a latent and plastic fingerprint.
2. Summarize how to dust and lift a latent fingerprint.
3. Lift latent fingerprints from a glass surface.
4. Design an experiment to demonstrate plastic fingerprint impressions.
5. Identify ridge patterns from lifted and plastic fingerprints.

Time Required to Complete Activity:

Part A: 40 minutes; Part B: 40 minutes

Materials:

Act 6-3 WKST *Latent Print*
Act 6-3 WKST *Plastic Prints*
Newspaper
Black dusting powder or brush and magnetic powder
Adhesive tape 3/4 inch wide
Dusting brush
Cloth
Magnifying glass
Drinking glass, glass petri dish, beaker, other pieces of glass or Plexiglas®
Soap or moist hand wipes
Paper towels
3 × 5-inch card per student
Digital camera (for plastic print procedure)

SAFETY PRECAUTIONS:

Cover the work area with newspapers.
Remember that the dusting powder can be very messy.

Introduction:

Every person has a unique set of fingerprints, even an identical twin. Whenever you touch a surface without gloves or other protection, you leave behind an invisible (latent) fingerprint. Law-enforcement agencies use various fingerprint powders and chemicals to help visualize these telltale prints. Plastic fingerprints are the impressions left in soft material, such as wax.

Engage

Have students make their own inexpensive magnetic fingerprint brushes. Refer to Act 16-3 TN *Making Magnetic Wands* located on the Companion Site. If you make your own magnetic wands and purchase iron fillings, clean-up is much easier.

Activity 6-3

BACKGROUND

In this activity, students touch a piece of glassware and dust the glass to reveal the latent fingerprint.

SAFETY PRECAUTIONS

1. Make sure to cover the work area with newspapers.
2. Emphasize that students must handle the dusting powder with care because it can be very *messy* and difficult to clean if spilled.
3. Be prepared. Dust will settle on everything in the room no matter how careful the students are.
4. Emphasize to students how important it is to be careful blowing off the excess dust.
5. Have dusting cloths and a broom ready for cleanup at the end of the lab.
6. Set up one area of the room for fingerprint powders.

PROCEDURE

Print and distribute Act 6-3 WKST *Latent Print* and Act 6-3 WKST *Plastic Prints* from the Companion Site.

Teach

Substitutions for some materials can be made. Fingerprinting tape purchased from a forensic supply house works the best, but if you don't have the budget for this special tape, a wide, clear tape works well.

Magnetic dusting powder can be substituted for fingerprint dusting powders. You will also need a magnetic wand if you use magnetic powders.

If dusting powder is unavailable, you can dust with carbon powder on a light surface or talcum powder on a dark surface.

Enrich

This activity can be extended by having four anonymous students leave thumbprints on a piece of glassware. Lift these prints yourself. Do not reveal which four students left the latent print. Ask the class to determine whether the four latent prints lifted from the glass are consistent with any of the other members in the class. Fingerprints can be compared to prints previously taken, or ask the students to design how they will determine whether any students can be excluded or included.

Teach

Some suggested items for plastic fingerprints are silicone putty, poster putty, and moist (not wet) soap.

Procedure:

PART A: LATENT FINGERPRINTS

1. Cover the worktable with newspaper.
2. Wipe off your glass or Plexiglas® with a clean cloth.
3. Take your thumb and run it along the side of your nose or the back of your neck. These areas of your body are rich in oils and will help lubricate the ridges of the thumb to produce a clearer print.
4. Choose an area on the glass object and touch the glass with your thumb. Use a paper towel or other type of cloth in your other hand to prevent leaving other fingerprints. Avoid placing any other fingerprints in this area.
5. Dip the dusting brush lightly into the fingerprint powder. Place the brush between your hands and gently twist the brush back and forth, so that the bristles spin off excess powder near the surface of the object you are dusting. A latent (hidden) fingerprint should begin to appear. Continue to dust lightly, touching the surface until you have exposed as much of the latent print as possible. Gently blow off the excess powder. (Be prepared for dust to settle on everything in the area.)
6. Tear off a 3-inch piece of adhesive tape and place it over the fingerprint and press down.
7. Peel off the tape and place it on a 3 × 5-inch card. This process is called lifting the print.
8. On the 3 × 5-inch card or on the ACT 6-3 WKST *Latent Print*, identify and record the ridge pattern.

Loop Arch Whorl

PART B: PLASTIC FINGERPRINTS

1. Design an experiment to demonstrate how plastic fingerprint impressions are formed. Include the following in your design:
   a. Materials list
   b. Procedure
2. Have another student create a plastic fingerprint impression using your procedure.

3. Take a digital image of the plastic fingerprint and attach to or digitally embed the photo within your Act 6-3 WKST *Plastic Prints*.
4. Discuss with your partner ways to improve your procedure and record your suggestions on Act 6-3 WKST *Plastic Prints*.
5. (*Optional*) Create a PowerPoint presentation of the digital images of the class's plastic fingerprint impressions. Ask students in the class to identify the ridge patterns seen in the presentations.

Going Further:

1. If time permits, clean the glass and place additional fingerprints on the surface and repeat the technique; then exchange your glass for a classmate's. Dust, lift, and identify their fingerprint pattern.
2. Fingerprints are not the only latent prints left at a crime scene. Sometimes, if someone is trying to look into a window from the outside, they will cup their hands around their eyes to shield the light and lean against a window this way. Try creating and lifting a latent print from side of your hand (nearest the little finger). Can you identify ridge patterns in the latent print?
3. Research the National Palm Print System (NPPS). When was it formed? How many law-enforcement agencies use NPPS?

Teach

Ask students to watch episodes of *CSI* or movies that show a variety of surfaces from which fingerprint evidence was collected and then compare the differences in the techniques and materials used to collect them.

Engage

Challenge your students to lift a latent fingerprint from an uneven surface such as a door knob, tool handle, or ball. Perhaps make this a contest between different groups of students to see who develops the best method.

Section III
Student Worksheets and Teacher Notes – Excerpts from Chapter 6

The following files are available to download from the Instructor Companion Site. These include the student worksheets and Teacher Notes to support the chapter Activities (including this example for teachers to create inexpensive magnetic powder wands).

Name _____

ACTIVITY 6-1: STUDY YOUR FINGERPRINTS

Act 6-1 WKST: DATA TABLE

Identify your fingerprint pattern type: _____

Which hand? _____

Which finger? _____

Ridge pattern type? _____

DATA TABLE

Data Collection From the Class	Loop	Whorl	Arch
Number of students showing trait			
Total number of students in the class **(*This will be the same total for each column.*)**			
Percentage of class showing the trait **(*Divide the number of students with the trait by the total number in the class, and then multiply by 100.*)**			
National averages	**65%**	**30%**	**5%**

QUESTIONS

1. Did the class percentage agree with the national averages? Explain your answer using data from your data table.

2. Describe how to improve this data-collecting activity so that your results are more reliable.

Name _____

ACTIVITY 6-2: GIANT BALLOON FINGERPRINT

Act 6-2 WKST: DATA TABLE

DATA TABLE

Student Name for Fingerprint	Loop	Whorl	Arch
Your name			
Name			
Name			
Name			
Name			

Name _____

ACTIVITY 6-3: STUDYING LATENT AND PLASTIC FINGERPRINTS

Act 6-3 WKST: LATENT PRINT

	Thumbprint
Tape your latent print in the box to the right.	
Identify your print pattern as a loop, arch, or whorl.	

Name _____

ACTIVITY 6-3: STUDYING LATENT AND PLASTIC FINGERPRINTS

Act 6-3 WKST: PLASTIC PRINTS

Design an experiment to demonstrate how plastic fingerprint impressions are formed.

a. Materials list

b. Procedure

After your partner has produced a plastic print using your procedure, take a digital image of the print. Then discuss and record ways to improve upon the procedure to produce better and more reliable results.

Name _____

ACTIVITY 6-3: STUDYING LATENT AND PATENT FINGERPRINTS

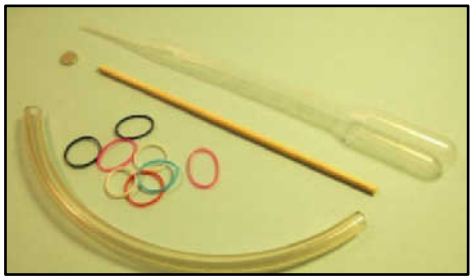
Act 6-3 TN: MAKING MAGNETIC WANDS

Round Disk magnet and pencil

COST ~15 cents per wand.

MATERIALS

- 5” lengths of plastic tubing (aquarium tubing or tubing for oxygen use)
- Wooden skewers from the dollar store that fit snugly in tubing.
- Transfer pipettes (droppers), 3 ml, graduated, large bulb, 155mm Karter Scientific 206H3 (Amazon) or small test tubes
- Disc magnets 100 Grade N42 Super ¼” x 1/16”
- Small rubber bands (used to make bracelets-Dollar Store)

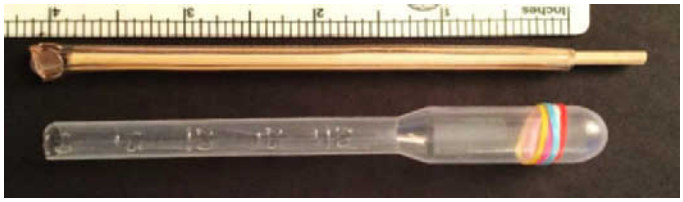


Materials for making wand

Tubing with small, round magnet and wooden skewer inserted in the tube.

Name _____

PROCEDURE



1. Cut tubing to 5” length.
2. Insert magnet into one end of the tubing.
3. Insert skewer into tubing to straighten and stabilize it.
4. Cut skewer to length of tubing.
5. Prepare the droppers by cutting 1½ inches from the tip end.
6. Insert the tubing, magnet side down, into the stem and finally into the bulb of the pipette.
7. Add 3-5 rubber bands as shown in the diagram. This will help ‘slough off’ excess magnetic powder.
8. Push skewer so magnet can attract powder for transfer.
9. Pull up on skewer to release magnetic powder

Note magnet end is inside the bulb end of the tube (left photo). When magnet is below the rubber bands, the magnetic powder sticks. (Right photo)

Rubber bands

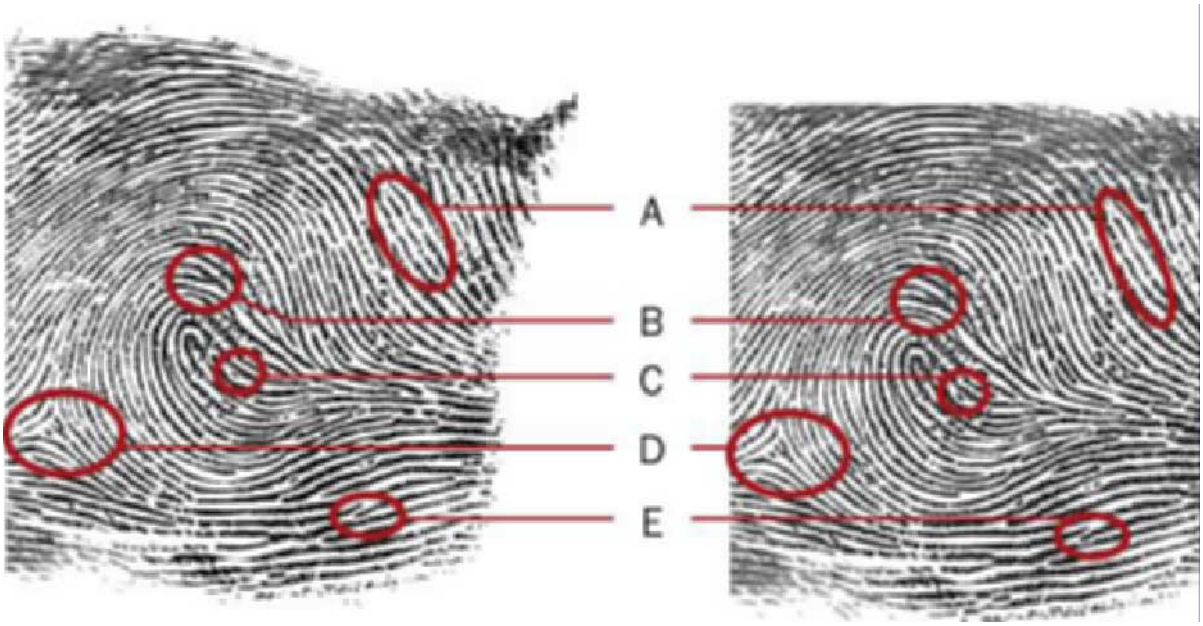
When skewer is pulled above the rubber band, powder drops from wand. (Right photo)

Name _____

ACTIVITY 6-5: MINUTIAE PATTERNS

Act 6-5 WKST: MINUTIAE PATTERNS

1. Study the following picture and use the table of minutiae patterns (**Figure 6-10**) to identify the specific types of minutiae. Record your answers for A–E below the diagram.



A. _____

B. _____

C. _____

D. _____

E. _____

Name _____

2. Examine each of the following fingerprints. Refer to textbook **Figure 6-10**, minutiae patterns. For each fingerprint, circle any of the minutiae patterns found in the fingerprint.

Arthur

1. **Bifurcation**
2. **Island ridge**
3. **Ridge ending**

Doris

4. **Eye**
5. **Spur or hook**
6. **Ridge ending**

Alice

7. **Double bifurcation**
8. **Island ridge**

Joe

9. **Bridge**
10. **Delta**
11. **Bifurcation**
12. **Dot**

Name _____

ACTIVITY 6-6: FINGERPRINT ANALYSIS

Act 6-6 WKST: INCLUDE OR EXCLUDE?

Refer to the two sets of fingerprint examples below. The print on the left is from a suspect. The fingerprint on the right is latent print recovered from the crime scene. Use colored pencils to circle consistent minutiae. Determine if they are consistent or not. Justify your claim by citing evidence from your analysis.

Example 1 Suspect Print Crime-Scene Print

Example 2 Suspect Print Crime-Scene Print

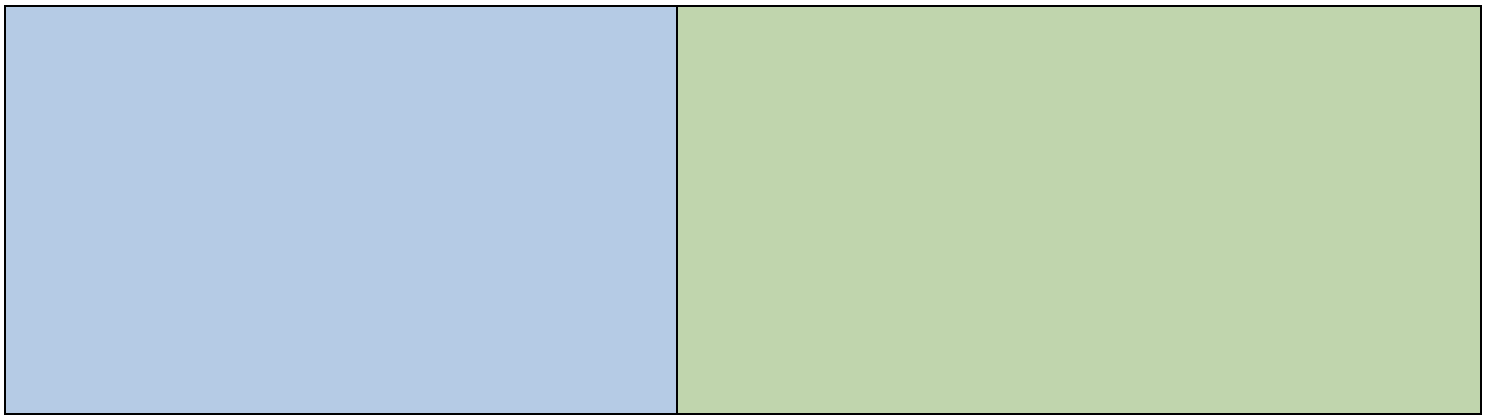
Section IV
Correlation to the Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS) – Chapter 6

The following files are available to download from the Instructor Companion Site. The NGSS correlation shows the specific Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts that the Chapter 6 content meets. The CCSS correlation shows the specific standards for literacy and math met in Chapter 6.

The NGSS standards listed in this document have been selected as those most closely aligned with the content in this specific chapter of the third edition of Forensic Science: Fundamentals and Investigations. There may be cases in which portions of a standard are outside the scope of knowledge required for a forensic science course as it is dictated in the standard. Or there may cases in which a concept in the standard is built by scaffolding across chapters. In these cases, the specific portion of the standard is italicized.

Chapter 6 Fingerprints	
Introduction The History of Fingerprinting The Science of Fingerprints Formation of Fingerprints Characteristics of Fingerprints Types of Fingerprints Basic Ridge Patterns Subdivisions of Ridge Patterns Minutiae and Fingerprint Identification Collection and Documentation of Fingerprints Photographing Fingerprints Methods of Collection Collecting Latent Fingerprints Collecting Patent Prints Collecting Plastic Prints Collecting Suspect Prints Forensic Analysis of Fingerprinting How Are Fingerprints Analyzed? Fingerprint Reliability and Validity Can Fingerprints Be Altered or Disguised? Advances in Fingerprinting Chapter Overview Case Studies Careers in Forensics *Peter Paul Biro* Chapter 6 Review Activity 6-1 Study Your Fingerprints Activity 6-2 Giant Balloon Fingerprint Activity 6-3 Studying Latent and Plastic Fingerprints Activity 6-4 How to Print a Ten Card Activity 6-5 Minutiae Patterns Activity 6-6 Fingerprint Analysis Activity 6-7 Using Cyanoacrylate to Recover Latent Fingerprints Activity 6-8 ACT Print Variations	**Disciplinary Core Ideas** **PS1.A: Structure and Properties of Matter** • *The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1), (HS-PS1-2)* **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS4.C: Information Technologies and Instrumentation** • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5) **LS1.A: Structure and Function** • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and

	decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)
Science and Engineering Practices	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) **Obtaining, Evaluating, and Communicating Information** • Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **Developing and Using Models** • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1), (HS-PS1-2), (HS-PS1-3), (HS-PS1-5) **Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2), (HS-LS1-4) ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)



The Chapter Activities build toward competence in the following Performance Objectives:

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties**.**

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Forensic Science: Fundamentals and Investigations, 3e
Common Core Language and Common Core Math Correlation

Chapter 6 Fingerprints	
Introduction The History of Fingerprinting The Science of Fingerprints Formation of Fingerprints Characteristics of Fingerprints Types of Fingerprints Basic Ridge Patterns Subdivisions of Ridge Patterns Minutiae and Fingerprint Identification Collection and Documentation of Fingerprints Photographing Fingerprints Methods of Collection Collecting Latent Fingerprints Collecting Patent Prints Collecting Plastic Prints Collecting Suspect Prints Forensic Analysis of Fingerprinting How Are Fingerprints Analyzed? Fingerprint Reliability and Validity Can Fingerprints Be Altered or Disguised? Advances in Fingerprinting Chapter Overview Case Studies Careers in Forensics *Peter Paul Biro* Chapter 6 Review Activity 6-1 Study Your Fingerprints Activity 6-2 Giant Balloon Fingerprint Activity 6-3 Studying Latent and Plastic Fingerprints Activity 6-4 How to Print a Ten Card Activity 6-5 Minutiae Patterns Activity 6-6 Fingerprint Analysis Activity 6-7 Using Cyanoacrylate to Recover Latent Fingerprints Activity 6-8 ACT Print Variations	**Common Core (CCSS Science Literacy, Language Arts)** CCSS.ELA-LITERACY.RST.9-10.1 RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. CCSS.ELA-LITERACY.RST.9-10.2 RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. CCSS.ELA-LITERACY.RST.9-10.3 RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. Craft and Structure: CCSS.ELA-LITERACY.RST.9-10.4 RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*. CCSS.ELA-LITERACY.RST.9-10.5 RST.9-10.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*). CCSS.ELA-LITERACY.RST.9-10.6 RST.9-10.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. Integration of Knowledge and Ideas: CCSS.ELA-LITERACY.RST.9-10.7 RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. CCSS.ELA-LITERACY.RST.9-10.8 RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. CCSS.ELA-LITERACY.RST.9-10.9 RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own

	experiments), noting when the findings support or contradict previous explanations or accounts. Range of Reading and Level of Text Complexity: CCSS.ELA-LITERACY.RST.9-10.10 RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. CCSS.ELA-LITERACY.WHST.9-10.2 WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. CCSS.ELA-LITERACY.WHST.9-10.2.A WHST.9-10.2.A Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CCSS.ELA-LITERACY.WHST.9-10.2.B WHST.9-10.2.B Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. CCSS.ELA-LITERACY.WHST.9-10.2.C WHST.9-10.2.C Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. CCSS.ELA-LITERACY.WHST.9-10.2.D WHST.9-10.2.D Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. CCSS.ELA-LITERACY.WHST.9-10.2.E WHST.9-10.2.E Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CCSS.ELA-LITERACY.WHST.9-10.2.F WHST.9-10.2.F Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic). CCSS.ELA-LITERACY.WHST.9-10.4 WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

	CCSS.ELA-LITERACY.WHST.9-10.7 WHST.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. CCSS.ELA-LITERACY.WHST.9-10.8 WHST.9-10.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. CCSS.ELA-LITERACY.WHST.9-10.9 WHST.9-10.9 Draw evidence from informational texts to support analysis, reflection, and research. CCSS.ELA-LITERACY.WHST.9-10.4 WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. CCSS.ELA-LITERACY.WHST.9-10.10 WHST.9-10.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. CCSS.ELA-LITERACY.RST.11-12.1 RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. CCSS.ELA-LITERACY.RST.11-12.2 RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. CCSS.ELA-LITERACY.RST.11-12.3 RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Craft and Structure: CCSS.ELA-LITERACY.RST.11-12.4 RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are

	used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*. CCSS.ELA-LITERACY.RST.11-12.5 RST.11-12.5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. CCSS.ELA-LITERACY.RST.11-12.6 RST.11-12.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. Integration of Knowledge and Ideas: CCSS.ELA-LITERACY.RST.11-12.7 RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CCSS.ELA-LITERACY.RST.11-12.8 RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. CCSS.ELA-LITERACY.RST.11-12.9 RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. Range of Reading and Level of Text Complexity: CCSS.ELA-LITERACY.RST.11-12.10 RST.11-12.10 By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently. CCSS.ELA-LITERACY.WHST.11-12.2 WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. CCSS.ELA-LITERACY.WHST.11-12.2.A WHST.11-12.2.A Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CCSS.ELA-LITERACY.WHST.11-12.2.B WHST.11-12.2.B Develop the topic thoroughly by selecting

	the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. CCSS.ELA-LITERACY.WHST.11-12.2.C WHST.11-12.2.C Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. CCSS.ELA-LITERACY.WHST.11-12.2.D WHST.11-12.2.D Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. CCSS.ELA-LITERACY.WHST.11-12.2.E WHST.11-12.2.E Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). CCSS.ELA-LITERACY.WHST.11-12.4 WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. CCSS.ELA-LITERACY.WHST.11-12.7 WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. CCSS.ELA-LITERACY.WHST.11-12.8 WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. CCSS.ELA-LITERACY.WHST.11-12.9 WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Forensic Science: Fundamentals and Investigations, 3e
Common Core Language and Common Core Math Correlation

	Common Core (CCSS Mathematics)
	CCSS.Math.Practice.MP2 - Reason abstractly and quantitatively. CCSS.Math.Practice.MP3 - Construct viable arguments and critique the reasoning of others. CCSS.Math.Practice.MP4 - Model with mathematics. CCSS.Math.Practice.MP5 - Use appropriate tools strategically. CCSS.Math.Practice.MP8 - Look for and express regularity in repeated reasoning. CCSS.Math.Content.HSS-IC.B.6 - Evaluate reports based on data.

Section V
Student Learning Objectives – Chapter 6

The following files are available to download from the Instructor Companion Site. This is an introduction to the Student Learning Objectives, their benefits, and recommendations for how and when to use them during instruction, followed by the actual objectives for Chapter 6.

Student Learning Objectives (SLOs) Introduction

Forensic Science: Fundamentals and Investigations, 3rd edition

STUDENT LEARNING OBJECTIVES: ADDITIONAL SUPPORT FOR STUDENTS

Student Learning Objectives (SLOs) are single concept, testable skills that are expected outcomes of each topic of study. Teachers and students should use SLOs throughout the course. We recommend that teachers ask students to review the objectives related to information already discussed in class for 10 minutes every few days. This allows the teacher to do frequent, brief, on-going assessments and identify misconceptions, allowing the teacher to modify instruction. It also ensures that students understand the basics before advancing to the more complex topics.

Teachers are encouraged to have students work in small collaborative learning groups to review the objectives. The small-group collaboration encourages the more reserved students to comfortably ask questions and orally express their comprehension of the concepts. Additionally, it allows students who are more confident in their comprehension of the topics to assist other students.

REMOTE LEARNING AND STUDENT LEARNING OBJECTIVES

The SLOs follow the sequence of topics found in the text and the accompanying lesson plans. This can be especially useful for teachers who have students working remotely from home. Teachers can assign specific sections of the chapter and the objectives that correspond them. The objectives help students to focus on the main ideas of the text to improve and enhance their comprehension.

HETEROGENEOUSLY GROUPED FORENSIC SCIENCE CLASSES

Most high school forensic science classes are composed of heterogeneously grouped students with different ranges of ability. Teachers can easily tailor the extensive list of SLOs to best suit the needs of students. The Word document enables teachers to easily delete objectives or include additional objectives. By changing the verb, teachers can modify the level of the SLO to a higher-level objective.

STUDENT LEARNING OBJECTIVES: ADDITIONAL SUPPORT FOR TEACHERS

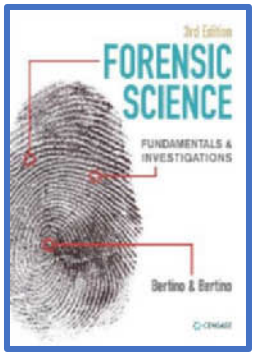
The SLOs, along with the Lesson Plans, provide guidance for teachers by outlining each chapter in a logical sequence and identifying learning outcomes for students. We understand that many first-time forensic teachers do not have formal forensic science training. By reviewing the SLOs and the Lesson Plans, first-time forensic teachers can map out their own forensic science syllabus and lesson plans.

STUDENT LEARNING OBJECTIVES: AN ASSESSMENT TOOL

Use the SLOs as a source for developing higher order thinking questions for testing. Inform students that some of the longer response test questions will be selected from the SLOs. Students are more interested in reviewing the objectives knowing that the review helps them to not only understand the content, but the review will also improve their test grades. Student success in your forensic science class builds their confidence in their abilities to do math and science!

Chapter 6 Fingerprinting

Forensic Science*: Fundamentals and Investigations, 3rd ed.,* Bertino & Bertino, 2021



Student Learning Objectives

At the conclusion of this chapter, the student should be able to:

INTRODUCTION

_____1. Describe has technology impacted on fingerprinting analysis.

HISTORY

_____2. Briefly discuss the history of fingerprinting as a means of individual identification. Include in your answer:
a. early evidence of fingerprinting.
b. recognition of distinct fingerprint ridges as a means of identification.
c. Bertillion method of personal identification.
d. ten card.
e. increasing use of technology.

_____ 3. Explain and provide examples of new biometric means of identification.

_____ 4. Describe the advances in fingerprint identification using each of the following:
a. IAFIS (Integrated Automated Fingerprint Identification System)
b. NGI (Next Generation Identification)

SCIENCE OF FINGERPRINTING

_____ 5. Describe what are dermal or friction ridges found on fingers, palms, toes, feet and state their function.

_____ 6. List the materials secreted by the sweat glands in your fingerprint ridges that result in leaving a fingerprint on a surface.

_____ 7. Label a diagram of human skin. Include in your diagram:
a. Epidermis
b. Dermis
c. Sweat gland
d. Oil gland
e. Hair follicle
f. Pores

_____ 8. Discuss fingerprint ridge development. Include in your answer:
a. when do fingerprints form?
b. what layer of the skin contains forms fingerprint ridges?
c. what influences the development of fingerprint ridges?

_____ 9. Elaborate on why identical twins may have identical DNA but do not have identical fingerprints.

_____ 10. Describe any changes that may occur to fingerprints over time and their significance to forensic fingerprint identification.

CHARACTERISTICS OF FINGERPRINTING

TYPES OF RIDGE PATTERNS

_____ 11. Define with an example each of the three types of fingerprints that could be found at a crime scene. Include in your answer how each fingerprint type is formed.
a. Latent
b. Patent
c. Plastic

_____ 12. Distinguish among latent, plastic, and patent fingerprints in terms of:
a. which forms of fingerprints are visible to the naked eye?
b. which can be seen if the hands come in contact with blook, paint, grease and the hand transfers the fingerprint to another surface?
c. which on has to be made visible using powders or other enhancers?
d. which can be seen as in an impression in soft materials such as clay, soap or putty?

_____ 13. Distinguish among the three basic types of fingerprints ridge patterns *loops, whorls* and *arches*. Include in your answer:
a. direction of the ridge patterns.
b. general shape of the ridge patterns.

_____ 14. Describe a *delta* ridge pattern within a fingerprint. Include in your answer description of the ridge pattern around the delta.

_____ 15. Compare the number of deltas found in each of the following ridge patterns and describe how this is used to identify fingerprints:
a. arch
b. loop
c. whorl loop

_____ 16. Describe the *core* of a loop or whorl pattern ridge pattern.

_____ 17. Demonstrate how a *ridge count* in a fingerprint is obtained using the core and a delta. Explain the significance of a ridge count in forensic analysis of fingerprints.

SUBDIVISIONS OF RIDGE PATTERNS

_____ 18. Identify the following print variations:
- a. Plain arch
- b. Tented arch
- c. Plain whorl
- d. Central pocket loop whorl
- e. Radial loop
- f. Ulnar loop
- g. Double loop

_____ 19. Explain how to distinguish between each of the following fingerprint ridge patterns:
- a. plain whorl pattern and a central pocket loop whorl fingerprint pattern.
- b. double loop whorl and an accidental whorl.
- c. plain arch and a tented arch.

_____ 20. Describe the difference between an ulnar loop and a radial loop.

MINUTIAE AND FINGERPRINT IDENTIFICATION

_____ 21. Discuss the significance of minutiae patterns in fingerprint analysis.

_____ 22. Given a reference sheet and several fingerprints, be able to identify the following fingerprint minutiae patterns in fingerprints:
- a. Island
- b. Hook or spur
- c. Bifurcation
- d. Double bifurcation
- e. Ridge ending
- f. Bridge
- g. Delta
- h. Dot

COLLECTION AND DOCUMENTATION OF FINGERPRINTS

_____23. Describe the type of training required to become a fingerprint CSI.

_____ 24. Describe the proper procedures involved in documenting and photographing fingerprint evidence. Include in your answer:
- a. What is the role of lasers or LED devices in locating fingerprints?
- b. Are photos taken with and without powders or enhancers or just with the enhancers or powders?
- c. Why are photos taken both in close up and from a distance?
- d. Besides the actual photo, describe how and when each photo is documented.

_____ 25. Describe the technique used to make latent fingerprints visible using powders or stains and a fingerprint brush or magnetic wand.

_____ 26. State what each of the following chemicals react to in a latent fingerprint that enhances the print:
a. cyanoacrylate vaper (super glue)
b. iodine fuming
c. Silver nitrate
d. ninhydrin

_____ 27. Explain how to use tape to lift a fingerprint to preserve the print.

_____ 28. Describe 2 things that must occur prior to collecting a patent fingerprint.

_____ 29. Explain why it's important to dry any plastic prints before collecting the print.

_____ 30. Describe an alternative procedure for collecting a plastic print that does not involve bringing in the entire plastic print.

_____ 31. Analyze an inked fingerprint or ten card using fingerprint characteristics.

_____ 32. Describe a ten card of fingerprints and describe how it is produced.

_____ 33. Distinguish among the various powders used to lift a fingerprint:
a. When one should use a dark powder vs. a light-colored powder
b. Compare and contrast the use of magnetic powders over non-magnetic powders

ANALYZING THE EVIDENCE

_____ 34. Analyze fingerprints and ten cards using the characteristics described in this chapter including:
a. type of ridge pattern.
b. identification of minutiae patterns.
c. presence or absence of deltas or core patterns.
d. unique scar tissues

_____ 35. Discuss why a fingerprint expert analyst is needed both at the beginning of the analysis and at the end of the analysis.

_____ 36. Discuss the changes made to fingerprint identification and storage in 1999 when *IAFIS* (Integrated Automatic Fingerprint Identification Systems) was introduced. Include in your answer:
a. how computerized analysis is more objective, reliable and valid.
b. digital fingerprint searches.
c. electronic storage of fingerprint files containing large databases.

_____ 37. Summarize the fingerprint analysis improvements of the 2011 *NGI* (Next Generation Identification). Include in your answer:
a. latent searches.
b. mobile fingerprint identification.
c. biometric identification.
d. ability to easily and quickly share information locally, nationally and internationally.

_____38. Discuss how computers use algorithms to compare fingerprints rather than to find individual minutiae patterns. Include in your answer:
a. What is an algorithm as used for fingerprint analysis?
b. What type of mathematical calculations are made within the algorithm?
c. How has the use of algorithms improved the speed and reliability of fingerprint identification?
d. Has computerized algorithms replaced fingerprint experts?

_____ 39. Describe the role of population databases and statistical analysis of fingerprints for improved evidence reliability.

_____ 40. Discuss the role of technology in analyzing fingerprints. Include in your answer:
a. image enhancers of fingerprints.
b. scanners to identify and mark minutiae.
c. software used for measurements within a fingerprint.

_____ 41. List suggestion made by the SWG and OSAC organization to improve fingerprint analysis and expert witness testimony.

_____ 42. Compare and contrast the reliability and validity of fingerprint evidence analysis as performed by fingerprint experts with fingerprint analysis today performed using mostly technology.

_____ 43. Describe the effect of someone trying to permanently alter their fingerprints.

ADVANCES IN TECHNOLOGY

_____ 44. Explain how technology has improved fingerprint sweat pore analysis.

_____ 45. Discuss how fingerprint analysis is being used to obtain:
a. trace amounts of DNA
b. trace amounts of explosives technology required to use fingerprints to:

ACTIVITIES

_____ 46. Analyze fingerprints to:
a. determine if the fingerprints are loops, whorls or arches.
b. determine if the fingerprint represents a specific subdivision of loops, whorls, or arches.
c. identify minutiae patterns found in the fingerprint.
d. claim whether or not the suspect can be excluded or included based on your fingerprint analysis and support your answer with evidence from your analysis.

_____ 47. Dust latent fingerprints using magnetic or ink powders or enhancers.

_____ 48. Lift an enhanced latent fingerprint using tape and:
a. graphite
b. fingerprint ink
c. different fingerprint powders.

_____ 49. Design an experiment to collect plastic fingerprints from a surface and analyze the fingerprint.

_____ 50. Photograph, document and collect latent, patent and plastic fingerprints.

_____ 51. Prepare and analyze the fingerprints on a Ten Card.

_____ 52. Given a partial crime-scene fingerprint and fingerprints of suspects, be able to determine if any of the suspects fingerprints are consistent with the crime scene fingerprint. Support your claim using evidence found in the fingerprints.

_____ 53. Use cyanoacrylate to recover latent fingerprints.

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Section VI
Lesson Plans – Chapter 6

The following files are available to download from the Instructor Companion Site. This is an introduction to the Lesson Plans available for each chapter, their benefits, and recommendations for how and when to use them during instruction, followed by the actual Lesson Plans for Chapter 6.

A Note About the Lesson Plans

Forensic Science: Fundamentals and Investigations 3rd ed.

Anthony (Bud) Bertino and Patricia Nolan Bertino

Due to the variability in which a forensic science course may be taught, time allotments – allocations for the amount of time required for a particular topic or chapter– were not included in the Lesson Plans.

Time dedicated to topics and chapters will vary based on student background, grade level and abilities, as well as length of course and depth of coverage. Forensic science is a course that can be modified to accommodate middle school students to high school AP students. Therefore, it is important to consider the heterogenous nature and the unique needs of your forensic science class when planning out your lessons.

Along with the Lesson Plans, there are many other tools on the Companion Site to assist you with your lesson planning, including:

- PowerPoint® presentations
- Student Learning Objectives
- leveled assessments
- activity worksheets and teacher notes
- additional activities
- standard correlations
- additional resources

Be sure to refer to the Wrap Around Teacher's Edition, which is full of teaching tips located in the side margins. Look for headings such as Engage, Enrich, Explore, Teach, Assess, Activity and Capstone Project. These tips are provided to help you:

- introduce topics
- motivate and capture the interest of your students
- provide you with guidance on how to teach a difficult concept
- locate additional enrichment or online activities to enhance student learning
- identify where in the lesson to introduce the various activities

Additionally, Differentiated Learning tips address the needs of a heterogeneously grouped forensic class consisting of accelerated students, students in need of additional support, and English-language learners.

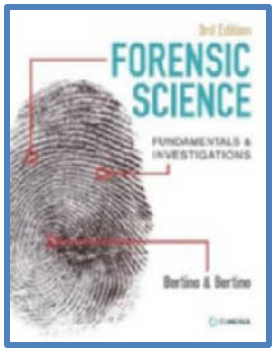
We encourage you to review these materials and any accompanying instructions prior to implementing them in your course.

Chapter 6: Fingerprints Lesson Plans

Preparation:

These lesson plans are designed to help guide you in preparing your lessons for your forensic science course, including classroom and lab time. Each topic and corresponding learning objective are broken down for you with specific time estimates. A correlating PowerPoint presentation is also available to help engage students in the classroom. In addition to these Lesson Plans, we encourage you to refer to the Wraparound Teacher's Edition which contains additional information intended to assist you in teaching the topics introduced in this chapter. It includes background information, ways to engage students and enrich the learning experience, and explains how to differentiate learning for a heterogenous class. Review this additional information, found in the margins of the Wraparound Teacher Edition, when preparing to present your lesson.

Time Allocation:



Class/Lecture: Approximately 60 minutes
Activity 6-1: Approximately 40 minutes
Activity 6-2: Approximately 20 minutes
Activity 6-3: 40 minutes for Part A and 40 minutes for Part B
Activity 6-4: Approximately 45 minutes
Activity 6-5: Approximately 15 minutes
Activity 6-6: Approximately 45 minutes
Activity 6-7: 45 minutes for Part A and 60 minutes for Part B

Learning Objectives:

Covered in Lesson Plan

1. Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.
2. Describe fingerprints and how they are formed.
3. Describe different characteristics and types of fingerprint patterns.
4. Describe the proper procedures involved in collecting and documenting fingerprint evidence.
5. Explain how fingerprints are analyzed and the reliability of fingerprint identification.
6. Discuss advances in fingerprinting that have enhanced the analysis and reliability of fingerprints in identifications.

Covered in Activities

7. Lift a latent print using different methods to analyze the print's ridge and minutiae patterns. (Activities 6-1, 6-2, and 6-7)
8. Distinguish among latent, plastic, and patent fingerprints. (Activity 6-3)
9. Prepare a ten card and analyze the ridge patterns of the prints. (Activity 6-4)
10. Analyze a fingerprint to determine if it is consistent with a fingerprint on record. (Activities 6-5 and 6-6)

Key Terms Introduced:

- **arch** a fingerprint pattern in which the ridge pattern originates from one side of the print and continues to the other side
- **biometrics** uses measurements and statistical analyses of someone's physical characteristics to aid in their identification
- **core** a center of a loop
- **delta** a triangular ridge pattern created when ridge patterns diverge
- **fingerprint** an impression left on any surface that consists of patterns made by the ridges on a finger
- **Integrated Automated Fingerprint Identification System (IAFIS)** FBI-developed national database of more than 76 million criminal fingerprints and criminal histories
- **latent fingerprint** a concealed fingerprint that is made visible through the use of powders or forensic techniques
- **loop** a fingerprint pattern in which the ridge pattern flows inward and returns in the direction of the origin
- **minutiae** the combination of details in the shapes and positions of ridges in fingerprints that makes each unique; also called ridge characteristics
- **patent fingerprint** a visible fingerprint produced when fingers coated with blood, ink, or some other substance touch a surface and transfer their print to that surface
- **plastic fingerprint** a three-dimensional fingerprint made in soft material such as clay, soap, or putty
- **ridge count** the number of ridges between the center of a delta and the core of a loop
- **ridge pattern** the recognizable pattern of the ridges found in the end pads of fingers that form lines on the surfaces of objects in a fingerprint. They fall into three categories: arches, loops, and whorls. They are also visible on the soles of feet and bottoms of toes
- **ten print card** a form used to record and preserve a person's fingerprints
- **whorl** (plain whorl) a fingerprint pattern that resembles a bull's-eye

References:

Forensic Science, 3e

Search the Internet for "FBI-Latent Print of the Year 2012" and read how a cold case was solved using IAFIS.

I. Introduction

[Time Allocation: 5 min.]

A. Analyzing fingerprint evidence today involves far more than looking at the fingerprints left at a crime scene.
B. As technology has advanced, so has the world of fingerprint analysis.
C. Today, law-enforcement officers can quickly and easily submit fingerprints to a national database and obtain the identity of a suspect if their prints were entered into the database.
D. Although fingerprints are mostly considered individual evidence, biometrics have improved the ability to establish one's identity.

Reference: *Forensic Science*, p. 192
Slide: 6-2 and 6-3

II. The History of Fingerprinting

Learning Objective 6-1: Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.

[Time Allocation: 5 min.]

A. Ancient interest in fingerprints
   1. Chinese use fingerprints and palm prints pressed into clay for official seals and legal documents in the third century BC
   2. Fingerprints pressed into clay tablet contracts date to Babylon 1792–1750 BC
   3. In ancient China, inked fingerprints on all official documents were common practice
B. Western Culture
   1. 1684
      a. Earliest record of the study of the patterns on human hands
   2. 1788
      a. Johann Christoph Andreas Mayer described "the arrangement of skin ridges is never duplicated in two persons"
   3. 1800s
      a. 1823: Jan Evangelist Purkinje described nine distinct fingerprint patterns
      b. 1856: Sir William Herschel noted that fingerprint patterns were unique to each person and not altered by age
      c. 1896: New system created with all 10 fingerprints of a person on a card; now called ten print card
   4. 20th century

   a. 1902: Fingerprints replaced the Bertillon measurements for identification
   b. 1980: AFIS used by individual states
   c. 1999: IAFS replaced manual fingerprint searching
5. 21st century
   a. 2011: NGI launched matching algorithmic patterns in its AFIT; launch of RISC
   b. 2013: NGI implemented palm and hand edge prints
   c. 2014: NGI added facial recognition and added Rap Back
   d. 2015: NGI included iris and identification examination in addition to scars, marks, and tattoos
   e. 2018: EBTS implementation; will ultimately contain complete biometric and biographical profiles

Reference: *Forensic Science*, pp. 192-194
Slides: 6-4 and 6-5

III. The Science of Fingerprints

Learning Objective 6-2: Describe fingerprints and how they are formed.

[Time Allocation: 5 min.]

A. Ridges on fingers
   1. Raised portions of skin
   2. Arranged in connected units
      a. Dermal, or friction, ridges
   3. Leave marks when pressed against things
      a. Impression is called a fingerprint
      b. Consist of secretions from skin and dirt
      c. Considered individual evidence
B. Formation of fingerprints
   1. Patterns are formed during the 10th week of gestation
      a. Similar ridges form on palms and sides of hands, soles of feet and toes
   2. Ridge patterns
      a. Found on end pads of fingers
      b. Form lines on the surfaces of objects
      c. Grow in the basal layer
      d. May be altered by scars with damage to the dermal layer

Reference: *Forensic Science*, p. 195
Slides: 6-6 and 6-7

IV. Characteristics of Fingerprints

Learning Objective 6-3: Describe different characteristics and types of fingerprint patterns.

[Time Allocation: 10 min.]

A. Types of fingerprints
   1. Patent fingerprints
      a. Visible prints
   2. Plastic fingerprints
      a. Actual indentations left in a soft material
   3. Latent fingerprints
      a. Not visible to the unaided eye
      b. Can be made visible (developed)
         i. Dusting with powders
         ii. Lifting by using tape or adhesive lifter

B. Basic ridge patterns
   1. Named for their general visual appearance
      a. Loops (about 65 percent of population)
      b. Whorls (about 30 percent of the population)
         i. Plain whorl (24 percent)
         ii. Central pocket loop whorl (2 percent)
         iii. Double loop whorl (4 percent)
         iv. Accidental whorl (0.01 percent)
      c. Arches (about 5 percent of the population)
         i. Plain arch (4 percent)
         ii. Tented arch (1 percent)
   2. Ridge count is the number of ridges between the core and center of the delta
      a. The core is the center of a loop or whorl
      b. A delta is a triangular ridge pattern

C. Minutiae and fingerprint identification
   1. Unique ridge characteristics details
      a. Number and location of minutiae create a unique signature
      b. About 150 individual characteristics are on a full print
   2. Minutiae patterns
      a. Ridge ending (including broken ridge)
      b. Fork (or bifurcation)
      c. Island ridge (or short edge)
      d. Bridge
      e. Spur (or hook)
      f. Eye (enclosure or island)
      g. Double bifurcation

h. Delta
i. Trifurcation

Reference: *Forensic Science*, pp. 195-198
Supplements: Activity 6-1, Activity 6-2, and Activity 6-5
Slides: 6-8 through 6-10

V. Collection and Documentation of Fingerprints

Learning Objective 6-4: Describe the proper procedures involved in collecting and documenting fingerprint evidence.

[Time Allocation: 10 min.]

A. Training for CSIs
   1. Where to look for fingerprint evidence
   2. Identifying different types of fingerprints
   3. Type of lighting, powders, or chemicals should be used to enhance the fingerprint
   4. How to photograph and document each fingerprint
B. Photographing fingerprints
   1. Using alternative light sources
      a. Lasers
      b. LED devices
   2. Photographing *in situ* before lifting
C. Methods of collection
   1. Collecting latent fingerprints
      a. Enhancing the print
         i. Dusting with carbon or magnetic powder
         ii. Using fluorescent dye stains or powders
      b. Lifting the print
         i. Using tape
   2. Collecting patent prints
      a. Patent or visible prints found in blood or ink
      b. Immediately photographed
      c. Source is dried and bagged
   3. Collecting plastic prints
      a. Appear as indentations on soft items
      b. First photographed
      c. Source collected and cast if necessary
   4. Collecting suspect prints
      a. Rolling each of the 10 fingers in ink
      b. Rolling them onto a ten print card

Reference: *Forensic Science*, pp. 199-200

Supplements: Activity 6-3, Activity 6-4, and Activity 6-7
Slides: 6-11 through 6-13

VI. Forensic Analysis of Fingerprinting

Learning Objective 6-5: Explain how fingerprints are analyzed and the reliability of fingerprint identification.

[Time Allocation: 10 min.]

A. Initial assessment
   1. Made by fingerprint expert
   2. Determines if fingerprint has adequate quality and quantity of features
B. Automated fingerprint searches
   1. 1999: IAFIS
      a. Digital fingerprint searches
      b. Latent print searches
      c. Electronic storage of fingerprint photo files
      d. Electronic exchange of fingerprints
      e. Operates 24 hours a day, 365 days a year
   2. 2011: FBI's NGI
      a. Enhanced and will ultimately replace IAFIS
      b. Improved automated fingerprint, latent capabilities, mobile fingerprint identification, and electronic storage
      c. Incorporated biometrics, facial recognition, iris scans, and palm and hand edge prints
   3. 2019: RISC
      a. NGI contained Repository for Individuals of Special Concern with 5 million sets of fingerprints
      b. Over 24,000 law-enforcement agencies submit fingerprints and other identify information to NGI
   4. Today
      a. Most fingerprints are compared using technology first
         i. Image enhancement algorithms
         ii. Scanners used to identify and mark minutiae points
         iii. Software to calculates distances and angles between key minutiae points
      b. Final comparisons are made by an expert
         i. Today, there has been a 90 percent reduction in the number of manual fingerprint reviews
C. Fingerprint reliability and validity
   1. Subjectivity of the examiner
      a. Problem of fingerprint evidence analysis in the past
      b. Led to creation of SWGs

i. Ensure high standards of evidence evaluation
ii. Became OSAC in 2014

2. Recommendations made by SWG and OSAC
   a. Results need to be double-checked
   b. Language for trials needs to be standardized
      ii. Conclusions can be: exclusive, inclusive, or inconclusive

D. Altering or disguising fingerprints
   1. John Dillinger
      a. Put acid on his fingertips to change their appearance
      b. Based on Cuban pineapple field workers
         i. Did not have readily visible fingerprints
         ii. Effects of working with pineapple plants was temporary
   2. Fingerprints from Dillinger's body
      a. Had grown back even after putting acid on them
      b. Allowed him to be identified

Reference: *Forensic Science*, pp. 201-203
Supplements: Activity 6-6 and Capstone Project 3
Slides: 6-14 through 6-17

VII. Advances in Fingerprinting

Learning Objective 6-6: Discuss advances in fingerprinting that have enhanced the analysis and reliability of fingerprints in identifications.

[Time Allocation: 5 min.]

A. New technology
   1. Significantly improved fingerprint analysis
      a. Speed, accuracy, and reliability
   2. Scanning technology and digital systems of identifying patterns
      a. Algorithm that automates and standardizes the key first step
      b. Assesses a fingerprint's quality and quantity for usability
   3. Analysis of trace amounts of DNA found in fingerprints
      a. Fingerprints contain sweat that can be chemically analyzed
      b. Can determine if explosive or chemicals were handled
   4. Molecular fingerprint
      a. Technology under development
      b. May be able to tell us much more about the lives of the fingerprint donor than just identity

Reference: *Forensic Science*, pp. 203-204
Slide: 6-18

VIII. Summary

[Time Allocation: 10 min.]

- Humans have noticed the patterns on their hands for thousands of years, but it was not until 1684 that these patterns were described in detail. In the mid-1800s, the idea of a fingerprint's uniqueness was studied, and the application of fingerprints to an identification system began. By the late 1800s, two effective systems were being used to identify criminals, and fingerprints were being collected as evidence in crimes. In the past 20 years, improvements in technology have improved fingerprint analysis and reliability.
- The elevated regions in the skin of the finger are called friction ridges formed early in development between two layers of skin. Unique to individuals, their shape does not change during their lifetime.
- Fingerprints left on an object are created by the naturally occurring ridges in the skin of fingertips and secretions from sweat glands that leave small amounts of oils and salts when the ridges are pressed against an object. The residues leave a reproduction of the ridges found on the finger of the donor.
- Fingerprints found at a crime scene are latent, not easily seen without the addition of powders or chemical; plastic prints are found embedded in soft materials; patent prints are formed when fingers come in contact with a material and are transferred to a surface.
- Fingerprint patterns are classified as loops, whorls, and arches. A core is the center of a loop or whorl. A delta is a triangular region where the ridges diverge. Ridge counts, measured from the center of the delta to the center of a core, provide distinguishing characteristics of fingerprints. The three basic patterns of fingerprints can be further subdivided into more specific subcategories.
- Minutiae patterns are small distinguishing features used to analyze fingerprints.
- Prior to advancements in scanners, fingerprint analysis was a very slow process undertaken by a fingerprint expert that was not always reliable.
- Criminals have sought to alter their fingerprints with chemicals, surgery, and superficial destruction. Some fingerprints can temporarily be altered by long-term contact with rough surfaces. Attempts at permanent fingerprint alteration have been painful, leaving mutilated, deformed, and even more recognizable fingerprints than the original fingerprints.
- Fingerprints must be properly collected and documented to be an acceptable evidence. Both the SWG and OSAC have developed

standards and protocols to improve fingerprint evidence reliability and validity.

- Fingerprint collection and documentation may involve dusting with specialized powders or chemicals, casting of plastic prints, and photographing the print.
- Today, much of fingerprint analysis is automated. Fingerprints of suspects can be quickly scanned and compared to a national FBI database of over 149 million fingerprints.
- Mobile handheld scanners obtain fingerprints of suspects, forward them to the national database. Within minutes, the police officer knows if the suspect has an open warrant for arrest, is on a terrorist or sex offender list, or has previously committed crimes.
- New technology continues to improve fingerprint analysis through machine learning to access usability of prints and improved scanning technologies using nanoparticles for pore analysis.
- New uses of fingerprints include DNA analysis and chemical analysis of the sweat found in prints using infrared spectromicroscopy to detect evidence of what donor touched or consumed.
- Fingerprint analysis has become less subjective, faster, and more reliable with advances in technology. AFIT's use of algorithms and NGI's inclusion of palm prints, rapid ID in the field, and biometrics have improved both reliability and validity of fingerprint analysis.

Reference: *Forensic Science*, pp. 204-205
Slides: 6-19 through 6-22

IX. Assignment – Review Chapter 7 and reference accompanying teacher notes in the Wraparound Teacher's Edition of *Forensic Science, 3e*.

Section VII
PowerPoint Lecture Slides – Chapter 6

The following is a representation of what is available to download from the Instructor Companion Site. This shows thumbnail versions of the entire PowerPoint lecture slide deck for Chapter 6 including chapter outlines and summaries with key images. Once downloaded, these files can be customized by the teacher.

1.

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Chapter 6

Fingerprints

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2.

FORENSIC SCIENCE
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3rd Edition
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Introduction

- Analyzing fingerprint evidence today involves far more than looking at the fingerprints left at a crime scene
- Technology has advanced the world of fingerprint analysis
- Law-enforcement officers can quickly submit fingerprints to a national database

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3.

FORENSIC SCIENCE
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Introduction

- Although fingerprints are mostly considered individual evidence, biometrics have improved the ability to establish one's identity

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4.

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The History of Fingerprinting

LO1: Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.
(1 of 2)

- Ancient interest in fingerprints
  - Chinese use fingerprints and palm prints pressed into clay in the third century B.C.
  - Fingerprints pressed into clay tablet contracts date to Babylon 1792–1750 B.C.
  - Ancient China, inked fingerprints on official documents were common

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5.

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The History of Fingerprinting

LO1: Summarize the history of fingerprinting including the development of new systems used in fingerprint analysis and identification.
(2 of 2)

- Western Culture
  - 1684: Earliest record of the study of the patterns on human hands
  - 1823: Jan Evangelist Purkinje described nine distinct fingerprint patterns
  - 1856: Sir William Herschel noted that fingerprint patterns not altered by age
  - 2014: NGI added facial recognition

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6.

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The Science of Fingerprints

LO2: Describe fingerprints and how they are formed.
(1 of 2)

- Ridges on fingers
  - Raised portions of skin
  - Arranged in connected units
    - Dermal, or friction, ridges
  - Leave marks when pressed against things
    - Considered individual evidence

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The Science of Fingerprints

LO2: Describe fingerprints and how they are formed.
(2 of 2)

- Formation of fingerprints
  - Patterns are formed during the 10th week of gestation
  - Ridge patterns
    - End pads of fingers
    - Form lines on the surfaces of objects
    - Grow in the basal layer
    - May be altered by scars with damage to dermal layer

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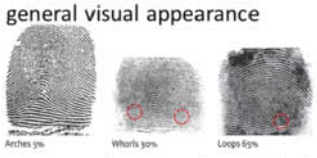
Characteristics of Fingerprints

LO3: Describe different characteristics and types of fingerprint patterns.
(2 of 3)

- Basic ridge patterns
  - Named for their general visual appearance
    - Loops
    - Whorls
    - Arches
  - Ridge count
    - Number of ridges between the core and center of the delta



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9.

Characteristics of Fingerprints

LO3: Describe different characteristics and types of fingerprint patterns. (3 of 3)

- Minutiae and fingerprint identification
  - Unique ridge characteristics details
  - Minutiae patterns
    - Ridge ending, fork, island ridge, bridge, spur, eye, double bifurcation, delta, and trifucation

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10.

Collection/Documentation of Fingerprints

LO4: Describe the proper procedures involved in collecting and documenting fingerprint evidence. (1 of 3)

- Training for CSIs
  - Where to look
  - Identifying different types
  - Enhancing the fingerprint
  - How to photograph and document

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11.

Collection/Documentation of Fingerprints

LO4: Describe the proper procedures involved in collecting and documenting fingerprint evidence. (2 of 3)

- Photographing fingerprints
  - Alternative light sources
  - Lasers
  - LED devices
  - Photographing *in situ* before lifting

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12.

Collection/Documentation of Fingerprints

LO4: Describe the proper procedures involved in collecting and documenting fingerprint evidence. (3 of 3)

- Methods of collection
  - Collecting latent fingerprints
  - Collecting patent prints
  - Collecting plastic prints
  - Collecting suspect prints

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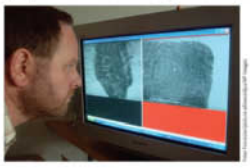
13.

Forensic Analysis of Fingerprinting

LO5: Explain how fingerprints are analyzed and the reliability of fingerprint identification. (1 of 4)

- Initial assessment
  - Made by fingerprint expert
  - Determines if fingerprint has adequate quality and quantity of features



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14.

Forensic Analysis of Fingerprinting

LO5: Explain how fingerprints are analyzed and the reliability of fingerprint identification. (2 of 4)

- Automated fingerprint searches
  - 1999: IAFIS
  - 2011: FBI's NGI
  - 2019: RISC
  - Today
    - Image enhancement algorithms
    - Scanners and software

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15.

Forensic Analysis of Fingerprinting

LO5: Explain how fingerprints are analyzed and the reliability of fingerprint identification. (3 of 4)

- Fingerprint reliability and validity
  - Subjectivity of the examiner
  - Recommendations made by SWG and OSAC
    - Results need to be double-checked
    - Language for trials needs to be standardized

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16.

Forensic Analysis of Fingerprinting

LO5: Explain how fingerprints are analyzed and the reliability of fingerprint identification. (4 of 4)

- Altering or disguising fingerprints
  - John Dillinger
    - Put acid on his fingertips
    - Fingerprints grew back allowing identification
  - Cuban pineapple field workers
    - Did not have readily visible fingerprints
    - Effect was temporary

17.

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Advances in Fingerprinting

LO6: Discuss advances in fingerprinting that have enhanced the analysis and reliability of fingerprints in identifications.

- New technology
  - Speed, accuracy, and reliability
  - Scanning technology and digital systems of identifying patterns
  - Trace amounts of DNA
  - Molecular fingerprint

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18.

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Summary

(1 of 4)

- Humans have noticed the patterns on their hands for thousands of years
- The elevated regions in the skin of the finger are called friction ridges
- Secretions from sweat glands leave small amounts of oils and salts
- Fingerprints found at a crime scene are latent

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19.

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Summary

(2 of 4)

- Fingerprint patterns are classified as loops, whorls, and arches
- Minutiae patterns are small distinguishing features
- Criminals have sought to alter their fingerprints with chemicals, surgery, and superficial destruction

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20.

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Summary

(3 of 4)

- Fingerprints must be properly collected and documented
- Fingerprint collection and documentation may involve dusting with specialized powders or chemicals
- Today, much of fingerprint analysis is automated

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21.

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Summary

(4 of 4)

- Mobile handheld scanners obtain fingerprints of suspects
- New uses of fingerprints include DNA analysis and chemical analysis
- Fingerprint analysis has become less subjective, faster, and more reliable

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Section VIII
Cognero Test Bank Question Sample – Chapter 6

Cognero is an online test bank and customized test generator available to teachers as a link from the NGLSync portal. Once in the Cognero site, teachers can customize quizzes and tests from a bank of hundreds of questions available by chapter. There are many question types for each chapter including True/False, Multiple Choice, Matching, Multiple Select, Short Answer, and many more. The following is a brief selection of available questions in multiple question types for Chapter 6.

Name:_____ Class:_____ Date:_____

Chapter 6 Sample

Indicate whether the statement is true or false.

___ 1. Electronic Biometrics Transmission Specifications matches algorithmic patterns in the FBI's AFIT.
a. True
b. False

___ 2. Fingerprints are considered individual evidence.
a. True
b. False

___ 3. Most fingerprints have a loop pattern.
a. True
b. False

___ 4. Identical twins do not have the same fingerprints.
a. True
b. False

___ 5. RISC fingerprints make up the majority of fingerprints in the NGI database.
a. True
b. False

___ 6. NGI and the use of computer algorithms has improved evidence reliability.
a. True
b. False

___ 7. Nanoparticles added to fingerprint powders makes pore patterns appear sharper.
a. True
b. False

___ 8. New scanning technology allows fingerprints to be scanned at a resolution of 10,000 dots per inch.
a. True
b. False

Indicate the answer choice that best completes the statement or answers the question.

___ 9. _____ fingerprints can be analyzed to determine if someone was exposed to or handled explosives.
a. Using infrared spectromicroscopy
b. Nanoparticle-powder infused
c. Digitally scanned
d. New molecular

Chapter 6 Sample

___ 10. When technology is used to analyze fingerprints, _____.
a. the software examines individual ridges of a print
b. identifications can be made in a matter of seconds
c. experts have 100 percent certainty in identifications
d. the final comparison is made by a human expert

___ 11. Ninhydrin, used to visualize latent fingerprints, _____.
a. reacts with fatty acids
b. should not be inhaled
c. creates a black print
d. is applied in a vapor tent

___ 12. A latent print visualized with cyanoacrylate vapor _____.
a. will be a white print
b. fades quickly
c. must be sprayed with a starch solution
d. can be viewed only under UV light

___ 13. Fingerprints on household items, such as plastic, metal, and glass can be visualized using _____.
a. super glue
b. iodine fuming
c. ninhydrin
d. silver nitrate

___ 14. The ridge count, _____, helps to distinguish one print from another.
a. the total number of ridges on the end pad of a finger
b. calculated from the center of the fingertip to the outside edge
c. is determined by counting the number of deltas in a fingerprint
d. the number of ridges between the core and the center of the delta

___ 15. Secretions of the skin _____.
a. are a mixture of water, oils, and salts
b. make our fingers smooth and shiny
c. are created in the basal layer of skin
d. are by-products of skin cell development

___ 16. Minutiae patterns _____.
a. cannot be identified unless the fingerprint expert has a full fingerprint to analyze
b. account for less than 50 individual ridge characteristics on the average full fingerprint
c. can have island ridges, spurs, dots, bridges, bifurcations, and broken ridges
d. are individualized for every person except for identical twins, triplets, or quadruplets

Name:_____ Class:_____ Date:_____

Chapter 6 Sample

Answer Key

1. False
2. True
3. True
4. True
5. False
6. True
7. True
8. False
9. a
10. d
11. b
12. a
13. a
14. d
15. a
16. c

Additional Information

Fingerprinting Webinar

Please also see the recording of a webinar featuring the authors of Forensic Science: Fundamentals and Investigations, Bud and Patti Bertino. In this webinar, the Bertino's discuss inexpensive tricks and tools to collect and analyze fingerprints, and suggestions for remote learning using the program.

Click here to access the recording or visit our blog for more webinars: https://exploreinside.ngl.cengage.com/

Author Website

The Bertino website has hundreds of additional tips, advice, and support for starting a new Forensic Science program and enhancing and improving on existing programs.

Click here to explore everything the authors have to support forensic science teachers or visit http://bertinoforensics.com/