Part II

Physical Evidence

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Chapter 8

Fingerprint Evidence

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... This autograph consists of the delicate lines or corrugations with which Nature marks the insides of the hands and the soles of the feet.

Pudd'nhead Wilson, 1894
Mark Twain (1835–1910)

CHAPTER OBJECTIVES

The study of this chapter will help the learner to

- List the contributions of historical individuals who developed and refined fingerprint evidence.
- Describe the categorical methods for fingerprint processing.
- Explain ACE-V.
- Distinguish between the two primary methods of U.S. fingerprint classification.
- Define AFIS.
- Explain SWGFAST and how it relates to fingerprints.

KEY TERMS

ACE-V
Alternate Light Source (ALS)
Anthropometry
Automated Fingerprint Identification System (AFIS)
Classification
Cyanoacrylate Ester Fuming
FBI National Crime Information Center–Fingerprint Classification (NCIC-FPC)
Henry System
Latent Prints
Minutia
Ninhydrin
Patent Prints
Plastic Prints
Points of Comparison
Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST)
Small Particle Reagent (SPR)

History of Fingerprints

Since the beginning of humankind, there has been a desire and attempt to identify individuals. Fingerprints are among the oldest and most probative types of forensic evidence. There is evidence throughout history, from Neolithic cave carvings to Chinese artifacts over 5,000 years old, that humans have had some inclination of the individuality inherent in fingerprints.

But while artifacts upon which this historical premise is based are thousands of years of age, modern study and understanding of fingerprints has its foundation in 1684.

Nehemiah Grew (1641–1712)

British horticulturalist Nehemiah Grew is the first documented person to study and accurately describe the ridge patterns present on the surfaces of the hands and feet. In addition to writing on the topic, he also published detailed drawings of finger and palm patterns and descriptions of pore detail (Ramotowski, 2001).

Although Grew published these findings, more than 200 years would pass before the permanency, classification, and individualized identification of fingerprints were studied in depth and presented to the world. Those influential in such matters are given in the next sections.

Alphonse Bertillon (1853–1914)

Anthropometry: A series of 11 body measurements of the bony parts of the body, and an in-depth description of marks (scars, moles, warts, tattoos, etc.) on the surface of the body; developed by Alphonse Bertillon, as a method of criminal identification.

Bertillon's system, entitled **anthropometry**, was a series of 11 body measurements of the bony parts of the body, and an in-depth description of marks (scars, moles, warts, tattoos, etc.) on the surface of the body. Anthropometric measurements could be taken from individuals who were over the age of 20, as it was assumed that such individuals had completed their vertical growth so their measurements would remain constant from that point onward. Bertillon's system of identification was the accepted method for policing agencies until 1903, when an incident at the federal penitentiary in Leavenworth, Kansas identified the shortcomings of the system.

Upon being incarcerated, Will West was photographed and his Bertillon measurements taken. The resulting photograph and measurements were nearly identical to those of another prisoner, William West, already on file. Will West denied having ever been incarcerated at Leavenworth, and a subsequent investigation led authorities to realize that they had two separate prisoners—Will and William West—both incarcerated within the walls of the penitentiary, who bore an almost identical resemblance both visually and in their anthropometric measurements. However, when authorities decided to collect fingerprints from the two men, they realized that each had unique fingerprints from the other. This event led authorities to realize that Bertillon anthropologic measurements were an unreliable method for personal identification, and that two people who have nearly identical facial features and measurements nevertheless have unique fingerprints.

Sir William J. Herschel (1833–1917)

As an Englishman stationed in India during the mid-1800s, Herschel was flummoxed with designing a method for having Indian workers sign legal documents for the British government in a way that was not subject to ease of forgery, such as signing with an "X" or other non-unique mark. He began experimenting with having the workers "sign" legal documents by applying their inked palm and, later, thumb impressions, to the documents. Through examination of hundreds of such document signatures and examination of his own fingerprints for over 50 years, he noted that the prints did not change over time. He attempted—unsuccessfully—to convince others within the government to implement his practices (James & Nordby, 2009).

Henry Faulds (1843–1930)

Faulds, a Scottish physician working in a hospital in Tokyo, Japan, became involved in local archeological digs. Noticing the fingerprints of artisans left on pottery shards, he began to study contemporary hand and fingerprints. In 1880 he is reported to have written a letter to the scientist Charles Darwin about his findings, suggesting that fingerprints could be classified and noting that their ridge details appeared to be unique between individuals. Faulds also mentioned that he had used these unique print details to apprehend criminals and to exonerate the innocent. Darwin forwarded Faulds' letter to his half-cousin, Sir Francis Galton, an English scientist.

Sir Francis Galton (1822–1911)

In 1892 Galton published the first recognized in-depth study of fingerprint science, entitled *Finger Prints*. This text included the first classification system for fingerprints, wherein Galton identified the characteristics that enable fingerprints to be identified. These minute variances within fingerprints are termed **minutia**, but are often referred to as Galton points or Galton details in honor of his recognition of such characteristics. However, although Galton's work in fingerprints became the foundation for modern fingerprint science, his method of classification was much too awkward and involved to make it practical for use in criminal investigations.

Minutia: Tiny variations and irregularities within fingerprint ridges that are unique and identifiable; also known as ridge characteristics.

Sir Edward Henry (1850–1931)

In 1897, a trainee of Galton's developed a more functional classification system independent of Galton, while working in India. In 1901, Scotland Yard appointed Edward Henry their Assistant Commissioner of Police. While working in this capacity, he introduced his fingerprint system, and within a decade, Henry's system had been adopted by police and prison forces in most English-speaking countries around the globe, and it remains in use to this day (Girard, 2013).

Another individual, however, is responsible for development of a classification system used in many non–English speaking countries.

Juan Vucetich (1855–1925)

The Argentinean police official Vucetich came to understand the value of fingerprints as a method of criminal identification because of his correspondence with Galton. Through his growing interest in the matter, he developed his own system for classifying fingerprints. Vucetich originally named his system *icnofalangometrica*, meaning "finger track measurement." In 1896, he renamed the system *dactiloscopia,* meaning "finger description" (Rodriguez, 2004). By 1896, Argentine police had implemented Vucetich's system of identification involving fingerprints and had abandoned anthropometry. Vucetich has the distinction of being involved with the first recorded case in which fingerprints were used to solve a crime. This case took place in 1892 and involved the homicide of illegitimate children. As a result of his experience with this case and his continued study of fingerprints, Vucetich wrote *Dactiloscopia Comparada* in 1904 (Caplan, 2001). The system of classification developed by Vucetich is still in use in many Spanish-speaking countries, particularly in South America.

What Are Fingerprints?

Structure of Fingerprints

Skin is the outer covering of the human body and is the largest and heaviest organ of the body. The majority of the skin on the human body is referred to as smooth skin. Smooth skin contains hair, sebaceous glands, and sweat glands. Volar skin, on the other hand, is found on the soles of the feet, palms of the hands, and on the underside of the fingers and toes. It is furrowed, hairless, lacks pigmentation, and only contains sweat glands. Volar skin does not secrete sebaceous oils, but sometimes body oils are found on volar skin (especially the hands) due to contact with other areas of the body's skin surface. The friction ridges present on volar skin are a textured surface, continuously corrugated with narrow ridges that run parallel to one another and form patterns that do not appear in the same place or sequence from one finger, hand, or toe to another. The purpose of friction ridges is to increase friction between the volar surfaces and any other surface they contact.

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

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

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

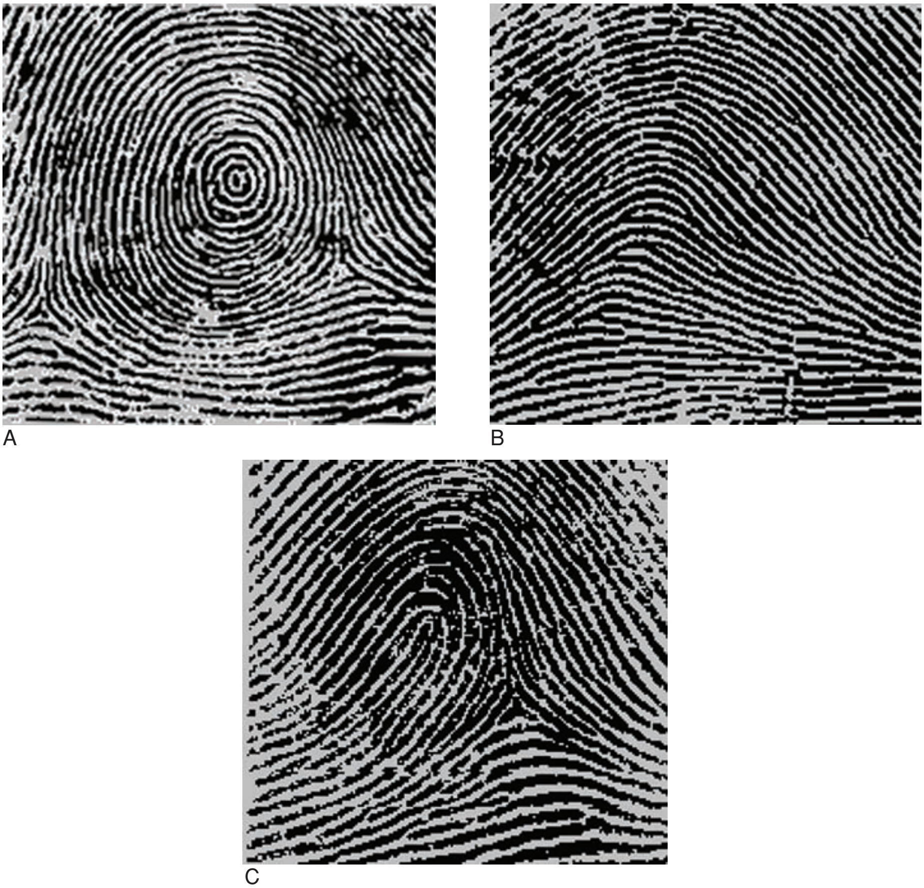
Composition of Fingerprints

> *You will observe that these dainty curving lines … form various clearly defined patterns, such as arches, circles, long curves, whorls, etc., and that these patterns differ on the different fingers. The patterns on the right hand are not the same as those on the left. Taken finger for finger, your patterns differ from your neighbor's. (p. 159)*
>
> Mark Twain
> *Pudd'nhead Wilson,* 1894

The term fingerprints actually refers to oil, perspiration, and other residue left behind by a person's friction ridge skin after they have touched something. Friction ridge skin is characterized by hills called ridges and valleys called furrows. These ridges and furrows form three basic fingerprint patterns—arches, loops, and whorls—with each pattern type having several subtypes: ulnar and radial loops, plain and tented arches, plain whorls, central pocket loop whorls, double loop whorls, and accidental whorls (**Figure 8.1**).

In addition to the overall patterns, there are many tiny variations and irregularities within the ridges themselves, termed minutia or ridge characteristics. The ridges of the fingerprint form the minutiae by doing one of three things: ending abruptly (ending ridge), splitting into two ridges (bifurcation), or by forming ridge dots.

These ridge characteristics result in individuality not simply between individuals but between the fingers themselves. No two prints have been found to be the same. The FBI has over 70 million fingerprints on file and not one is the same as another. While it is impossible to physically observe each and every fingerprint in the world throughout history, the study of fingerprints within the past 200 years has failed to produce two prints



Figures 8.1 A–C Basic fingerprint patterns: (A) whorl pattern, (B) arch pattern, and (C) loop pattern.
Courtesy of the Federal Bureau of Investigation.

with identical features. This has been known for over a century before the discovery of DNA. In fact, fingerprints are more unique than DNA, for while each person has his or her own DNA, monozygotic (identical) twins, triplets, and other multiples all have individual fingerprints. In in his book *Pudd'nhead* Wilson (1894), Mark Twain wrote about the individuality of fingerprints between twins:

> *The patterns of a twin's right hand are not the same as those on his left. One twin's patterns are never the same as his fellow-twin's patterns. You have often heard of twins who were so exactly alike that when dressed alike their own parents could not tell them apart. Yet there was never a twin born into this world that did not carry from birth to death, a sure identifier in this mysterious and marvelous natal autograph. That once known to you, his fellow-twin could never personate him and deceive you. (p. 159)*

View from an Expert

The Road to Becoming a Fingerprint Expert

So, you think you want to become a fingerprint examiner? Let me tell you a little about what I do every day so you can discover what the job is really like.

The general day-to-day activities in my position include conducting physical and chemical laboratory analysis on a wide variety of evidentiary items, capturing friction ridge detail using digital single-lens reflex (DSLR) photography or a flatbed scanner, using photo editing software to enhance the contrast of the images, comparing unknown friction ridge detail against known standards, running unknown prints through the Automated Fingerprint Identification System (AFIS) or the Federal Bureau of Investigation's Next Generation Identification System NGI databases, writing reports on my findings, and performing verifications and technical review of other analysts' work. In addition, I am required to testify in court, give laboratory tours, assist in training outside agencies in the proper collection of latent prints, and to answer any questions that officers or attorneys may call in to the unit. Plus, since I work in an American Society of Crime Lab Directors/Laboratory Accreditation Board (ASCLD/LAB) accredited laboratory, I am also responsible for being knowledgeable about the documented training and operations manuals and remaining up to date on the reading and review of these procedures.

Still interested? Great! If this sounds like something you would like to do, here are a few tips on how to get started in the field.

Since the publication of the National Academy of Sciences (NAS) report, *Strengthening Forensic Science in the United States: A Path Forward*, in 2009, more and more labs are becoming accredited and more analysts are seeking certification. Almost all positions within the laboratory require a science degree background, so unless you want to be an evidence technician or do clerical work, seeking a hard science degree (chemistry, biology, or physics) is the way to go. There are a few crime scene and fingerprinting positions available for those without a science degree, but they are usually through police organizations and not an accredited crime laboratory.

The number of crime labs in the United States is not very large, so finding a position directly out of college is not always an option. With the influx of applicants due to the growth in popularity of the forensic field, the labs can sometimes afford to even hire PhD holders for entry-level positions. If you are not able to get into the crime lab right away, a good place to look is in a laboratory or analytical setting where you can hone your skills and show that you are a hard worker and a competent analyst.

Once you have the degree, there are a few other things that would really be beneficial for working in a crime lab. If you are looking to get into the forensic field, do your research! Read up on real-life forensic professionals and then try and decide where you see yourself fitting into the vast framework of forensic science. If forensic identification (fingerprints, footwear, etc.) is your thing, get that science degree and try your hardest to get into a crime lab for an internship. Any experience you can get with fingerprint comparisons and fingerprint database software is very beneficial. Another thing to consider is your skill in photography. Some labs are fortunate enough to have a photography section to send evidence to, if need be, but many labs do not. Oftentimes, the best way to capture latent prints is through photography, so learning the basics of macro DSLR photography would be a great asset.

Another suggestion is to be passionate about what you want to do. It is pretty easy to tell the difference between someone who just wants a job and someone who wants *that* job. Get an ink pad and take your families' fingerprints, just to see if you can find any similarities. Read up on fingerprint articles and follow the International Association for Identification on social media. Better yet, become a student member and try to attend a conference or some other professional training. Participating in a moot court group or learning about legal proceedings would be a good task as well. All these things will really make you stand out to potential employers, and the exposure to them can help you decide if forensic identification is the field for you. Remember, you are most likely not going to get rich working in a crime lab, but the passion and drive of the people who work there can make the job more rewarding than simply receiving a paycheck.

So, now that I have the job, what have I learned since coming to work at the crime lab?

Initially, I was amazed at how committed, passionate, and professional the staff was about forensic science. One of my first on-the-job training assignments was to tour the various laboratory sections and learn about what they did. Through these interactions, I learned just how broad a field forensic science can be, and how much there is to learn. DNA analysis, fingerprint and footwear identification, ballistics, toxicology, controlled substances, forensic photography, crime scene response, evidence handling. . . they all have their own contribution to the proper function of the forensic field. Finding your niche, and what interests you, is very important.

Another thing to note is that things move quite a bit slower in real life than they do on TV. It often surprises people that AFIS software is just a database. It does not actually identify the latent prints for the examiner; it only generates a list of potential candidates. There is no auto-rotation where minutiae points magically appear as one fingerprint perfectly superimposes onto another. No special box pops up to tell the exact current location of the subject, and a fair amount of time is spent verifying other analysts' conclusions, both identifications and exclusions, and checking that all the "i's" have been dotted and "t's" have been crossed, so to speak. In general, most government labs are staffed by civilians, and they do not carry firearms or interrogate suspects. We are forensic *scientists* and it is our job to perform our analysis to the best of our ability and not to be concerned with what results we think the submitters want us to give them. One of my favorite quotes about forensic science comes from Dr. Paul C.H. Brouardel, a late 19th century

(continued)

French pathologist. He said, "If the law has made you a witness, remain a man of science. You have no victim to avenge, no guilty or innocent person to convict or save—you must bear testimony within the limits of science." This is very important to remember, and it helps safeguard an analyst from bias.

Since coming to the lab, I also learned that there are many challenges, and that forensic identification is not for everyone. One of the biggest challenges I have faced is the fact that being a fingerprint examiner is a lot harder than I thought it would be. It looks so easy on TV, but the small amount of information truly needed to make an identification was not something that I was prepared for when I came into this job. Fingerprints are rarely as nice, neat, or clean as you might expect. When there is no core or delta, or the print is distorted and incomplete, manually searching numerous fingerprint cards looking for one small piece of friction ridge detail is a rather daunting task. Do you like doing puzzles? Then perhaps this job is for you, because this is kind of like doing a very large puzzle where the piece that you have may or may not actually belong to that particular puzzle!

Before the comparisons even begin however, there is the challenge of processing the evidentiary items. Rarely are you given any sort of case scenario information. This can be good because it helps prevent contextual bias, but you can also expect to spend many hours examining and processing items that seem like they would have little or no probative value to the case. You may also get items that any number of people who are not even involved in the case might have touched, such as electronics on public display at a store or a letter sent through the post office.

Although I cannot speak for all the crime labs across the country and the world, most fingerprint examiners face similar job situations and challenges. This demanding job is a great opportunity to be surrounded by amazing, passionate people, and have the opportunity to have a career that can have a real impact on people's lives. This is the road that I am on; I hope that my story will help you find yours.

Vanessa Styx
Fingerprint Examiner
State of Wisconsin Crime Laboratory

Plastic:
A type of fingerprint having a distinct three-dimensional appearance, due to typically being impressed into a soft material; these often do not require further processing.

Patent:
Finger prints that require no processing to be recognizable and may be suitable for comparison.

Types of Fingerprints

Although personnel often use the term latent prints to describe all fingerprints found at a crime scene, many of the prints discovered are visible and should not be called latent. Any investigator, lawyer, or expert who inartfully uses "latent" to describe a visible print can expect to be challenged on competent cross-examination. Such a simple point is not lost on jurors, who generally are swayed by simple reasons to find one witness more believable than another. While there are three distinct categories of fingerprints (arches, loops, and whorls), the patterns can leave three different types of transfers. The three distinct types of prints found at a crime scene are **plastic**, **patent**, and **latent** impressions.

Plastic Fingerprints

If fingers come into contact with a soft material such as soap, wet putty, wet cement, wet paint, dust, or melted wax, a ridge impression may be left sufficient for performing a comparison. These impressions have a distinct three-dimensional appearance and often do not require further processing. They are documented using oblique photography (**Figure 8.2**).

Figure 8.2 Example of a plastic fingerprint.

Courtesy of Dana Gevelinger, University of Wisconsin-Platteville.

Latent:
Prints which are not visible to the unaided eye. These prints require additional processing to be rendered visible and suitable for comparison.

Patent Fingerprints

Patent prints are easily identifiable as fingerprints by the unassisted eye. Fingers that have been in contact with a colored material such as toner, ink, blood, paint, oil, or chocolate leave visible prints. Once the material has soiled the fingers, the material may be transferred to a surface with which the ridges come into contact. These prints require no processing to be recognizable as a fingerprint and are often suitable for comparison (**Figure 8.3**).

Latent Fingerprints

These are prints that require additional processing to be rendered visible and suitable for comparison. Body perspiration and oils might leave invisible residues on surfaces that, if visualized, would constitute a usable impression of the friction ridges. Processing of latent prints is accomplished through development, enhancement, or visualization appropriate for the type of surface upon which the prints repose (**Figure 8.4**).

Searching for and Processing Latent Prints

Although one might think that due to the general knowledge that fingerprints are individualistic and that finding prints at a scene might implicate someone, many criminals continue to deposit their prints at crime scenes. Therefore, fingerprints should be sought at all types of crime scenes, especially at scenes of crimes committed by unknown perpetrators. Recognition of fingerprint evidence requires training and experience, however.

Figure 8.3 Example of a patent fingerprint.
Courtesy of Dana Gevelinger, University of Wisconsin-Platteville.

Figure 8.4 Close-up photo of a powder-dusted latent fingerprint.

Persons processing a crime scene should keep in mind two seemingly paradoxical truths: (1) Latent prints can be found on almost any type of surface and (2) latent prints will not be developed on every attempt. Past studies have shown that many departments locate usable latent prints at 30% to 50% of the scenes visited, and in some of those cases the prints belong to persons with legitimate access. Investigators should not be discouraged by recovery rates as low as one in three crime scenes. The likelihood of the recovery of usable latent prints is increased by the resourcefulness and diligence of the person conducting the search.

Another important consideration is to initiate a search for latent prints as soon as possible after the discovery of the crime and to protect areas to be processed for prints from adverse weather conditions. Ordinarily, fingerprints are primarily composed of water and body fats and oils. These can evaporate if not processed in a timely manner or if exposed to sun, heat, or wind. Prints may be washed away by rain or dew if not protected.

Searches for latent prints should progress from the least invasive and destructive method to the most invasive and destructive method in hopes of minimizing potential evidence damage and maximizing the evidence potential. Suggested search and processing guidelines are in the box.

Once a print has been located, it must be documented with photography and then a processing methodology must be determined. How a print is developed, enhanced, or visualized is dependent upon a number of factors including substrate of the material on which the print is located, age of the print, color of the background on which the print is found, environment (wet/dry/humid), and other factors. While there are over 80 ways to process a fingerprint, they can be grouped into four methods: physical, chemical, special illumination, and a combination approach.

General Rule

Evidence should be collected intact and submitted to the lab for processing and examination. If impossible or impractical, apply latent development techniques at the scene, preferably by trained personnel.

Search and Processing Guidelines for Fingerprints

Visual Examination

- Sometimes all that is needed to visualize a print is to use oblique lighting.
- After a visual exam, use a laser/alternative light/ultraviolet (UV) light search.
- Photograph all patent prints and other evidence in the impressions prior to removal or tape lifting.

Processing with Physical or Chemical Methods

- Photograph latent prints after development or visualization.
- Draw sketches of the location and orientation of the latent impression on the lift card or in the investigator's notes. The documentation of the location and orientation of the latent impressions detected will provide details for any reconstruction efforts for testing statements by a suspect with regard to innocent placement of the latent impressions.
- As a rule, wet items or surfaces should be allowed to air dry without the use of heat or forced air before processing.
- Items in freezing weather should be allowed to warm to room temperature before dusting.
- When drying is not feasible, the item may be processed for latent prints by applying small particle reagent (small particle reagent discussed later in this chapter).

Casting Plastic Impressions

- Impressions should be photographed with oblique lighting and a cast prepared from silicone casting material in the case of indented patent impressions.

Remember at all times that crime scene fingerprints are perishable.

Physical Methods

Methods that do not involve chemicals or reactions are physical methods. These utilize the application of fine particles to the fingerprint residue, thereby creating a contrast between the ridges and background. The most common physical method is *powder dusting* with a brush and inorganic powders. Another variant is *magnetic powder dusting*, which has the advantage of being gentler and not as destructive as inorganic dusting because no bristles make contact with the print. A third common physical method is small particle reagent, which typically is used on evidence that has been wet.

Powder and Brush

Fingerprints on smooth, nonporous surfaces such as glass, paint, glossy plastics, and other polished surfaces can usually be developed with inorganic (non–carbon-based) powders. The fingerprint brush should be clean and free from oils or other materials that may affect the efficiency of dusting with the brush. The brush should be swirled vigorously to remove excess powder, and then dipped lightly into the powder with a swirling action, lifted, swirled again, and finally applied lightly to the surface in a circular manner (**Figure 8.5**).

Figure 8.5 Inorganic powder and brush.
Courtesy of Nick Vesper, University of Wisconsin-Platteville.

Once the latent becomes visible, the print should be dusted lightly in the direction of the ridges until clearly visible. It is important to avoid over-dusting because the print may be wiped clean by too much dusting. The print is then lifted with fingerprint tape. The fingerprint tape should be applied by releasing an adequate length of tape from the roll, placing the leading edge to the side of and over the print, and then sliding the finger down the tape to cover the entire area of the print while holding the tape roll in the other hand so that it does not fall onto the surface of the print. The tape should be rubbed sufficiently to remove any bubbles present. If the tape cannot be removed without destroying the print, then the tape is left on the surface and the object collected. If the tape can be removed, it should be pulled up from the end away from the tape roll, and the tape should then be transferred to a latent card. The card should be labeled immediately and a sketch placed on the card illustrating the location and orientation of the print.

Magnetic Powder Dusting

Magnetic powder has been available since the early 1960s and adds a wide range of flexibility to fingerprint processing techniques. Typically, magnetic powder is used on nonmagnetic surfaces, and inorganic powder on iron-based surfaces. However, the crime scene investigator will find that inorganic powder is inappropriate for some surfaces, including many textured and plastic surfaces (e.g., vinyl imitation leather, lightly textured automobile dashboards, automobile door panels), where magnetic powder performs quite well.

One of the primary advantages of magnetic powder over inorganic powder dusting is that with magnetic powder, there is no brush to touch and possibly damage the print. Nothing but the powder itself touches the print (**Figure 8.6**).

Small Particle Reagent

Small particle reagent (SPR) is a suspension of molybdenum sulfide grains in water and a detergent solution. The grains adhere to the fatty components of a latent print deposit and assist with visualizing latent fingerprints. The reagent is first shaken to disperse the molybdenum sulfide grains in the liquid and then sprayed onto the surface suspected of bearing latent deposits. The surface is next sprayed with clean distilled water to remove excess reagent. Developed impressions are then photographed or lifted with tape after drying. The SPR method has the advantage that it can be used on wet and/or dirty/greasy surfaces; however, it also can be used on dry surfaces. In any case, SPR must be used with the understanding that the possible benefit of latent recovery must outweigh the possibility of water damage to the object.

Chemical Methods

Chemical methods of fingerprint processing are those that involve a chemical reaction taking place in order to enhance, develop, or visualize a latent fingerprint. The two most frequently utilized methods are ninhydrin and cyanoacrylate fuming.

Ninhydrin

The amino acid reagent **ninhydrin** has been available for crime scene use since 1910. This chemical is used to detect ammonia or amino acids within print residue, which reacts to form a bluish-purple color (**Figure 8.7**). It is most useful on porous surfaces (e.g.,

Small particle reagent (SPR): A suspension of molybdenum sulfide grains in water and a detergent solution. The grains adhere to the fatty components of a latent print deposit, and assist with the visualization of latent print evidence.

Ninhydrin: A chemical used to detect ammonia or amino acids within print residue. It reacts with these amino acids and forms a bluish-purple color; most useful on porous surfaces (e.g., paper and raw wood) and is primarily used in document processing efforts.

Figure 8.6 Magnetic powder and applicator.
Courtesy of Nick Vesper, University of Wisconsin-Platteville.

paper and raw wood) and is primarily used in document processing efforts. Ninhydrin may also be used as a preliminary treatment prior to the use of other chemicals or the use of laser or an alternate light source (ALS). Heat and humidity expedite the development process (**Figure 8.8**). Because ninhydrin reacts with amino acids, it should only be applied in well-ventilated areas to prevent serious health complications ensuing from its improper usage.

Cyanoacrylate ester fuming:
A technique that stabilizes latent prints using super glue. Super glue is induced to fume and the fumes interact with latent fingerprint residue by polymerizing them, yielding a stable friction ridge impression off-white in color.

Cyanoacrylate Ester Fuming

Cyanoacrylate ester fuming (also called super glue fuming) is a technique that stabilizes latent prints. Super glue fuming has been used since the early 1980s. In this method super glue is induced to fume and the fumes interact with latent fingerprint residue by polymerizing them, yielding a stable friction ridge impression that is off-white in color (**Figure 8.9**). This process can be accomplished by placing the items to be processed in a fuming chamber and then fuming with any of a number of commercially available kits or with kits prepared by the analyst. Of particular interest is the development of the super glue fuming wand

Figure 8.7 Close-up of a latent print processed using ninhydrin.

for cyanoacrylate fuming (**Figure 8.10**). This technique should allow for effortless fuming in the field by investigators. The cartridges can be ordered with dye added, which can be visualized with fluorescent lighting and thus eliminate the additional step of treating the fumed impressions with a fluorescent dye or powder. The process requires humidity (moisture source). It is primarily used on nonporous surfaces and is an initial step in fingerprint processing. Due to the fact that cyanoacrylate ester encapsulates the latent print in an off-white polymer shroud, it does not necessarily lend itself to effective visualization for identification purposes. Prints often will need to be dusted or further processed to result in the best visualization or enhancement. This method is also used as a way of "fixing" a print prior to the object being transported. This method safely encapsulates and protects the print from any rubbing damage during transport and will allow the lab to continue visualization and enhancement methods.

Special Illumination

Sometimes all that is required to visualize a latent fingerprint is oblique lighting. Light is a basic tool for crime scene searches. Clean white light is necessary for basic observation;

Figure 8.8 An evidence technician using heat and humidity to expedite ninhydrin processing.

Figure 8.9 An example of a latent print processed using cyanoacrylate fuming.

Figure 8.10 Cyanoacrylate fuming wand and cartridges.

however, specialized lighting is often necessary. **Alternate light sources (ALSs)** are light-emitting devices supplied with colored filters that filter the source light so that the developed latent print can be viewed with light of a narrow wavelength range, rather than at the usual full spectrum ("white light") viewing range (**Figure 8.11**). The ALS produces additional light energy to visualize different types of evidence and can be used for more than simply visualizing latent prints.

Alternate light sources (ALS): Light-emitting device supplied with colored filters that filter the source light so that the potential evidence can be viewed with light of a narrow wavelength range, rather than at the usual "white light" viewing range.

An ALS will help visualize:

- Fluids and biological matter
- Fibers and some hairs
- Bruises or bite marks
- Nearly invisible bloodstains
- Alterations to documents

Full-Spectrum Imaging

Crime scene investigators are also making use of a number of commercially available products that are related to, or in the same technological family as, ALS. One of these, known as a full-spectrum imaging system, is a portable special illumination device that will allow investigators to view the crime scene while it is scanned by a shortwave ultraviolet (UV) light. The unit will also allow for the digital capture of the scene during imaging. It has been found to have useful application on documents as well as difficult surfaces, which do not typically lend themselves to processing by powders or chemicals. While not possible to be used in all environments and lighting conditions, it does present investigators with another forensic tool in the toolbox.

Figure 8.11 Alternate light sources and associated barrier filters.

Combined Approach

While many fingerprint development techniques can be divided into either physical or chemical types, often a combined approach will yield the best enhancement of a latent print. An example of a combined approach is utilizing the chemical method of cyanoacrylate ester fuming to locate and protect the print, and then following up this method with powder dusting to create the best contrast for visualization.

Advanced Lifting Techniques

For the majority of scenes, a simplified approach to latent processing, such as powder dusting, will be sufficient to properly locate and preserve latent fingerprint evidence. Sometimes, however, the crime scene investigator will encounter a surface believed to contain latent prints but that does not lend itself to processing in the typical manner (**Figure 8.12**). Irregular surfaces such as the dimpled surface of steering wheels and vehicle dashboards, or curved surfaces such as door handles or wood stairway spindles, may prove challenging for lifting prints.

A suggestion for dealing with these difficult surfaces is to utilize a combined approach of powder dusting along with lifting utilizing forensic casting material versus tape. The method is described below.

1. For rough or irregularly shaped objects:
   - Dust the location of the latent print with powder.
   - Apply a forensic casting material or silicon (e.g., Mikrosil™ casting putty) to the developed print area and lift the latent print (**Figure 8.13**).

Figure 8.12 Using silicon casting material to process human remains for fingerprints.

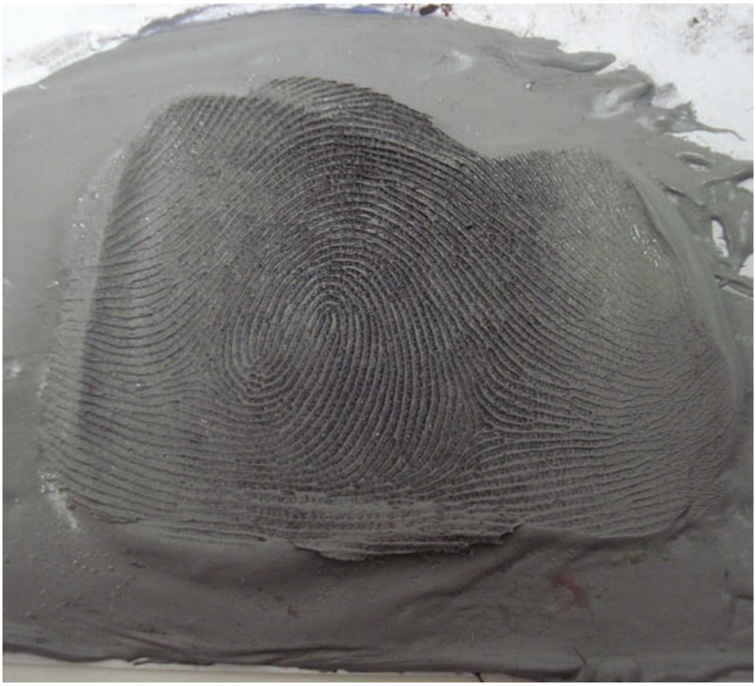


Figure 8.13 Using silicon casting material to obtain a fingerprint.

2. Certain surfaces are textured, which makes it difficult to lift powdered fingerprints in their entirety. Examples are Styrofoam and rough leather.
   - In these cases, white or black silicone rubber casting compound can be used. The casting compound is mixed and placed over the print developed with fingerprint powder. After the silicone rubber has cured, the fingerprint is lifted.
   - Depending on the color of the fingerprint powder that was used, white or black silicone rubber is used for contrast.

Preserving and Packaging Latent Prints

When a crime scene investigator applies physical or chemical methods of processing to latent prints, they are developing and visualizing the actual fingerprint that was left behind by an individual; they are not creating and lifting a copy of the print. The chemicals or powders will interact with or adhere to the residues left behind by the finger that touched the surface. Therefore, the recovery efforts and documentation should be the same as with any other item of physical evidence. When the print is collected and later presented within court, it does not simply represent the print left at the crime scene, it is the print that was at the crime scene. This is important for a crime scene investigator to realize so that, regardless of whether or not they believe the print to be identifiable, the print should be properly processed, documented, and recovered so that the print can serve as future evidence.

As with plastic and visible prints, once an investigator has developed a latent print, he or she must prepare and preserve it for possible use in the laboratory and courtroom. First, it must be photographed with a scale of reference. Next, if possible, the print should be removed from the crime scene, either by preserving the item upon which the print lays or by lifting the print. Numerous manufacturers provide specialized adhesive lifters for this purpose (**Figure 8.14**).

A lifter is a transparent tape that is placed on the powdered print with the adhesive side down. When the tape is removed, the fingerprint powder is removed with it. The lifter is provided with a black or white card onto which the transparent tape and powdered print can then be placed, adhesive side down. The colored card provides contrast to the colored powder used, helping to visualize the print. Lift tape also comes in a variety of sizes and configurations so that the right type can be chosen for the size, number, and location of the prints to be lifted.

The majority of times the prints recovered from crime scenes are used from a visual identification standpoint, using the actual characteristics within the print to identify the person whose print is a match to such characteristics. Lifted prints can be packaged either as tape lifts adhered to print cards, or protected within an evidentiary envelope. An object bearing friction ridge prints must be properly handled and packaged to avoid destroying the prints while in transit. Do not place items in plastic bags or allow surfaces that contain latent prints to come in contact with or rub against the sides of the packaging materials. Mark these containers with the word "Fingerprints."

Recent advances have allowed for the use of DNA analysis with regard to latent print lifts. Some chemical methods of processing may prohibit the ability of this type of forensic

Figure 8.14 Lifting a fingerprint using an adhesive lifter.
Courtesy of Sirchie Acquisition Company, LLC.

analysis to be performed. If DNA analysis of print residue is expected to be performed, the crime scene investigator is encouraged to contact their appropriate crime lab prior to utilizing chemical methods of processing so that any contamination or damage of DNA-related evidence can be avoided.

No two fingers have yet been found that have identical characteristics. Fingerprint individuality is not dependent upon age, size, gender, or race. Fingerprint individuality, and therefore fingerprint identification, rests on four premises:

1. Friction ridges develop in their definitive form when humans are still in the womb.
2. Friction ridges remain unchanged throughout life with the exception of permanent scars.
3. Friction ridge patterns and their details are unique.
4. Ridge patterns vary within certain boundaries that allow the patterns to be classified.

The entire point of recognizing and collecting fingerprints is to identify them in order to find a suspect or identify a person. However, most people have never given much thought to the process by which fingerprint identification is actually done. When prints are found, an expert compares them with samples known to have been made by a suspect. He/she first compares overall patterns and then looks for identical ridge characteristics. When these match, they are known as **points of comparison**. There is no definitive rule on how to achieve this comparison. Current training in fingerprint comparison stresses

Identifying Fingerprints

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. This signature is not his face—age can change that beyond recognition; it is not his hair, for that can fall out; it is not his height, for duplicates of that exist; it is not his form, for duplicates of that exist also, whereas this signature is each man's very own—there is no duplicate of it among the swarming populations of the globe! This autograph consists of the delicate lines or corrugations with which Nature marks the insides of the hands and the soles of the feet. (p. 159)

Mark Twain
Pudd'nhead Wilson, 1894

that the quality of the print and the quality of the comparison are more important than a numerical match (**Figure 8.15**).

The examiner must decide if sufficient quality and quantity of the ridge detail is present. If not, it may be concluded that there was "insufficient ridge detail to form a conclusion." The print is analyzed to determine its proper orientation, decide suitability, and then proceed to the comparison. The overall pattern and ridge flow is examined. Next, the minutiae are compared, point by point, as to type and location. Finally, pore shape, locations, numbers, and relationships, and the shape and size of edge features are compared. Any unexplained differences between known and latent during this process results in the conclusion that the known is "excluded as a source." If every compared feature is consistent with the known, and enough features are

Classification: A formula given to a complete set of 10 fingers as they appear on a fingerprint card generally based on pattern type, ridge count, or ridge tracing. The FBI National Crime Information Center—Fingerprint Classification (NCIC-FPC) and the Henry System are most commonly used to classify prints.

Henry System: Developed by Sir Edward Henry, a system of print classification used for well over a century. The system was built around the individual's whorl patterns in a fingerprint (primary classification) that were subdivided into five categories depending upon the type and size of the patterns.

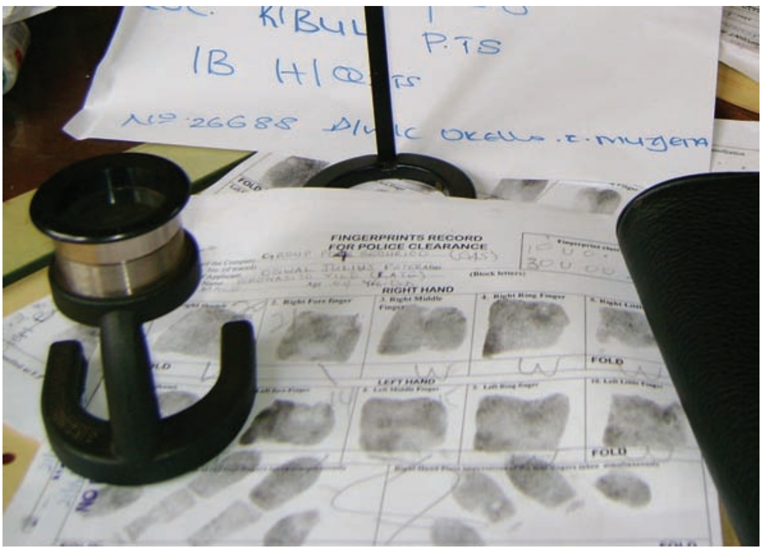


Figure 8.15 Manual identification using a 10-print card.

sufficiently unique when considered as a whole, the examiner makes an ID. Therefore, in fingerprint identification, there are three possible conclusions that can be drawn from an analysis:

1. Insufficient ridge detail to form a conclusion
2. Print exclusion
3. Print identification

In law enforcement, IDs are always made by trained and often certified examiners. Sometimes inked prints may be compared with a set of inked prints on file. More commonly, the examiner compares a developed latent print to inked prints from a known person.

Fingerprint examiners are trained extensively and are required to accumulate significant experience before being entrusted with this responsibility. In addition to the general principles and approaches used, therefore, the knowledge, training, and experience are also considered. Most examiners are certified or have been declared an "expert" by a court of law.

FBI National Crime Information Center—Fingerprint Classification (NCIC-FPC): A system of fingerprint classification developed by the FBI that assigns a 20 character string of letters and numbers to a person's fingerprints. The database is used to compare existing prints with those from unsolved crimes.

Classification of Fingerprints

A classification system is necessary if large sets of fingerprint files are to be useful for criminal identification. **Classification** is a formula given to a complete set of 10 fingers as they appear on a fingerprint card generally based on pattern type, ridge count, or ridge tracing. Today the **Henry System** and the **FBI National Crime Information Center—Fingerprint Classification (NCIC-FPC)** are used to classify prints.

Henry System

Developed by Sir Edward Henry, the Henry System of print classification has been used for well over a century and remains in use in many departments today. This system requires the complete classification of all 10 fingers of an individual in order to properly file the

Henry System of Classification

10	I	1	R	-	r	2
	S	17	U	2a		

This Henry classification is representative of the following:
Primary: 1/17
Secondary: R/U
Subsecondary/small letter group: r/2a
Major: I/S
Final: 2
Key: 10

When trained to understand the Henry System of classification, the examiner is able to determine that there is one whorl pattern present within the hand (in the right thumb), a radial loop with a ridge count of 10 is present in the right index finger, a radial loop is present in the right ring finger, ulnar loops are present in the right middle finger, the right little finger (with ridge count of 2), the left thumb, the left index finger, and the left little finger. There are also arches present in the middle and ring finger of the left hand.

Case In Point: Can Fingerprints Lie?

Fingerprints do not themselves lie; however, their interpretation can certainly mislead. Brandon Mayfield, an immigration lawyer from Washington State, found this out in a very publicly humiliating and professionally damaging way in the summer of 2004. After a misidentification led to his subsequent incarceration, the FBI issued the following press release:

May 24, 2004

Statement on Brandon Mayfield Case

After the March terrorist attacks on commuter trains in Madrid, digital images of partial latent fingerprints, obtained from plastic bags that contained detonator caps, were submitted by Spanish authorities to the FBI for analysis. The submitted images were searched through the Integrated Automated Fingerprint Identification System (IAFIS). An IAFIS search compares an unknown print to a database of millions of known prints. The result of an IAFIS search produces a short list of potential matches. A trained fingerprint examiner then takes the short list of possible matches and performs an examination to determine whether the unknown print matches a known print in the database.

Using standard protocols and methodologies, FBI fingerprint examiners determined that the latent fingerprint was of value for identification purposes. This print was subsequently linked to Brandon Mayfield. That association was independently analyzed and the results were confirmed by an outside experienced fingerprint expert.

Soon after the submitted fingerprint was associated with Mr. Mayfield, Spanish authorities alerted the FBI to additional information that cast doubt on our findings. As a result, the FBI sent two fingerprint examiners to Madrid, who compared the image the FBI had been provided to the image the Spanish authorities had.

Upon review it was determined that the FBI identification was based on an image of substandard quality, which was particularly problematic because of the remarkable number of points of similarity between Mr. Mayfield's prints and the print details in the images submitted to the FBI.

The FBI's Latent Fingerprint Unit will be reviewing its current practices and will give consideration to adopting new guidelines for all examiners receiving latent print images when the original evidence is not included.

The FBI also plans to ask an international panel of fingerprint experts to review our examination in this case.

The FBI apologizes to Mr. Mayfield and his family for the hardships that this matter has caused.

Source: Information retrieved from the Federal Bureau of Investigation (FBI). (2004). Press release. Statement on Brandon Mayfield Case. Retrieved August 3, 2009, from http://www.fbi.gov/pressrel/pressrel04/mayfield052404.htm.

information. When this system was developed, it allowed for efficient searching and maintenance of large fingerprint files. However, it did not allow for manually searching for a single print. The system was built around whether or not an individual had whorl patterns present within his or her prints (primary classification) and then had a series of five extensions to the primary classification, dependent upon the type and size of the patterns present in the fingers. An example of utilizing the Henry System of classification is shown in the box.

Although recognized the world over as an effective method for fingerprint filing, with the increased efficiency and affordability of computer systems, many departments are choosing to file and classify prints using a method developed by the FBI.

View from an Expert

A Life of Fingerprints

The first time I ever searched a fingerprint using a computer was in the mid-1960s. The computer was not a fingerprint computer at all; it was an IBM 083 card sorter. What I remember about it is it was a machine that sorted cards that had punch holes in them. As the cards passed through the machine at a very fast rate, they were sorted into various bins as the machine "read" the information provided by the punch holes on the cards. A system was devised whereby information about the fingerprint, such as loop, whorl, etc., type of loop or whorl, ridge count, tracing, and varied other information was "coded" onto the punch cards. When the "computer" made a hit, we would pull the latent from the file and make the manual comparison. A fingerprint examiner by the name of Alex Russak, who worked for the City of Miami Police Department, devised what I believe was the first such system (or at least one of the first) and the Dade County Sheriff's Office, now the Miami Dade Police Department, used a variation of that system. We had at best a database of a couple dozen, maybe a hundred, prints coded into the system. The coding process was cumbersome and tedious, but we did get a few "hits."

Automated fingerprint systems have come an astonishingly long way since then. Today these systems are searching multi-millions of fingerprints and palm prints with amazing speed and accuracy.

Live scan fingerprinting has been around for a number of years now. Live scan has replaced the ink and roller system in many police agencies; however, ink is still widely used. With live scan prints, the operator can watch the print being rolled on a monitor and check the quality of the prints before accepting them. That's only one small advantage of the new technology. With live scan, prints can be scanned directly into systems where they will be automatically searched through local, state, and federal databases.

Scanning technology is still evolving. There is technology available now that allows for the fingers to be scanned without the fingers ever touching the glass scanning plate.

From the earliest uses of fingerprints as a means of identification in criminal cases to today, the science has continually evolved.

Computers, as wonderful as they are, still require the competent comparison skills of a trained fingerprint examiner to make the final decision concerning the identification of a friction ridge print.

Training and continuing education are still extremely important factors. Unfortunately, with the budget problems realized by government at all levels over the past few years, many agencies are operating with very limited funds. Training of forensic personnel is all too often not a priority. There are differing views concerning what training a novice fingerprint examiner should receive. There are those that say: "We don't need to know the Henry System of Fingerprint Classification anymore because no one uses it. What good is learning about the history of fingerprints?"

I am a firm believer in knowing the basics of your science/profession. You need a solid foundation from which to build if your goal is to become an expert in your profession.

All of the skills you acquire and put to use in your examination of evidence in a criminal case will be put to the test when you are called to testify in court regarding the results of your examination. The courtroom is where you will have to explain and defend everything you did to reach the decision in the case you have worked. All of your time and effort will prove fruitless if you cannot explain yourself to the court and jury.

(continued)

You never know what questions might be asked in court; they might be as simple as "what is a fingerprint" or complex such as "can you explain to the jury how the error rate for fingerprint identification is calculated."

Although fingerprint identification has been accepted in court for over 100 years as a reliable science, attacks on the examiner and the science are a common occurrence and a fingerprint examiner has to be able to defend his/her testimony as well as the science.

There are those who claim that fingerprint identification is not a proven science, or perhaps not scientific at all. Since the late 1990s there have been numerous attacks against the fingerprint community in the form of Daubert hearings in various courts across the United States. Simply put, Daubert is concerned with the admissibility of scientific evidence in court. A Daubert motion is a motion raised before or during trial to exclude the presentation of unqualified evidence to the jury. The Daubert rule requires the judge to be a "gatekeeper" in determining whether certain scientific evidence is admissible. It must past certain standards, such as:

1. Is the evidence based on a testable theory or technique?
2. Has the theory or technique been peer reviewed?
3. Is there a known error rate?
4. Is the underlying science generally accepted?

Fingerprint examiners today have to be better educated and have a solid understanding of what it is that leads one to form an opinion and reach a conclusion. I believe that the basics of fingerprint identification were and still are very important. These skills must now be coupled with a better understanding of the methodology that leads you to your conclusion.

Continued training and education, certification, and laboratory accreditation have all been positive steps in the career of latent print examiners. To date, all of the challenges to the science have been successfully met; however, fingerprint examiners continue to face challenging cross-examination from attorneys who are keeping abreast of all of the latest information on fingerprint identification. The Internet is a wealth of information available to anyone, including defense attorneys, who want to learn about the science of fingerprints.

Recent published accounts of "mistakes" and outright wrongdoing by a small minority of fingerprint examiners have provided fodder not only for defense attorneys, but also for those who would like to see the demise of the fingerprint science. When all is said and done, I believe that fingerprint science is extremely sound and will continue to be an effective tool for law enforcement and civilian use for many years to come.

Each generation of fingerprint examiner has the advantage of learning from those who have preceded him/her, and today's examiners have the further advantage of being part of an age of exploding technology. Digital information is the norm for just about everything now, a far cry from the photophone of years ago used to send fingerprint images anywhere in the world in a matter of seconds. Many of the old tried and true methods are still very useful and productive, and they have a place alongside of today's lightning fast computers, scanners, and new chemical development methods. Fingerprint powder and a fingerprint brush can obtain amazing results in the hands of a knowledgeable latent print examiner.

Carmine Artone
Retired Branch Chief
Identification and Research Branch
Forensic Services Division
United States Secret Service

National Crime Information Center-Fingerprint Classification (NCIC-FPC)

This system of classification, developed by the FBI (2012), assigns a 20-character string of letters and numbers to a person's fingerprints. Every print entered into the FBI system is classified by this method, and it allows trained law enforcement personnel in the field to determine fingerprint compatibility with prints on record, along with providing an efficient and effective way for filing fingerprints. The following is an example of an NCIC-FPC.

POAA05TT19CISR58DIXX

PO: Right thumb is a plain whorl with an outer tracing.
AA: Right index finger is a plain arch.
05: Right middle finger is an ulnar loop with a ridge count of 5.
TT: Right ring finger is a tented arch.
19: Right little finger is an ulnar loop with a ridge count of 19.
CI: Left thumb is a central pocket loop whorl with an inner tracing.
SR: Left index finger is unclassifiable due to scarring.
58: Left middle finger is a radial loop with a ridge count of 8.
DI: Left ring finger is a double loop whorl with an inner tracing.
XX: Left little finger is missing (possibly amputated, or missing since birth).

ACE-V

A systematic and thorough approach to crime scene processing means employing the scientific method within the efforts, referred to as scientific crime scene investigation. A similar methodology is utilized with reference to the comparison and identification process of latent fingerprints. David R. Ashbaugh, a scientist with the Royal Canadian Mounted Police, developed a formal method known as **ACE-V** for the scientific comparison of prints. The acronym stands for analysis, comparison, evaluation, and verification. The purpose of this comparison methodology is to either identify a print, via individualization, as having originated from the same source, or exclude impressions as having no common origin (Coppock, 2007). There remains the possibility of the print ID process being determined as inconclusive.

ACE-V: An acronym for Analysis, Comparison, Evaluation, and Verification. A systematic method devised for the scientific comparison of prints to either identify a print (via individualization, as having originated from the same source) or exclude impressions as having no common origin.

Analysis

The first level of this process begins with the study of the questioned print to determine the overall print orientation, quality, shape, and ridge flow. The comparison (or known) print is analyzed in the same manner. If the information derived is found to be consistent, the analysis proceeds to the next level. If nonmatching characteristics are observed, the examination is terminated, which results in an exclusion.

Comparison

If the analysis portion of the process yields sufficient information to warrant a further investigation, the next level begins with orienting the questioned and known print in the same manner and identifying a common unique point in each print to utilize as a starting point. The examination will continue from this common starting point and progress along with recognition of other areas of commonalities between the prints, with regard to ridge characteristics, beginning with the most distinctive feature identified and continuing until all of the characteristics are accounted for and there are no unexplainable variances. Differences may exist due to print quality; however, it is the print characteristics present that are being compared, not necessarily their clarity.

Evaluation

In the event of a clear variance between the prints, following the comparison stage, an exclusion would be made. However, if the information appears consistent between the two prints, an ID can be made. Typically, this ID is based upon the degree of ridge detail. If the print is lacking in sufficient print detail, then pore distribution and ridge shapes and edges may be utilized instead or in combination.

Verification

Regardless of the conclusion reached, either exclusion or identification, another examiner reexamines the print for verification utilizing the aforementioned process. Under ideal conditions, the examiner making the identification or exclusion should be an analyst who is in no way associated with the case, or who had any significant knowledge of the case. This could impart bias to the decision process.

One important case of misidentification was the FBI's arrest of American citizen Brandon Mayfield in 2004 in connection with the Madrid bombings that killed 191 and injured over 2,000. It wasn't until the Spanish government identified a different man from the fingerprint evidence that Mayfield was released (see Case in Point).

Automated Fingerprint Identification System

Television, books, and movies often emphasize the value of fingerprints in solving serious crimes. Until the advent of computer technology, however, that value was mostly mythical.

Ripped from the Headlines

Selfie Identification

Detectives in Florida recently used a popular method of self-photography to identify and convict a suspect. Dannie Horner, 34, was arrested for sexually abusing a 1-year old boy. As part of the post-arrest evidence gathering, to support the charges, police confiscated and analyzed his cell phone. On the phone were a number of selfies, which did not show the photographer's face, but which showed the suspect holding the camera and conducting his abuse in front of a mirror. Detectives were able to use the images displayed in the mirror to isolate the suspect's fingers and fingerprints and compare them to the inked images collected at the time of his arrest. They were a direct match to one another. According to an interview conducted by the *New York Daily News*, the evidence was of paramount importance.

"We didn't have a face of an individual in a photo, but this was even better," Capt. Charlie Thorpe, head of the department's Investigations Bureau, told the *Daily News*. "In this case, you are looking at the actual print on the actual finger in an image. If the ridge detail is there, without the physical finger, what could be better? It made it a clear conviction," Thorpe said. "(The jurors) had no doubt in their mind."

A jury found Horner guilty of 26 charges, including capital sexual battery, molestation, and possession and transmission of child pornography. The modern method can be more reliable than lifting prints off an object, which can become problematic if there are smudges and debris on the print, the investigators said.

Source: Chan, M. (2015, June 23). Detectives use fingerprints from photo of suspect's hand to ID him in child porn case. *New York Daily News*. Retrieved October 7, 2015 from http://www.nydailynews.com/news/national/detectives-fingerprints-photo-perp-hand-id-article-1.2268308

Fingerprints were used to inculpate or exculpate based on a suspect group. A search of fingerprint files for the match to a fingerprint found at the scene of a crime occurred mostly in fiction. The classification system used in categorizing stored fingerprints and the large number of fingerprints stored made it impossible to check through a fingerprint collection manually looking for a match. Computers turned fantasy into reality.

An **Automated Fingerprint Identification System (AFIS)** is a digitally automated pattern recognition system that consists of three fundamental stages:

1. *Data acquisition:* The fingerprint to be recognized is sensed.
2. *Feature extraction:* A machine representation (pattern) is extracted from the sensed image.
3. *Decision making:* The representations derived from the sensed image are compared with a representation stored in the system.

Automated Fingerprint Identification System (AFIS):
A digitally automated pattern recognition system, for the identification of fingerprints that consists of three fundamental stages: data acquisition, feature extraction, and decision-making.

Different systems may use different numbers of available fingerprints (multiple impressions of a single finger or single impressions of multiple fingers) for person identification. The feature extraction stage may involve manual override and editing by experts. Image enhancement may be used for poor-quality images. Depending on whether the acquisition process is offline or online, a fingerprint may be one of three types: an inked fingerprint, a latent fingerprint, or a live-scan fingerprint.

Fingerprints no longer need to be manually matched to files. Time is often the critical factor in determining the success of a criminal investigation. The use of this computer technology not only saves time, but significantly increases the accuracy match rate compared to manual comparisons. Because of this, and due to the systems becoming more affordable, AFISs are rapidly being implemented throughout law enforcement agencies (see **Figure 8.16**).

Figure 8.16 AFIS terminal.

© Kevin L Chesson/ShutterStock, Inc.

Ten-print cards are scanned into the system. They are run against current latent prints within the system from "unknowns." The AFIS also can scan in latent prints and compare them against the 10-print cards on file. The computer assigns a percentage of probability on the matches generated. Searches can be conducted in seconds/minutes versus months for manual searches. It should be noted, however, that final determination is always left up to a professional print examiner and NOT the computer.

For the AFIS to pull up candidates for a "match," an examiner must first ensure that minutia points are properly identified; sometimes these must be added or edited manually, which can be very time consuming. However, if not performed, and minutia points are incorrectly identified, or unidentified altogether, then the chances of finding a proper match decrease dramatically.

This often tedious and problematic situation saw a dramatic improvement when in April 2009 the National Institute of Standards and Technology (NIST) released results of biometric research they had conducted with reference to Automatic Feature Extraction and Matching (AFEM). Utilizing automated fingerprint feature extraction, most of the tested print's identities were found within the top 10 prints listed as possible matches. This shows a dramatic increase in efficiency of automation and bodes well for accelerating fingerprint data input and identification (Indovina, Dvorychenko, Tabassi, et al., 2009).

Today, the FBI has an Integrated Automated Fingerprint Identification System in place (IAFIS). This system allows agencies to be linked together and compare/share evidence. However, not all systems are integrated. The majority of time when someone thinks of AFIS, they believe the system to be an IAFIS, but that is not necessarily the case. An AFIS accepts and stores input data within that system alone, and is not integrated with outside systems. Therefore, if a comparison to other prints outside of the agency's own system

AFIS Interoperability

Statement of the Issue

Since the 1970s, AFIS system design has been left to hardware and software vendors resulting in differing approaches to algorithm coding in recognizing images. The varying approaches to algorithm coding developed by vendors through the free market has resulted in incompatible proprietary systems. This lack of "interoperability" has created sophisticated, stand-alone AFIS systems that cannot share data.

Background

For over a century, the criminal justice system has relied on fingerprint technology to support public safety throughout the world to identify individuals suspected in criminal and terrorist events, among other uses. During a criminal investigation, latent fingerprints located, developed, and recovered from a crime scene are compared with fingerprint records of known individuals. Latent fingerprints from unknown sources, whether left behind as complete or partial fingerprints, can be searched with today's technology in an automated, electronic system, called AFIS, which uses image recognition algorithms that produce a list of potential candidates that share similar fingerprint features.

(continued)

When true interoperability is achieved, AFIS systems will have technical compatibility standards, interagency network connectivity, and quality assurance within and between systems. The lack of interoperability has not been hampered for technical reasons; it has been policy and practice that have prevented true interoperability.

Recommended Implementation Strategy

The U.S. Attorney General should support, recommend, and fund interoperability through collaboration, education, and outreach. The U.S. Attorney General, with guidance from the National Commission on Forensic Science as well as the Organization of Scientific Area Committees (OSAC), should ensure that decision makers and practitioners are aware of the importance of AFIS interoperability and how to achieve it, including its potential impact on privacy and state's rights issues. This should include proper governance, funding incentives, and the assignment of an appropriate DOJ entity for implementation responsibility.

1. Standards for Interoperability
   a. Require that any AFIS system that is acquired using federal funding meet interoperability standards using the Extended Feature Set (EFS), the Latent Interoperability Transmission Specification (LITS), and/or any interoperability standards developed in the future.
   b. Make sufficient funds available to support procurement or upgrades of interoperable AFIS systems so that true interoperability can be achieved by October 1, 2020.
   c. Recommend that future state and local AFIS systems consider, and Federal AFIS systems require, collection and reporting of data in a standard format (to be defined by the Organization of Scientific Area Committees [OSAC]).
4. Interagency Connectivity
   a. Review and revise policies to ease restrictions to state and local agencies' access to the Federal Bureau of Investigation's Next Generation Identification System (FBI NGI).
   b. Direct that studies or pilot programs be conducted to assess the value of giving more agencies (whether federal, state, or local) direct access to Department of Defense and Department of Homeland Security fingerprint databases.
3. Quality Assurance
   a. Develop conformance testing criteria in collaboration with OSAC to verify AFIS system compliance to standards and make that a criterion for interagency connectivity.

Source: National Commission on Forensic Science. (2015, April). Initial draft recommendation on *Automated Fingerprint Identification System (AFIS) interoperability*. Retrieved May 21, 2015 from http://www.regulations.gov/#%21documentDetail;D=DOJ-LA-2015-0004-0002

is to take place, the print must be e-mailed or otherwise sent digitally to an agency that has IAFIS capabilities. Agencies that are integrated, whether to the FBI IAFIS system or simply to a larger network such as several interstate crime laboratories, are able to run a print against all prints within the integrated system.

Palm Prints

The palms of the hands (as well as the soles of the feet) yield the same volar skin, and thus friction ridge skin, as that of the fingers (and toes). However, the large-scale classification of palm impressions relating to data entry or archiving is a relatively new concept. Until recently, the technology necessary to document and compare such information was not available on a large scale. Most AFIS computer databases would only allow searches of fingerprints.

However, an increasing number of vendors are making modifications and updates to their systems that will allow for the input of and comparison of palm print impressions.

Although palm prints are relatively new for AFISs, latent print comparisons are not new. One of the earliest latent print identifications, possibly the first in a criminal case in this country, was a palm print identification. Palm print and footprint identifications have been part of the friction ridge identification process for many years. Palm print identifications at the U.S. Secret Service, for example, historically have been very high because of the large number of forged U.S. Treasury checks that were processed. This was especially true before forgery and general financial fraud became mostly electronic in nature. Quite often palm prints of the side of the palm are developed under the signature area. This area of the palm is sometimes referred to as the writer's palm because it contacts the document when a person is writing (Artone, personal communication, October 25, 2008).

Palm prints often are found during crime scene search efforts. The most commonly encountered areas of friction skin impressions typically correspond to the large padded areas of the palmer surface. As technology continues to improve, the comparison and identification efforts will also improve. A crime scene investigator should not let this deter him or her from the collection of the friction ridge evidence. To a crime scene investigator, all prints should be viewed as potentially identifiable. Such identification efforts are left up to the experience and technology of the forensic laboratory.

Preparing Fingerprint Cards

The 2009 Wisconsin Department of Justice (WisDOJ) *Physical Evidence Handbook* suggests the following with regard to collection of inked fingerprints:

> Law enforcement personnel should strive to develop the skills necessary to take legible record ("inked") finger and palm prints (**Figure 8.17**) [*sic*]. Absolute clarity of detail is paramount. Unless ridge detail is perfectly clear, it may be impossible to conduct comparisons against the latent prints. This can result in identifications not being made that would have been possible if the inked impression had been clearly recorded. Submissions made to the laboratory should record finger and palm prints of all persons known to have had or suspected of having had access to the item or scene. (It is especially important to secure finger and palm prints of the victim if he/she has died, since it will be nearly impossible to secure prints once the body has been interred.) (WisDOJ, 2009, p. 103).

Taking Record Fingerprints

Preparing Inked Fingerprint Cards

Prepare the inking slab by placing several small dabs of ink on the surface and rolling it uniformly over the surface. Be careful not to use too much ink. The rolled out ink should be only thick enough so that when a digit is rolled across the surface, the areas where the ridges picked up the ink will appear clean. The print recorded should have good contrast with the card. Practice will allow for proper inking on a consistent basis. It is suggested that a test ink impression be made on a scrap of paper to check for proper ink density. If possible, adjust the fingerprint cardholder so that it is at the height of the person's elbow.

Figure 8.17 A 10-print fingerprint card.

The person to be printed should wash his or her hands if excessive grease, dirt, or perspiration is present. Inked impressions should not be taken of digits having open cuts. The person being fingerprinted should be instructed not to assist with the process, but to cooperate by relaxing his or her arm so it pivots more easily. With the person positioned to the right side of the person taking the prints and slightly to his or her rear, the right hand of the person to be printed should be grasped firmly. Then, holding the four fingers back and clear of the inking slab, the thumb is inked by rolling it toward the body. Then roll the inked thumb in the designated space on the card. Repeat the process for the fingers, except roll the fingers away from the person's body. This prevents possible drag and secures a more uniform impression. When the right hand is completed, have the person turn so he or she is standing at a right angle to the card stand, with his or her back to you. Grasp the left hand and repeat the process. Do not push down on the fingers while recording them; use only enough pressure to guide and to ensure the digit does not slip. Excessive pressure will blur the impression.

To record the simultaneous impressions, re-roll ink on the slab (add more ink if necessary) and have the person wipe excess ink from his or her fingers with lint-free toweling. Simultaneous prints are not rolled; the four fingers are extended and joined. Ink and print by pressing them straight down in the appropriate block. Use only a very slight amount of pressure on the back of the person's fingers when pressing them onto the card. Repeat with the thumbs. If the inked impressions are not properly inked or recorded, re-take them.

Recording Palm Prints

If palm prints are found at the crime scene then palm prints should be recorded from suspect(s) and victim(s) (**Figure 8.18** and **Figure 8.19**). To do this, remove excess ink

Figure 8.18 Example of palm print card.
Courtesy of Nick Vesper, University of Wisconsin-Platteville.

from the person's hands and then re-ink the entire palm and fingers. Palm prints are more clearly recorded by the following method:

> Secure an 8" × 8" plain card to a 3" to 4" diameter cylinder with rubber bands. Possible cylinders include a short section of plastic drain pipe or a section of the cardboard tubing on which carpet is shipped. Place the tube (with card attached) on a counter top so it can roll toward the front edge, placing it so it can make one complete revolution. After inking the palm, instruct the person to hold his/her hand perfectly flat, palm down and parallel to the counter top. Grasp the person's arm and guide the hand so the wrist is placed on the card at the bottom, ending with the tips of the fingers at the top edge of the card. As the palm draws across the card, apply very slight pressure to the back of the person's hand with the heel of your hand (this will ensure the hollow of the palm will be recorded). The impression will be more clear if only slight pressure is applied during the

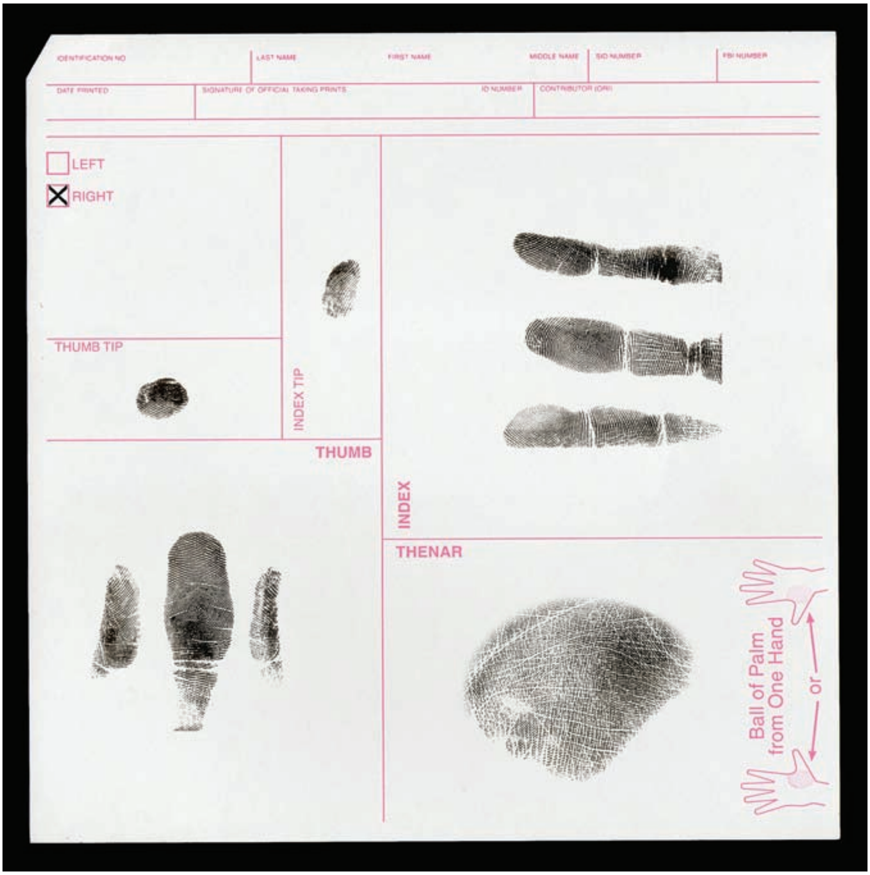


Figure 8.19 Example of palm print card.

Courtesy of Nick Vesper, University of Wisconsin-Platteville.

procedure (only enough pressure to ensure the hand does not slip across the surface of the card) (WisDOJ, 2009, p. 105).

All finger and palm print cards must be signed and dated by both the person and the officer. The fingerprinted person should fill out all information required on the card. This information should appear in the person's handwriting or printing.

Scientific Working Group on Friction Ridge Analysis, Study, and Technology

The **Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST)** was established in 1997 in response to a number of inconsistencies and controversies relating to fingerprint identification and technological advancement, and continues to operate through sponsorship from the FBI. Its mission is to assist the latent print community in providing the best service and product to the criminal justice system. Membership in

Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST): A working group established in 1997 in response to a number of inconsistencies and controversies relating to fingerprint identification and technological advancement; operates through Federal Bureau of Investigation sponsorship with a mission to assist the latent print community in providing the best service and product to the criminal justice system.

SWGFAST comprises a diverse group of professionals within the fingerprint community. This includes not only latent print examiners from law enforcement agencies, but also defense experts, researchers, instructors, academics, managers, and others. This group's diversity provides an objective yet varied perspective to all matters of interest to the group. The group was formed to establish consensus guidelines and standards for the forensic examination of friction ridge impressions. To date, that has been limited to the concerns of the latent print community. Although it has been realized that there are areas of common interest to other fingerprint applications (e.g., criminal history and biometrics), the existing SWGFAST guidelines were not developed with the intention of being applied to nonlatent print-related matters.

Strengthening Fingerprint Science

More recently, as discussed in the previous chapter, the National Institute of Standards and Technology (NIST) has developed the Organization of Scientific Area Committees (OSAC) to develop consistent standards and guidelines associated with each sub-discipline (OSAC, n.d.). Amongst these is a committee dedicated to "Physics/Pattern," of which "friction ridge" is a sub-component area of responsibility. Eventually, we will likely see SWGFAST and OSAC Physics/Pattern merge or morph to form a recognized set of standards associated with training and identification processes. As of the printing of this text, the committee was just beginning to assemble draft documents to be passed around to noted professionals for review. For more information on the Organization of Scientific Area Committees (OSAC), please see Appendix E.

Wrap Up

Summary

What is not looked for will not be found. What is not found cannot be identified. Fingerprints are one of the most probative types of evidence in crime scene investigation and as such, they should be searched for and gathered whenever possible. A crime scene investigator should consider all prints as being potentially identifiable and should call upon his or her training and experience to determine the best method for processing latent prints at a crime scene. If it is possible to collect the item and submit it to the lab for processing, it is always preferable to do so. Lacking that, processing and recovery efforts should be put to use at the crime scene.

Review Questions

1. _____________ are a textured surface, continuously corrugated with narrow ridges and found on the surface of the volar skin.
2. Friction ridge skin is characterized by hills called ___________ and valleys called _____________.
3. What are the two paradoxical truths of processing a crime scene for latent fingerprints?
4. What is the primary advantage of magnetic powder over inorganic powder?
5. What is SPR and what is it made of?
6. What types of evidence can an ALS be used to visualize?
7. List the four premise on which fingerprint individuality rests.
8. The two types of classification systems used today in the United States are ___________ and ____________.
9. What is ACE-V and how is it used in fingerprint analysis?
10. What is SWGFAST and what is its purpose?

Questions for Discussion

1. Discuss what ACE-V is and how it is used in fingerprint analysis.
2. Discuss the differences between AFIS and IAFIS.
3. Discuss the limitations of AFIS.
4. Discuss the benefits of including palm prints in collection efforts.

Wrap-Up (*continued*)

CASE STUDIES

1. Research one of the cases that appear on the FBI's "Latent Hit of the Year Awards" (https://www.fbi.gov/about-us/cjis/fingerprints_biometrics/iafis/iafis_latent_hit_of_the_year)
2. Research the 2008 case against Donald Smith in Gwinnett, GA and explain how fingerprints helped to exonerate him, but convict Ronald Smith. Why was this case so unique? Also explain how the case mirrored an event in Kansas from 1903.