Case Study 6.1

The First Fingerprint Identification in a Criminal Case

The illegitimate children of a woman named Rojas were murdered June 18, 1892. She acted distraught and accused a man called Velasquez, who she said committed the act because he wanted to marry her and she had refused. Velasquez maintained his innocence and had an alibi. An investigator assisting with the case from La Plata, the provincial capital, found out that another of Rojas's boyfriends had made statements about being willing to marry Rojas except for the children. The investigator, a man named Alvarez, who had been trained by Vucetich, found a bloody fingerprint at the scene and collected it. After comparison with Rojas's prints, the latent turned out to be of her right thumb. She confessed when confronted.

he discovered that the same measurements fit a William West who was already incarcerated at the prison (and unrelated to Will West though they looked a lot alike). The two did have different fingerprints. This incident, and probably others, came to convince police agency identification personnel that fingerprints represented the basis for a superior method of personal identification.

About 1893, the London Metropolitan Police ("Scotland Yard") added fingerprints to the Bertillon cards for criminals in the identification system. Soon the success of fingerprints overshadowed that of bertillonage in criminal identification, and anthropometry was abandoned in 1901.

Juan Vucetich is the Western Hemisphere's fingerprint pioneer. An employee of the police department in La Plata, Argentina, he became convinced of the value of fingerprints as a means of criminal identification and wrote a book on the subject in 1894. By 1896, the Argentine police were using fingerprints in criminal records. Vucetich devised a classification system for fingerprints that was used in Argentina and throughout South America. The first recorded case in which fingerprints were used to solve a crime took place in Argentina in 1892 (see Case 6.1).

Like William Herschel, Sir Edward Henry was also in the British Indian civil service in the late 19th century. He was interested in fingerprints and read Galton's book. He corresponded with and later visited Galton, who shared everything he had on the subject with Henry, including materials he had obtained from Herschel and Faulds. Henry worked out, and is widely known for, a fingerprint classification system that was adopted in British India, the United Kingdom, and in a modified form in the United States. Henry wrote a book entitled *Classification and Uses of Fingerprints*. In 1901, he became assistant commissioner of police for criminal identification for the London Metropolitan Police and he rose to commissioner in 1903.

In North America, the New York City civil service was using fingerprints by 1903 to prevent impersonations during examination, and fingerprints were introduced about the same time in the New York State prison system and at Leavenworth Penitentiary. A number of police departments began using fingerprints as identifiers in criminal records as well. The 1904 St. Louis World's Fair provided the venue for a chance meeting between Inspector Edward Foster of the Royal Canadian Mounted Police and Detective John Ferrier of Scotland Yard. As a result of what he learned in St. Louis, Foster convinced his superiors in the RCMP of the usefulness of fingerprints.

In 1910, a man called Thomas Jennings was arrested in Chicago and brought to trial for murder. The primary evidence against him was fingerprint evidence. The state, wanting to ensure that the fingerprint identification evidence would survive appeals to the Illinois Supreme Court, called Edward Foster of the RCMP as an expert witness. The defendant was convicted, the evidence did survive appeal, and the *Jennings* case is considered a landmark fingerprint case in American jurisprudence.

Fingerprint Classification, Management of Large Files, AFISs

Classification systems are based on ten-print sets from a person. Although very useful for managing large files of ten-print cards, the classification systems do not help in searching files for a single print. And, single prints (or partials of single prints) are generally what is recovered from crime scenes or evidence.

Classification and Large Files

The early pioneers in the use of fingerprints for criminal identification realized that a manageable, consistent **classification system** was necessary to manage large sets of fingerprint files. In the United Kingdom and the United States, the classification systems are variants of the one Henry developed. In Argentina and other South American countries, a different system based on the one developed by Vucetich has been used. Until fairly recently, when computer-based image file management was developed, fingerprint files consisted of 10-print cards (Figure 6.4). The modified Henry system as used in the United States is a scheme for the classification of 10-print sets, or a fingerprint card for one individual (Figure 6.5). Use of the classification system enabled efficient searching of large files of 10-print cards to see if a new 10-print set was there. The 10-print card files, especially the large ones, weren't much help in cold-searching for a single print. Of course, cards of suspects could be pulled to see if the single print belonged to any of them, but there had to be suspects. The development of computerized fingerprint search systems (see the next section) enabled cold searches (searches with no suspect) of large files for single prints or partials. For years, the fingerprint classification of wanted suspects was shown on wanted posters distributed to police agencies and displayed in public places such as post offices.

With the development and widespread adoption of computerized fingerprint storage and retrieval systems, searching large files for single and partial prints is now

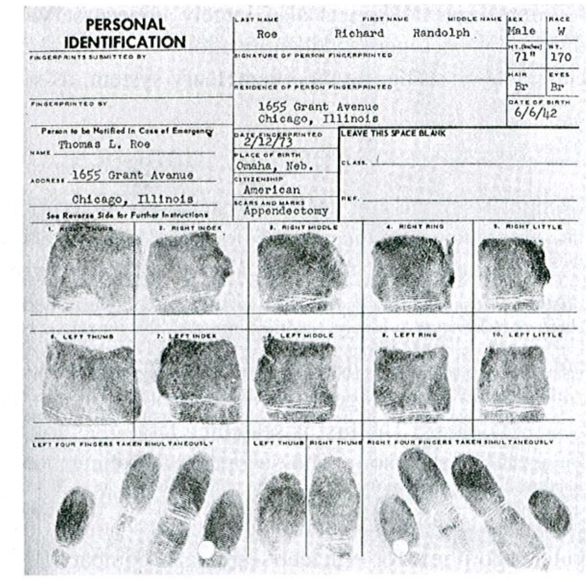

Figure 6.4
A 10-print card.

classification system
A method of organizing large files of 10-print cards according to the features of the fingerprints; in the United States, a modified Henry system of classification was used.

Classification	Formula	Description
Primary	17 L **10** U 10M / **19** W 011 10	Obtained through the summation of the value of the whorls as they appear in the various fingers
Secondary	17 L 10 **U** 10M / 19 **W** 011 10	The type of pattern appearing in the index fingers
Subsecondary	17 L 10 U **10M** / 19 W **011** 10	The value of the ridge counts of loops or tracing of whorls of index, middle, and ring fingers
Final	17 L 10 U 10M / 19 W 011 **10**	The ridge count of loops of little fingers
Major	17 **L** 10 U 10M / 19 W 011 10	The value of the ridge counts of loops or tracing of whorls of thumb
Key	**17** L 10 U 10M / 19 W 011 10	The ridge count of the first loop appearing in fingers other than the little finger

Figure 6.5
Fingerprint classification by the modified Henry system.

routine. Classification is also largely unnecessary. At one time, not long ago, all fingerprint examiners and identification personnel were extensively trained in fingerprint classification using the modified Henry system, as were many police officers.

Automated Fingerprint Identification Systems (AFISs)

AFISs
Automated Fingerprint Identification Systems; several AFISs are commercially available for the imaging, storage, and rapid retrieval of single fingerprints; national system maintained by the FBI is called IAFIS (for Integrated AFIS).

Computer storage and retrieval systems for fingerprints were originally developed for law enforcement applications. Efforts to develop the systems began in the early 1960s. In the United States, there was a collaboration between the FBI, which maintains the largest (and the only national) fingerprint database, and scientists at the National Bureau of Standards (which later became the National Institute of Standards and Technology, or NIST). The law-enforcement-based automated systems are commonly called Automated Fingerprint Identification Systems, or **AFISs.** There are two principal applications. The first is searching large files for the presence of a 10-print record (taken from a person). The second is searching large files for single prints, usually developed latent fingerprints (see later) from crime scenes. Fingerprint patterns are complex, and development of appropriate scanning and storage technologies and computer algorithms for efficient search and comparison was far from trivial.

By the late 1980s, there were at least five operational AFISs, four of which had been commercialized. Just about all larger jurisdictions had systems in place by the 1990s. Because different commercial vendors use different technologies, the systems are not intrinsically compatible with one another. Another important point about AFIS is that a given person's fingerprints may be in one system, but not in others. For example, depending on the criteria for including a set of prints in the files, a large city system could have someone's prints, but the corresponding state system might not have them.

An AFIS is a complicated, expensive set of computer hardware and software for image processing and storage. A central mainframe or large server holds the database. There are multiple workstations for scanning, input, and searching. Large systems could have workstations distributed over dozens of locations in a state. Figure 6.6 shows some AFIS components.

AFISs can be viewed in perspective as one of the three types of major electronic databases for law enforcement purposes that are now available. The others are CODIS (Combined DNA Indexing System), which holds DNA profiles (Chapter 10), and NIBIN (National Integrated Ballistics Information Network), which holds searchable image information from fired bullets and cartridge cases (Chapter 8). Each of these databases holds two types of files or profiles. One is the knowns. In the AFIS, this file contains the prints of known individuals. Any questioned specimen, image, or profile can be searched for in the "known" file, and if it is found, its source is thereby identified. The other type is often called the "forensic" file. It consists of images or profiles from unsolved cases, the sources of which are not known. In the AFIS case, for example, the forensic file contains images of developed latent single fingerprints from unsolved cases. It contains evidence fingerprints that have not yet been associated with an individual. The file is valuable to investigators, however, in that it allows cases that are not obviously related to be connected because they have the same fingerprints. This kind of connection allows investigators to share information and leads, thus increasing the probability of apprehending a suspect.

The FBI criminal fingerprint database, called IAFIS for Integrated AFIS, is now available to law enforcement agencies nationally. It has been estimated that about 15 percent of latent prints entered into an AFIS result in identifications.

Another important application for AFISs is reexamination of unsolved older cases. Routine searching of latent or other single prints was not possible until fairly recently. Thus, there are many unsolved cases with fingerprints of a possible perpetrator in which it was not possible to search at the time. In addition, individuals whose prints were not in the file at the time of the crime and are later arrested can then be associated with the earlier crime. This chapter's lead case illustrates this point.

(a) (b)

Figure 6.6 (A) A live-scan station for taking fingerprints without paper or ink directly into an AFIS. (B) Two workscreens of an AFIS.

(Images courtesy of Sagem Morpho, Inc., Tacoma, WA)

As we noted earlier, an AFIS should be seen today as part of a larger picture that includes an array of automated systems for human biometrics—the use of some type of body metric for identification. It may be that the Bertillon system of anthropometry previously described was the first well-defined system of human biometry that made use of a database. Today, systems based on retinal scans, iris scans, and rapid fingerprint scanning, followed by quick comparison with database records, are available for security purposes. Criminal identification and related law enforcement applications of automated fingerprint systems remain very important, but AFISs and other biometric systems are rapidly finding their way into use as public and private security methods. These systems can help control entry and/or access into computers or structures, can identify persons for security purposes to prevent identity theft, and can help control welfare or social services fraud. Biometrics is further discussed later in the chapter.

Collection and Preservation of Fingerprint Evidence

Most of the time, collection of fingerprint evidence involves collecting and submitting the intact item that bears, or might bear, the fingerprint. At scenes, fingerprints are frequently not visible, but latent (see the next section). Latent prints must be developed using a physical or chemical technique to make the print clearly visible for comparison.

At a scene, logic may suggest collecting items for fingerprint processing at the laboratory. These items would be those that might have been touched or handled by people involved in the case. The purpose might be to try and identify fingerprints so a cold search can be done in AFIS to try and identify or eliminate possible suspects. Another purpose might be to find out who among several people involved in a case touched or handled an item.

At times, fingerprints may be on items that would be difficult or impractical to collect for processing at the laboratory. In addition, some crime scene investigators have knowledge and training in the development of latent fingerprints at the scene. Whether to attempt development of latent prints at a scene is a decision that has to be made in each case. It will be based on the practicality of submitting the intact item, on the latent print knowledge and skills of the investigators, and to some extent on which development technique is judged best in the circumstances.

Classically, powder-dusted fingerprints were collected by tape lifting. This is still a good technique. But powder dusting is no longer among the best choices as a technique for developing latent prints. Latent prints developed by other techniques at a scene should be carefully photographed, and the developed print then documented and collected if possible. The fingerprint should be documented by photography from a distance to show where the fingerprint lies in relationship to surrounding objects and up close to capture enough of the fine detail for comparison. With most techniques other than powder dusting, collection will involve submitting the intact item or object.

The principles of evidence documentation (Chapter 3) apply to fingerprint evidence. The location of prints at the scene and their orientation, or the location of objects or items that are later found to have prints, must be documented.

Latent Prints and Their Development

Developing latent fingerprints, to try and make them suitable for comparison, is an important aspect of crime scene and evidence processing.

Types of Evidentiary Fingerprints

Essentially, three types of prints may be encountered at crime scenes and/or on items of evidence: visible (patent), plastic (impression), and latent. A **visible (patent) print** is one that needs no "enhancement" or "development" to be clearly recognizable as a fingerprint. Such a print is often made from grease, dark oil, dirt, ink, blood, or other visible material. It may be suitable for comparison with no additional processing. A **plastic (impression) print** is a recognizable fingerprint indentation in a soft receiving surface, such as butter, Silly Putty, tar, drying paint, and so on. These prints have distinct three-dimensional character but are immediately recognizable and often require no further processing. A **latent print** is one that, by definition, requires additional processing to be rendered clearly visible, and thus potentially suitable for comparison. The processing of latent prints to render them visible, and hopefully suitable for comparison, is called **development** (or **enhancement** or **visualization**). Great progress has been made in this area by the clever applications of chemical and physical principles, coupled with a better understanding of the composition of latent fingerprint residues.

visible (patent) print
A fingerprint impression that is visible with no enhancement or any special illumination.

plastic (impression) print
A three-dimensional fingerprint indentation in a soft receiving surface, such as tar, margarine, or Silly Putty.

latent print
A fingerprint impression that requires development or special illumination to reveal the ridge detail in sufficient detail for comparison.

development (enhancement, visualization)
Physical or chemical treatment or special illumination, or a combination of both, that enhance the visibility of ridge detail of a latent fingerprint impression sufficiently to enable comparison.

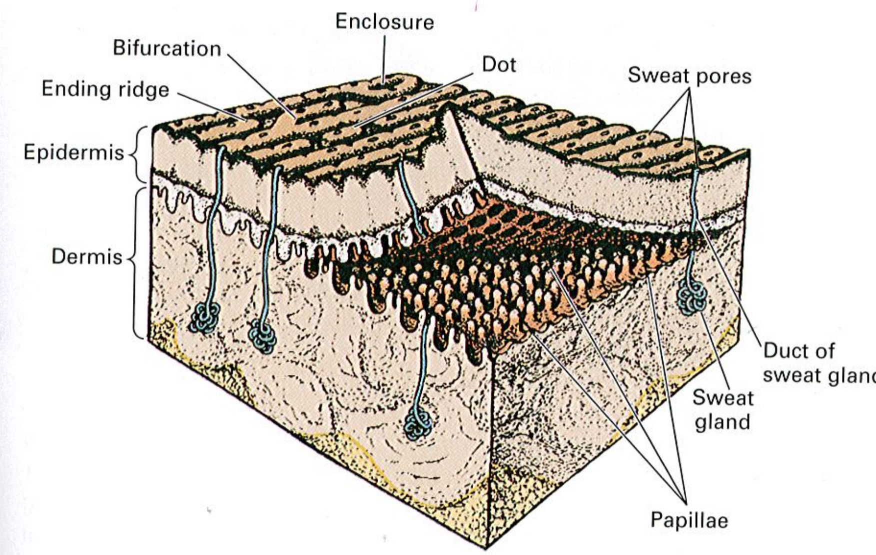

Figure 6.7
Friction Ridge Skin.
The diagram shows the epidermis and the dermis layers of skin, sweat glands and their ducts and pores, and several fingerprint minutiae on the epidermal surface.

(Modified from *The Science of Fingerprints: Classification and Uses*, Federal Bureau of Investigation, U.S. Government Printing Office, Washington, DC)

Development of Latent Fingerprints

Composition of Latent Print Residue Latent print developing techniques are based on using physical or chemical methods to target one or more components of the latent fingerprint residue itself. Friction ridge skin (Figure 6.7) has pores through which small sweat glands can empty their contents onto the skin surface. These sweat glands make a watery type of sweat, the composition of which forms a basis for latent fingerprint residue. Another type of sweat gland in other parts of the body secretes a more oily sweat. The oily material could become part of the latent residue from a person touching portions of his or her or another person's body such as forehead and hair, which have that type of residue, thereby transferring it to their hands. In addition, an almost unlimited variety of substances from the environment can get on to the friction ridge skin and can then be deposited with the latent residue when the person touches a surface. Thus, there are a number of common constituents of most latent print residues based on the composition of sweat, but the proportions can vary, and many other compounds and materials from the environment could be present. Table 6.1 shows some of the common constituents of the sweat that make up fingerprint residue.

Methods for developing latent prints were devised based on knowledge of the latent print residue composition. A method known to be capable of visualizing one of the compounds or elements present in latent residue is applied to try and target that compound or element. For the application to be successful, investigators must be able to apply the method to evidentiary fingerprints on the variety of surfaces where they are found, and without destroying the integrity of the impression pattern. The methods commonly used fall broadly into three groups: physical, chemical, and combination or special illumination methods (which often involve laser or narrow-band pass forensic light sources).

Scene or Laboratory When potential latent prints are recognized at a scene, investigators and scene technicians have a choice: apply latent print development methods at the scene or collect the relevant item or object intact and submit it to the latent print section of the laboratory.

Any item, object, or surface at a scene thought to contain latent prints should be documented by photographs and sketches. Smaller objects or items that are easy to collect and submit should be taken to the laboratory. If it is impractical or impossible

Table 6.1
Some components of latent print residue originating from sweat

Ions: sodium, potassium, calcium, iron, chloride, fluoride, bromide, iodide, bicarbonate, phosphate, sulfate, ammonium and some magnesium, zinc, copper, cobalt, lead and manganese
Proteins
Amino acids (serine, glycine, ornithine, alanine, aspartic acid)
Glucose
Lactic acid
Urea
Pyruvic acid
Creatine
Creatinine
Glycogen
Uric acid
Fatty acids
Triglycerides
Sterols

to remove a surface or object, investigators may have to apply latent development techniques at the scene. Depending on their training and experience, they may want to call on latent print examiners from a forensic lab or identification unit for consultation or assistance. Any fingerprints developed at the scene must be thoroughly photographed and lifted if possible. If neither the developed print nor the object can be moved or collected, the photographs will be the only record of the fingerprint.

Physical Methods Physical methods do not involve any chemicals or reactions. They usually work by applying some type of fine particles to the fingerprint residue; these particles adhere better to the print residue than to the background material, creating a contrasting ridge pattern on the background.

The best-known physical method is **powder dusting**—a mainstay of latent fingerprint detection. The most common powders are inorganic and come in several colors. A variety of brushes is also available. The principle of powder dusting is simply that the powder particles adhere to the latent residue. Careful use of the proper brush and powder often reults in the development of excellent prints. Black or chemist's gray powders are generally superior to other colors. These powders are produced in a way that yields more uniform particle size and generally produces better contrast. Figure 6.8 illustrates the technique. Also shown is the tape lifting of the dusted latent impression. The tape lift is then mounted on a backing with a color that provides maximum contrast with the powder (e.g., white backing for black powder). One-piece lifters (so-called hinge lifters) are commercially available for this purpose. A powder-dusted, lifted latent fingerprint is also shown in Figure 6.9A.

The magnetic brush is a variant of the simple brush and powder combination. The original trademarked version is called the Magna Brush. Actually it contains a small retractable magnet and is not a real brush at all. The magnet protruding from its tube holder is placed close to the magnetic powder, which is attracted to the magnet (and the particles are attracted to one another), thus forming a loose aggregate that acts as the "brush." The magnetic brush uses special magnetic powders that can be obtained in several colors. The principle of magnetic powder enhancement is the same as for conventional powder; namely, adherence of the fine particles to moisture or fatty components of the residue (Figure 6.9B). The **magnetic brush technique** is applicable to a larger variety of surfaces (especially vertical surfaces) than conventional power dusting is. It is also a gentler technique, in the sense that there is no actual brush, and thus no bristles, so it is less possible to damage the latent pattern in the brushing process.

Another physical latent print developing procedure involves **small particle reagent (SPR).** Typically applied by spraying or dipping, the most common

powder dusting
An old but tried-and-true method for visualizing fingerprints on nonporous surfaces.

magnetic brush technique
A variant of powder dusting that uses a magnet and magnetic particles instead of a brush and powder.

small particle reagent (SPR)
A formulation of small inorganic particles in special suspension that can be applied to latent print impressions to enhance ridge pattern features; can be useful with weathered latents, especially those that have been exposed to moisture.

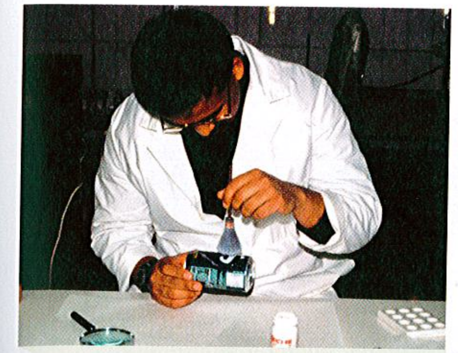

Figure 6.8A
Powder Dusting and Transparent Tape Lift Techniques.
(A) Dusting a soda can with black fingerprint powder.

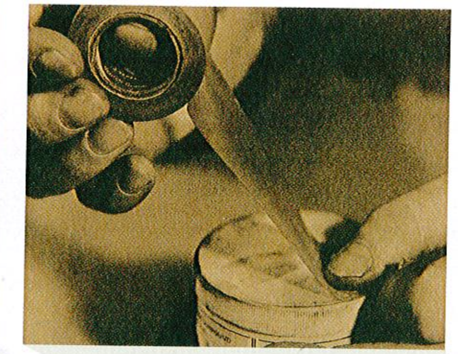

Figure 6.8B
(B) Using fingerprint lifting tape to lift dusted print.

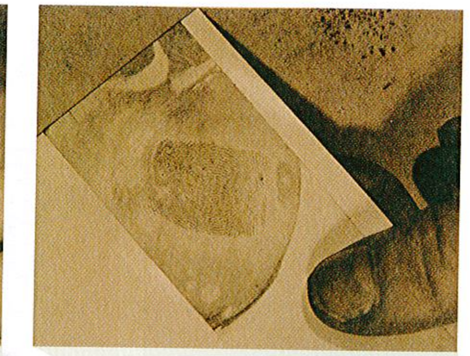

Figure 6.8C
(C) Lifted print placed on a card of contrasting color for easy viewing and preservation.

formulation of SPR is molybdenum disulfide (a heavy, black, very finely divided powder) suspended in a detergent solution. The particles adhere to the lipid components of the residue. SPR is most commonly used on evidence that has been wet or has been recovered from water.

Chemical Methods Classically, the chemical techniques were treatment with silver nitrate, iodine, or ninhydrin. Silver nitrate is now only used as part of physical developers (see later). Elemental iodine, which is a deep purple solid, is one of the compounds in nature that *sublimes;* that is, it can pass from the solid to the vapor state without becoming a liquid. Solid iodine crystals sublime easily, with moderate warming producing a purple vapor that dissolves in oily materials to produce a deep brown coloration. The iodine vapor can be directed toward a latent fingerprint with an iodine fuming gun. Alternatively, an object to be "fumed" can be placed in a closed cabinet, which is then filled with iodine fumes by warming a small dish of iodine crystals in the bottom of the cabinet. Iodine treatment of latent prints is usually called **iodine fuming,** because the latent print residue is actually exposed to the iodine vapors (fumes). Even though it has long been placed under the "chemical methods" category of latent print development methods, the iodine probably doesn't react chemically with any of the components in the residue. It probably interacts with the lipid components in such a way that it is selectively dissolved by the lipid residue, giving the ridge features a dirty-brown colored appearance (Figure 6.9C). The iodine-developed color is not stable in the latent print and the iodine will soon revaporize to return the latent print to its original colorless condition. Therefore, iodine prints must be quickly photographed. There are also chemical methods for converting iodine prints to a permanent color that will not fade. The traditional method involved using starch solution for that purpose, but 7,8-benzoflavone (α-naphthoflavone) treatment is the preferred method today. Iodine fuming is used primarily on inherently valuable items precisely because of its impermanence or where one wants to visualize where a print is located before applying another visualization technique.

One of the oldest chemical procedures for visualizing latent prints makes use of **ninhydrin.** Ninhydrin reacts with compounds called amino acids—amino acids are the building blocks of proteins, and they are found in fingerprint residue—to form another compound called Ruhemann's purple Ninhydrin can be applied by spraying, painting, or dipping. It reacts slowly unless the process is accelerated by heat and humidity. Ninhydrin used to be made up in Freon 113 (a compound similar to the one used in air conditioners), but the concern over the effect of these compounds on the earth's ozone layer culminated in the signing of the Montreal Protocol in 1987, resulting in a ban on the Freon. Now, ninhydrin can be made up in several

iodine fuming
A latent print development technique in which solid iodine is sublimed to iodine vapor, which can then deposit on the ridge patterns of a latent print impression, especially on porous surfaces.

ninhydrin
A chemical for latent print impression enhancement especially on porous surfaces; postninhydrin treatments can further increase the value of this method.

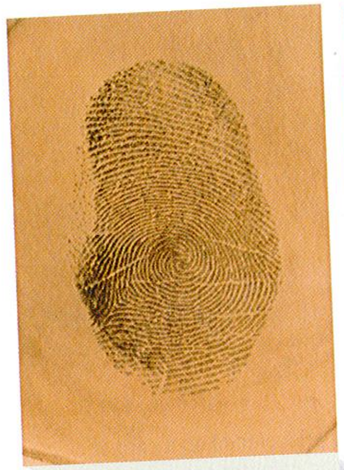

Figure 6.9A
Latent fingerprint visualized by powder dusting.

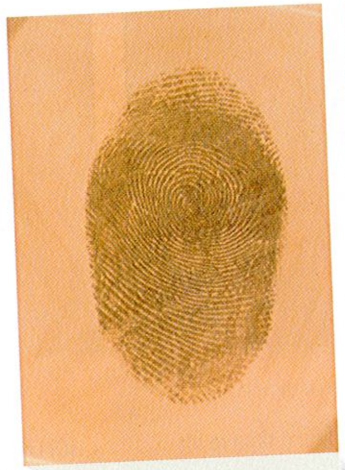

Figure 6.9B
Latent fingerprint visualized by dusting with magnetic powder.

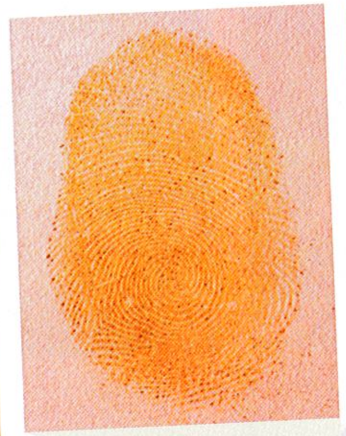

Figure 6.9C
Latent fingerprint visualized by iodine fuming.

Figure 6.9D
Latent fingerprint visualized by treatment with ninhydrin reagent.

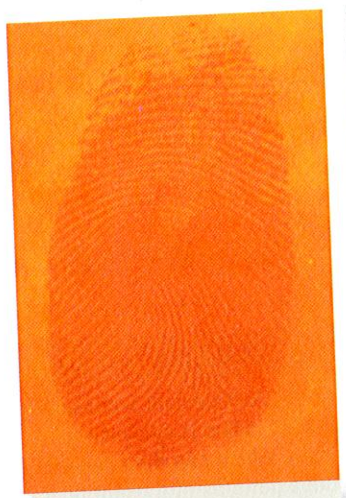

Figure 6.9E
Latent fingerprint visualized by treatment with ninhydrin, followed by zinc chloride, then viewed under a laser.

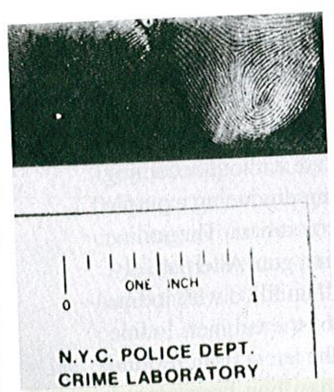

Figure 6.9F
Latent fingerprint visualized by fuming in a closed chamber with Super Glue (cyanoacrylate).

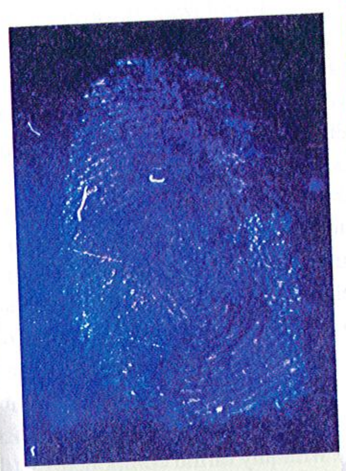

Figure 6.9G
Latent fingerprint visualized by Super Glue fuming and washing with laser dye Ardrox to produce a fluorescent print.

Figure 6.9H
Plastic fingerprint (impression) visualized by side (oblique) lighting.

different solvent systems. One selects the solvent system depending on the type of absorbent material to be processed and what else is present on the evidence.

Ninhydrin develops bluish-purple fingerprints (Figure 6.9D) and is extremely useful on porous surfaces (such as paper). Currently, ninhydrin is often used as a preliminary treatment in processing, followed by further treatment of the ninhydrin-developed prints with other chemicals, and subsequent viewing under laser or alternative light source illumination (see later). Figure 6.9E shows a ninhydrin-developed print, which has been treated with $ZnCl_2$, viewed under blue-green light.

Figure 6.10
Small handheld device used to deliver Super Glue (cyanoacrylate) vapor to a latent print, usually at a crime scene.

The most important other chemical procedure is treatment with **Super Glue (cyanoacrylate).** Super Glue "enhancement" of latent print residue was first observed by scientists at the National Police Agency in Japan. The method quickly caught on and is now used by latent print examiners all over the world. In the early 1980s, fingerprint examiners in the U.S. Army Criminal Investigation Laboratory in Japan, and a little later in the U.S. Bureau of Alcohol, Tobacco and Firearms (ATF) Laboratory, introduced Super Glue fuming for latent print development in the United States. Super Glue will fume (vaporize) with gentle heating, and the fumes will interact with latent print residue by polymerizing and yielding a stable friction ridge impression pattern off-white in color (Figure 6.9F). Items to be processed with Super Glue are usually placed into fuming cabinets where the glue is induced to fill the cabinet with vapors. Glue vaporization is very slow by itself, so it is usually accelerated with strong alkali or heating. Handheld devices have been designed to vaporize Super Glue for fingerprint work (Figure 6.10). Super Glue is an excellent method of developing latent fingerprints on many surfaces. Super Glue–developed prints, like ninhydrin-developed ones, can be further treated before examination. The simplest enhancement of a glue-developed print is powder dusting. Other posttreatments of Super Glue prints include **dye stains.** Because the Super Glue ridges will selectively absorb certain dyes, they can be "dye stained" to make them luminescent or fluorescent. Illumination with a laser or alternate light sources at the appropriate wavelengths for the particular dye used produces greatly enhanced visibility of the print. Gentian violet, coumarin 540 laser dye, Ardrox (Figure 6.9G), rhodamine-6G, and other chemical treatments have been used to produce Super Glue–developed print luminescence under alternate light or laser illumination.

Another chemical method is the use of **physical developer.** The process is obviously misnamed, because it involves chemical reactions. Physical developer enhancement is essentially a photographic process, based on the production of metallic silver on a latent fingerprint image by means of a reaction involving silver ions and an oxidation/reduction reaction involving iron salts. It is thought that physical developer reacts with lipid (fatty) material in the fingerprint residue. The procedure can be used for latent prints on paper, nonabsorbent surfaces, and pressure-sensitive tapes. It has been reported that physical developer sometimes works on latent prints that did not develop with ninhydrin. This result makes sense considering that this procedure is based on reactions with lipid components rather than the soluble amino acids.

Special Types of Illumination and Combination Methods Sometimes, a latent fingerprint can be visualized simply by illuminating it from an oblique angle (Figure 6.9H). This technique may work with white light or with what is often called

Super Glue (cyanoacrylate)
An adhesive material that polymerizes (the chemicals in it react to form a solid matrix) in place when applied to surfaces; Super Glue vapors, produced by heating it, interact with latent fingerprint residue and produce the solid matrix polymer on the ridges.

dye stains
Chemicals that stain cyanoacrylate polymer and can thus be used to further enhance the visibility of Super Glue–developed latent prints; some of the chemicals require the use of alternate light or laser illumination.

physical developer
A special silver-based solution for enhancing latent print impressions by reacting with the fatty (lipid) components; a chemical method.

More on the Science

Postninhydrin and Post-Super-Glue Treatments

In the book's Appendix *Scientific Tools of the Trade—Methods of Forensic Science,* the interactions of light with materials are discussed. Light impinging on a material may be reflected, transmitted, or absorbed. When light is absorbed, it brings about changes in the electronic structure of the material absorbing it. One potential change in the material is a state of temporary excitation. This excited state is not stable, and the material tends to relax back to the original state fairly quickly. In the process of relaxing, energy may be given off in the form of fluorescence or of phosphorescence. Fluoresced or phosphoresced light is always of lower energy (longer wavelength) than the light causing excitation of the material, because some energy is lost during the process of excitation and relaxation.

Different wavelengths of light are absorbed differently by different classes of chemicals. This behavior is the basis of spectrophotometry. A spectrophotometer is essentially an instrument that exposes a chemical or material to a range of wavelengths or light and can detect whether the material absorbs a particular wavelength or not. The result is plotted out pictorially on paper, or on a computer monitor, and is called a spectrum. There are also instruments called spectrofluorometers that can monitor fluoresced light as a function of excitation light wavelength.

Latent fingerprints treated with ninhydrin have formed Ruhemann's purple. Ruhemann's purple can, in turn, be treated with chemicals that form chemical complexes with it. These complexes have particular light absorption-emission characteristics. In the same way, Super Glue–treated fingerprints can be treated with dyes that have particular light absorption-emission characteristics. These characteristics can be exploited to help better visualize the treated latent prints.

In the simplest case, suppose one of the complexes or dyes absorbs red light of the visible part of the spectrum and reflects green light. We could then use an instrument or device to impinge light onto the material and look for green reflectance. The easiest way to do this might involve using a viewing filter that transmits the green light. In this kind of situation, a so-called alternate light source and viewing filter could be used. An alternate light source is really just a high-intensity white light source. Filters can be used to select a particular output color of light. Similarly, filtered viewers can be used to enable the observer to see particular wavelengths of light (that are reflected by the material).

Intense white light sources can also cause fluorescence or phosphorescence in some chemicals. From what has been said above, it should be clear that a particular wavelength of the "white" light is being absorbed, and thus giving rise to the fluorescence or phosphorescence. Alternate light source outputs can be filtered to select a narrowband of wavelengths containing the wavelength that is absorbed by the material of interest. Lasers are extremely intense light sources whose beams have particular vibrational characteristics while traveling through space and are of a single wavelength. For a laser to be useful as an excitation source, the material of interest (like the complex or the dye in the latent print cases) must absorb that wavelength of light. Thus, chemicals capable of being excited by certain wavelengths of light can be formed by appropriate latent print treatments. Then, lasers or alternate light sources can be used to produce reflected light, or fluoresced emissions, that can be visualized, and make the ridge characteristics of the fingerprint that much clearer. Certain lasers can be used to help visualize untreated latent prints. That fact means that there is something in the latent print residue that can absorb the laser light wavelength, and then give off phosphorescence. The Argon laser, with an output wavelength of 488 nm, has been used quite a bit in latent fingerprint enhancement techniques.

alternate light source

A high-intensity white light source filtered to emit only a limited range of wavelengths of visible light.

laser

A special light source that emits light that is of a single wavelength (monochromatic light) and, further, vibrates in a single plane; extremely efficient at exciting chemicals that absorb its wavelength, and can then fluoresce or phosphoresce as the molecules relax.

an **alternate light source,** or "alternative" light source. These are special, high-intensity light sources that often have filters to control wavelength (see the "More on Science" box). Sometimes, latent fingerprints show up better under illumination by certain wavelengths of light.

Alternative light sources are also regularly used in connection with some of the various chemical treatment methods discussed earlier. Often, the chemical treatments result in producing a compound that has a specific fluorescence when illuminated with light of a particular wavelength. This principle is the basis for using alternative light sources and lasers to visualize latent fingerprints. A **laser** emits high-intensity light beams of a single wavelength. Several methods have been developed to take advantage of the excitation wavelengths afforded by the lasers available. The undisputed pioneer in this field was the late Dr. E. Roland Menzel of Texas Tech University. The most recent development in this context has been the development of luminescent nanoparticles for latent fingerprint enhancement.

Bloody Fingerprints and Other Special Conditions Bloody fingerprints have a special value because they often allow experts to put a time on when a fingerprint print was made. One of the limitations on latent fingerprints is that when an individual has normal access to the crime scene it is not possible to say that a print was made at the time of a crime or had been made some time before or even shortly after the incident. Bloody prints must have been made at the time of bleeding and before the blood dries (Case 6.2).

Bloody fingerprints are not really "latent," in the sense that there is at least some faint visibility from the blood, and investigators may recognize that even a very faint pattern in blood could be a fingerprint (or palm print or footprint). However, the ridge characteristics may not be sufficiently defined to make the print suitable for comparison, or an area may have so little residual blood that prints are not visible at all. Under these conditions, use of a blood enhancement reagent might be considered. In this situation, investigators need to think about whether they should try DNA profiling of the blood that is forming the apparent ridge patterns. Substantial published evidence indicates that most latent fingerprint enhancement procedures, including those designed for bloody prints, do not interfere with subsequent DNA profiling. But this situation is one where discussion among latent print examiners, DNA analysts, and investigators is important. Bloody fingerprint enhancement reagents are usually applied as a very fine spray to keep from washing the print away. Some of the recipes produce a reagent that is not very stable in solution and thus has a short shelf life. These need to be prepared shortly before use. Further, there are potentially serious chemical hazards associated with some of the ingredients, so some training and experience are required to prepare and use these reagents. Many bloody fingerprint enhancement reagents are based on the "peroxidase reaction" chemicals (phenolphthalin, leucomalachite green, tetramethylbenzidine, etc.) that we talk about in connection with presumptive blood testing (Chapter 9). These interact with the hemoglobin portion of the blood. There are also some recipes and techniques based on general protein staining dyes like Amido Black and Coomassie Blue. They are generally less hazardous and easier to use than the peroxidase reaction chemicals.

Case Study 6.2

Bloody Fingerprint Helps Place a Suspect at a Homicide Scene at the Time of the Homicide

An elderly man was found dead in a pool of blood in his bed. He had few if any valuable possessions and lived on Social Security. Nevertheless, he was admired in the neighborhood for helping others in time of need. He had become close to a troubled youth who ran errands for him and came to see him and talk frequently. When the man's modest house was processed after the murder, the young man's prints were found everywhere. This had limited significance since he was known to be a frequent visitor. During the careful processing of the scene, however, a small patent print in blood was found on the back of the victim's headboard in a position consistent with where one would place one's hand to hold onto the headboard while attacking the man in the bed. Experts found that this print also belonged to the youth, and the blood was consistent with the victim. This established the youth's presence during the attack on the victim and proved to be a major piece of physical evidence in bringing him to justice.

Fingerprints deposited on tape, especially on the sticky surface, present another special situation. Techniques for visualization include staining with crystal violet and a material called "sticky side powder." Crystal violet stains skin cells trapped by the adhesive a deep violet. Sticky side powder is actually composed of lycopodium (a plant) pollen mixed with a detergent and water. The sticky side powder slurry is painted onto the sticky side of the tape with a brush, and the tape is then rinsed off with water. The tiny, brightly colored pollen grains preferentially adhere to the skin cells, making them visible. The process can be repeated until the desired contrast has been achieved.

Another special situation is the development of latent prints on human skin, almost always on a decedent's body. The idea is to bring up the fingerprints of those who have touched the person. In murder cases, especially involving manual strangulations, the murderer's fingerprints might be on the victim's skin. A variety of different techniques have been tried for this purpose over many years, but the success stories are few and far between. Although a generally useful, robust procedure has not yet been devised, tenting the area of suspected fingerprints and applying Super Glue vapors will occasionally work under ideal conditions.

Systematic Approaches Most latent fingerprint examiners probably use a "systematic approach" even if they don't say it quite that way. The idea is to apply latent development techniques in a way that maximizes the number of identifiable prints. The least destructive technique is applied first, and techniques are generally

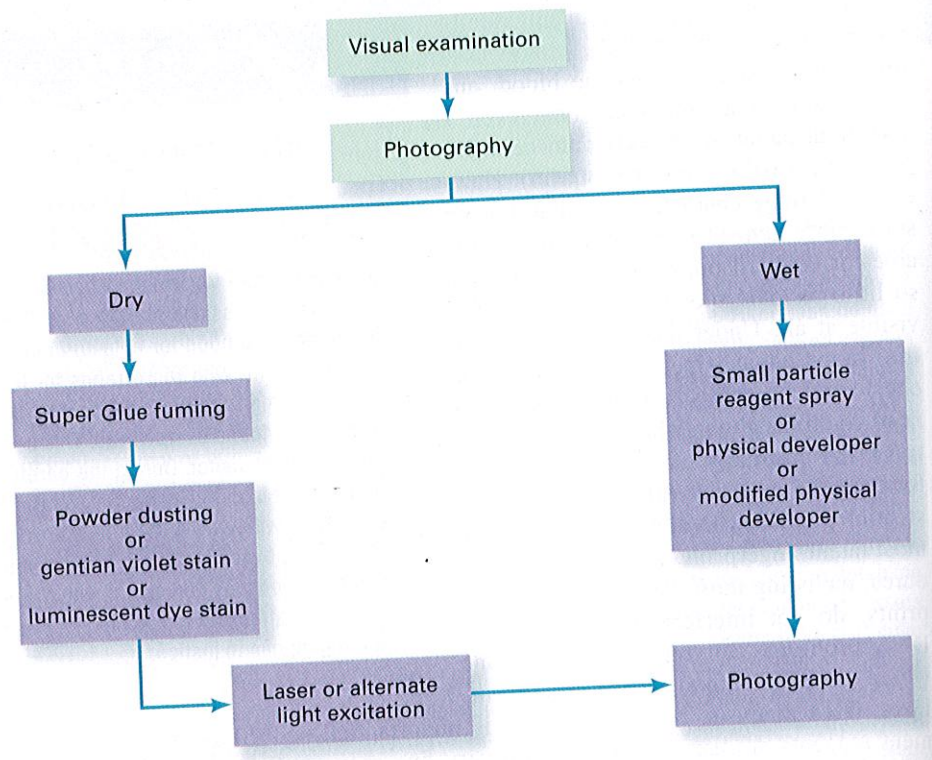

Figure 6.11A
Flowchart for sequence of reagents to use to develop a latent print on a nonporous surface.

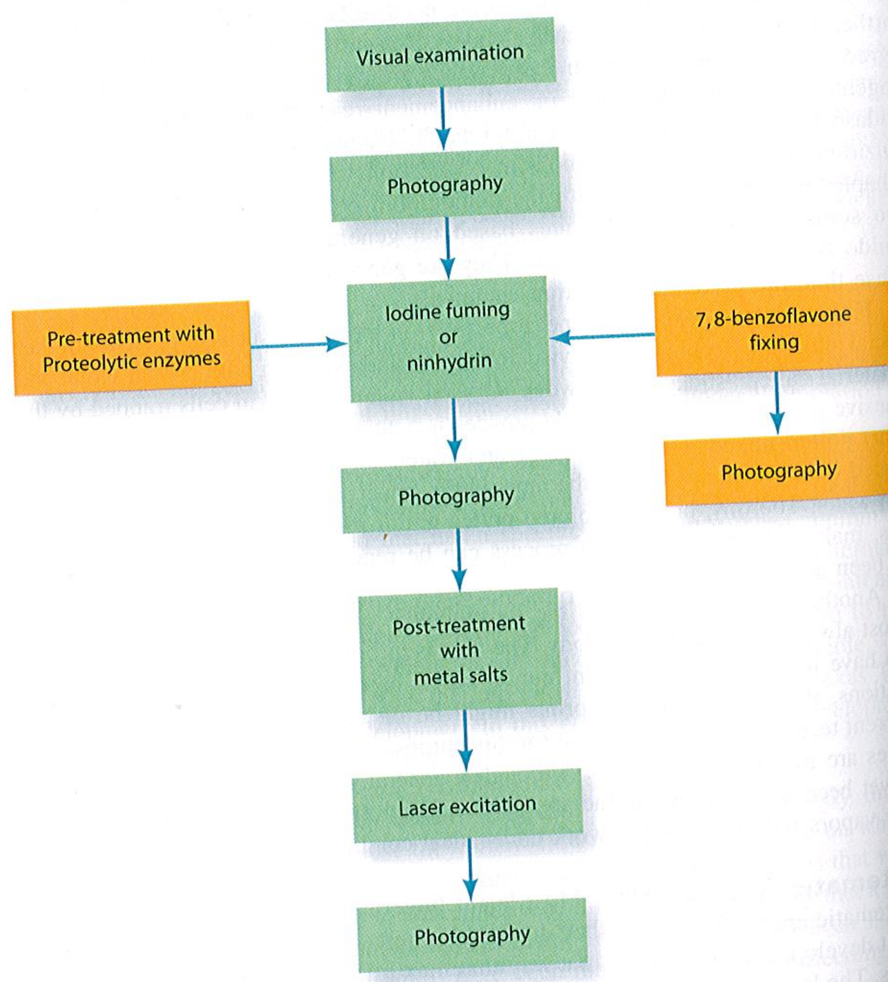

Figure 6.11B
Flowchart for sequence of reagents to use to develop latent prints on a porous surface.

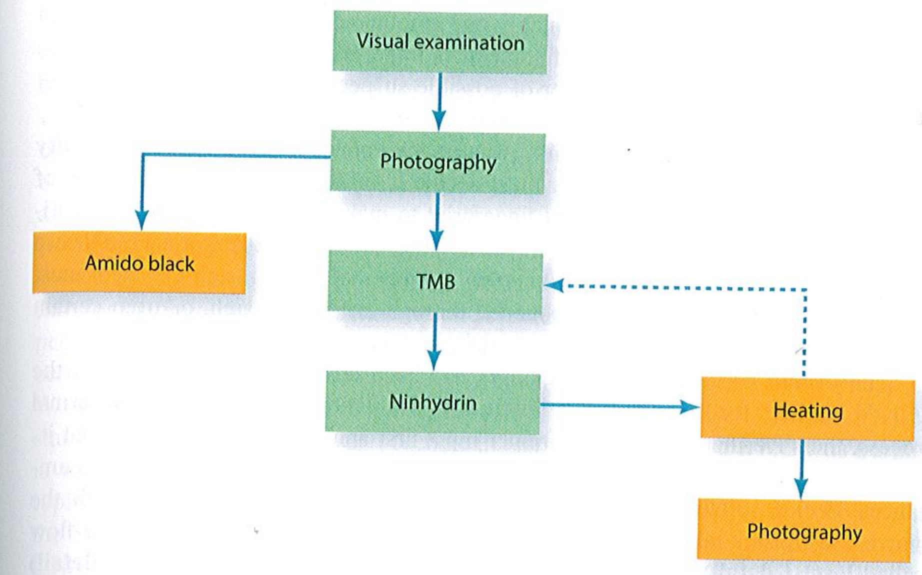

Figure 6.11C
Flowchart for sequence of reagents to use to enhance the visibility of fingerprints in blood.

applied in an order that allows the maximum number to be used until a "suitable" latent (one deemed suitable for comparison) is obtained.

Systematic approaches vary according to the surface (or substratum) on which the latent is located. Porous surfaces, such as paper, for example, call for a different set of techniques applied in a different order than nonporous surfaces. Flowcharts illustrating these approaches are shown in Figure 6.11.

Fingerprint Comparison and Identification

Everything we have talked about in this chapter—indeed, the reason there is a chapter on fingerprints at all—comes down to the use of fingerprints to identify persons. As noted earlier, the uniqueness of fingerprints is a matter of common knowledge. Ads and commercials commonly use phrases like ". . . as unique as a fingerprint," and so on. Even the term "DNA fingerprints," as undesirable and sometimes misleading as it is, was coined to reflect the notion that a DNA profile might be as "individual" as a fingerprint. And infrared spectra of pure compounds are sometimes called "chemical fingerprints."

David Ashbaugh, among others, has noted that fingerprint individuality, and therefore fingerprint identification, is based on four premises:

1. Friction ridges develop in fetuses before birth in their definitive form.
2. Friction ridges remain unchanged throughout life with the exception of permanent scars.
3. The friction ridge patterns and their details are unique and not repeated.
4. The ridge patterns vary within certain boundaries and allow the patterns to be classified.

Fingerprint examiners are generally extensively trained and required to accumulate significant experience before they are given the responsibility of making identifications in cases. Thus, in addition to the general principles and approaches used to make identifications, the knowledge, training, and experience of the individual examiner is an important factor. In law enforcement situations, identifications are always made by trained, often certified, examiners. Where unambiguous identification of someone arrested is the goal, inked prints from a person may be compared with a set of inked prints on file to determine if they came from the same individual. The more complex problem is where the examiner will be comparing a developed latent print, from a crime scene or a piece of evidence, with inked prints from a known person or persons. Evidence fingerprints may not be clear and/or may represent only a small