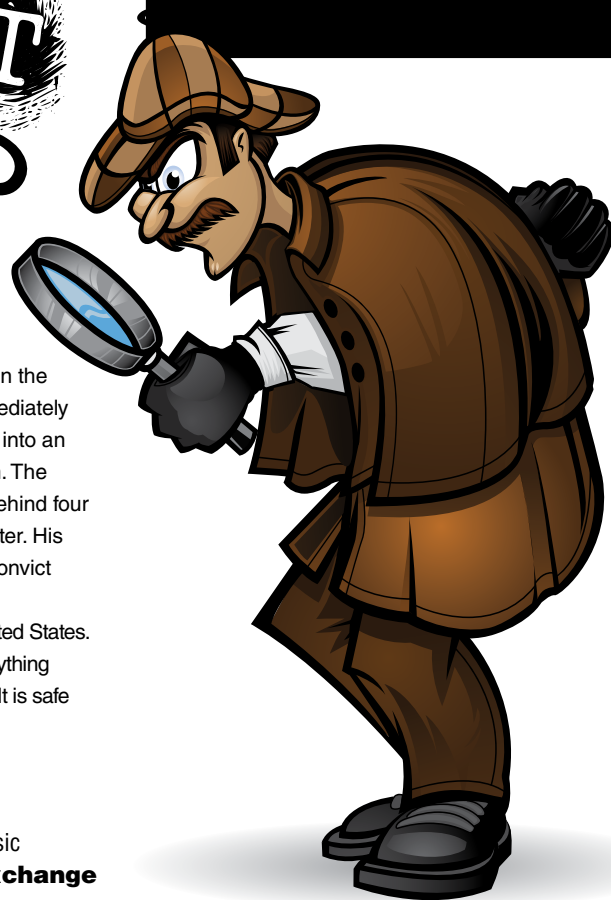


Fingerprints Tell the Story

GUILTY or INNOCENT?

By Brian Rohrig



ON THE NIGHT OF SEPTEMBER 19, 1910, Mary Hiller was awakened in the middle of the night by a noise coming from her daughter's bedroom. She immediately roused her husband, Clarence. On the way to check on their daughter, he ran into an intruder on the staircase. After a struggle, the intruder shot Clarence twice and killed him. The intruder, upon fleeing, touched the wet paint on a porch rail outside the house, leaving behind four fingerprints. A man named Thomas Jennings was apprehended by police a short time later. His fingerprints matched those found in the wet paint. These fingerprints would be used to convict him of the murder.

This case was the first time fingerprint evidence was used to secure a conviction in the United States. Today, fingerprinting is one of the major tools law enforcement uses to identify suspects. Everything about fingerprints—from how they are formed to how they are analyzed—involves chemistry. It is safe to say that without chemistry, forensic science as we know it would not exist.

Unique fingerprints

Even though there are 7.4 billion people in the world today, no two people have the same fingerprints. Even identical twins do not have the same fingerprints, because they form in the womb, beginning at around 10 weeks. While these fingerprints are forming, all the details of the environment in the womb can change how these fingerprints look. The fingerprints of the developing fetus become permanent at about 6 months.

In the 1930s, notorious U.S. bank robber John Dillinger tried to obliterate his fingerprints with acid. More recently, a suspect in the back of a police car bit off the ends of his fingertips so that he could not be identified. In both of these cases, the fingerprints could not be erased. Like it or not, your fingerprints are with you for life.

The value of fingerprints in forensic science is based on **Locard's exchange principle**, which suggests that a person always leaves something behind (and takes something with him or her, too) every time that person interacts with the environment. Named after Edmond Locard of France, one of the early pioneers of forensic science, this observation forms the basis of forensic science as it is practiced today.

Wherever you go, you are almost certain to leave something behind. It may be a strand of hair, a fiber from your clothing, or perhaps some skin cells. If you hug someone, or otherwise engage with a person physically, you will leave behind even more evidence. But perhaps the most important thing you may leave behind is your fingerprints.

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What makes fingerprints?

Fingerprints are sometimes visible, such as when someone gets blood, ink, or grease on their fingers and then touches a surface. These types of visible fingerprints are known as **patent fingerprints**.

If the fingerprints make a 3-D impression in a soft material, such as clay or a freshly painted surface, they are known as **plastic fingerprints**. A great way to make a plastic fingerprint is to push your finger into a glob of Silly Putty.

Latent fingerprints are those that are not readily visible to the naked eye. The word latent means hidden. These are fingerprints left behind every time you touch an object. To understand why you leave behind fingerprints, let's examine a fingertip closely. Under magnification, you will see a row of tiny holes along each friction ridge. Each of these holes is a pore connected to a sweat gland.

The most common type of sweat gland, found in virtually all skin, with the highest density on the hands and feet, is the **eccrine gland**. You have several million of these glands, explaining why your hands and feet often feel sweaty. Several hundred

compounds have been isolated from human sweat. While the primary component of sweat is water, many other substances—such as amino acids, salts, and lipids—are present. Lipids are molecules that contain hydrocarbons and make up the building blocks of the structure and function of living cells. Examples of lipids include fats, oils, waxes, certain vitamins, hormones, and most of the non-protein molecules in cell membranes.

Sweat is not the only source of lipids found in fingerprints, however. **Sebaceous glands** on your face and scalp secrete an oily substance known as sebum, which keeps your skin waterproof. It acts as a barrier that keeps too much water from getting into your body and prevents you from losing too much water through your skin. Sebum also protects skin from bacterial and fungal infections. When you touch your face or hair, you are transferring some of this sebum to your fingers.

This combination of sweat and sebum makes up the oily residue that coats our fingers. When we touch a surface, this oily substance is left behind, along with an impression of our fingerprints. This fingerprint residue is primarily nonpolar in nature, as it contains compounds that do not mix with water. Nonpolar molecules have their charges evenly distributed, whereas polar substances, such as water, have distinct regions of positive and negative charges within each molecule.

Many factors can contribute to the quality of a fingerprint left behind. If your skin is dry,



Lisa Miller (middle), a scientist working at Brookhaven National Laboratory, Upton, N.Y., shows two students why adults' fingerprints can last longer than children's fingerprints.

there will be fewer oils on the skin, and the fingerprint left behind will be less distinct. The type of surface on which the fingerprint is deposited plays a big role in whether a fingerprint can be recovered. A porous surface, such as paper or wood, will tend to absorb the fingerprint, making it last longer but also making it harder to visualize. A nonporous surface, such as glass, metal, or plastic, will leave a more distinct fingerprint. But because a fingerprint is only deposited on a surface, it can be wiped off easily.

Revealing latent fingerprints

Unlike crime shows on television, where perfect fingerprints are uncovered with relative ease, the actual process of revealing latent fingerprints is a tedious and time-consuming

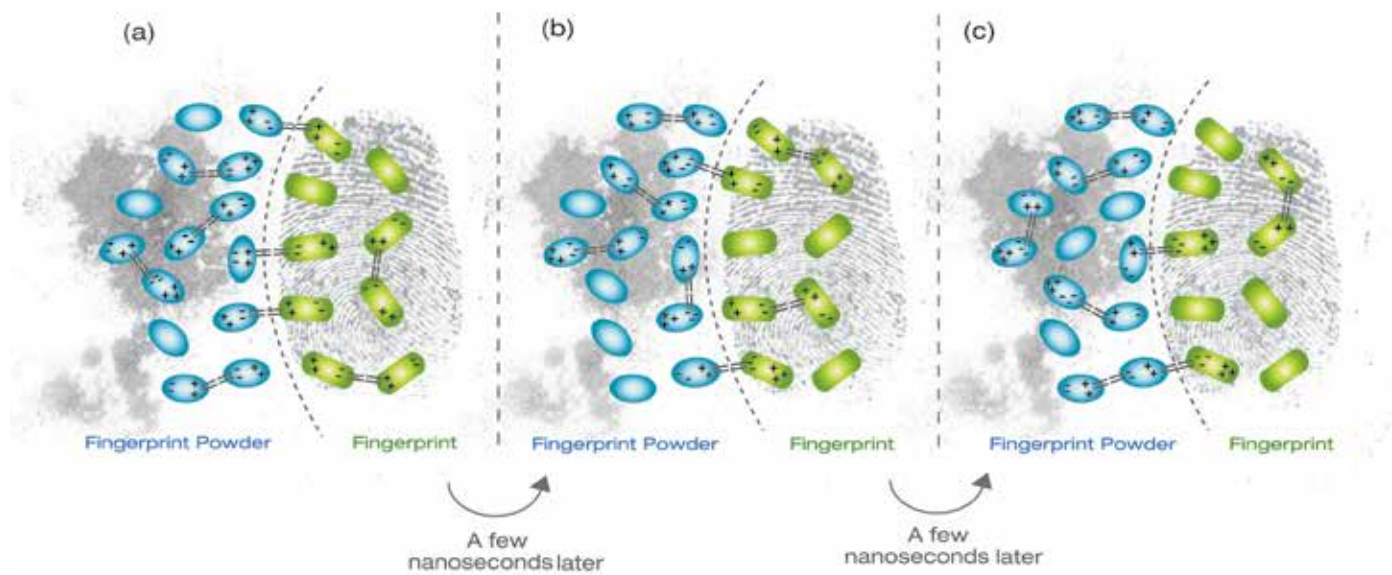


Figure 1. Schematic representation of dispersion-force attractions between nonpolar molecules in fingerprints (right) and fingerprint powder (left) at three times, a few nanoseconds apart (a–c). In nonpolar molecules, slightly negative and slightly positive charged areas of the molecules (indicated by the “+” and “–” signs) form and disappear continuously anywhere in the molecules due to slight fluctuations in the positions of the electron clouds within the molecules. At any instant, a few molecules may not have charged areas, because such charged areas are not permanent.

process. The most common method of revealing latent fingerprints—especially when they are left on a nonporous surface—involves dusting with fingerprint powder. Because like dissolves like, nonpolar fingerprint powder readily binds to a nonpolar latent fingerprint.

Nonpolar substances bind this way through dispersion-force attractions, which are a type of intermolecular force that occurs when areas of opposite charges form between two molecules. These charged areas do not last long, and new ones form in other parts of these molecules. It is these relatively weak and short-lived forces that enable the nonpolar fingerprint powder to adhere to the oily fingerprint (Fig. 1 on p. 6).

The most common type of fingerprint powder is composed of finely divided carbon particles. Fingerprint powders come in black, white, and silver colors to provide maximum contrast between the dusted fingerprint and the surface. But if you dust a black surface for fingerprints, it would not make sense to use a black powder. Instead, a white or silver powder would be preferred.

Also, some fingerprint powders are tagged with a fluorescent dye, causing the revealed fingerprint to glow brightly when illuminated by a black light, which emits ultraviolet light. These fluorescent dyes are highly sensitive to ultraviolet light and may be used if fingerprints are faint and hard to read or if a dusted print is difficult to see.

Once the fingerprint is revealed by dusting, it needs to be preserved. First, a photograph of the revealed fingerprint is taken. Then, a wide square of adhesive tape is applied directly over the dusted fingerprint. The piece of tape containing the powdery fingerprint is

placed on a card that will provide maximum contrast. If using a black powder, the piece of tape would be placed on a white card. This card is then carefully labeled and catalogued as evidence.

Finding a match


Once fingerprints have been revealed, the next step is to match them with those of a known offender. Because many perpetrators are repeat offenders, there is a good chance that fingerprints revealed from a crime scene are already on file from a previous arrest. The U.S. Federal Bureau of Investigation houses the largest computerized inventory of fingerprints in the world, known as the Integrated Automated Fingerprint Identification System (IAFIS), which contains the fingerprints of more than 70 million people. These people include not only convicted criminals and terrorists but also members of the military and those employed by the federal government.

unique. Matching fingerprints is as much of an art as it is a science, and it takes many hours of practice before one becomes proficient.

New frontiers

Recent analysis of fingerprints' oily residues has revealed a method that can determine the age of fingerprints, providing a vital piece of information for forensic investigators who are attempting to determine the time when a crime was committed. Palmitic acid, which is found in a fingerprint's oily residue, will migrate out of the fingerprint at a constant rate, allowing for a determination of the fingerprint's age.

A test was also developed to detect traces of cocaine in fingerprints and cocaine metabolites—products resulting from the breakdown of cocaine in the body—revealing not only that cocaine is present in fingerprints but also whether it was metabolized by the body.

The science of fingerprinting has made incredible strides in the past 100 years. Whereas fingerprinting began as an afterthought, fingerprints are now the first piece of evidence investigators look for when examining a crime scene. Millions of fingerprints are run through IAFIS each year, and numerous cases are solved using fingerprint evidence. Fingerprints are also being used for a lot more than just catching criminals. If you own a smartphone, there is a good chance you have already unlocked it using your fingerprint. There's no telling what your fingerprints may be used for in the future! 

Fingerprints and Gender

The gender of the person who left a fingerprint can be determined by analyzing the ratio of certain amino acids in a fingerprint's oily residue. Amino acids are excreted in sweat, which shows up in fingerprints. **Women have about twice as many amino acids in their sweat as men. Also, due to hormonal differences, women and men have different ratios of certain amino acids,** which can be analyzed to determine whether a fingerprint came from a woman or a man.

—Brian Rohrig

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Brian Rohrig is a science writer who lives in Columbus, Ohio. His most recent *ChemMatters* article, "A Close-Up Look at the Quality of Indoor Air," appeared in the April/May 2016 issue.



Unlike TV shows, in which the computer returns an exact match, when a suspect's fingerprints are run through IAFIS, the computer will return several fingerprints that are the closest match, and then a trained fingerprint analyst will make the final determination.

This determination is made by first classifying the fingerprint into one of three basic classifications—loop, whorl, or arch. Next, the analyst will look for the various factors that make each fingerprint