THE INTRODUCTION TO THE FORENSIC SCIENCES



David Doglietto
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The Introduction to the Forensic Sciences



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Dedication

> *I see no more than you, but I have trained*
> *myself to notice what I see- Sherlock Holmes*

Dedication

This book is dedicated to Monsieur Pierre Locard of Lyon, France. Pierre Locard is the grandson of Edmond Locard, the man who, in the opinion of your author, has contributed greatly to modern day forensics, and who appears throughout this book. Monsieur Locard and his celebrated grandfather have been the inspiration and invigoration of this project. Merci sincèrement pour l'inspiration que vous avez apportée à ce projet. J'espère sincèrement que nous pourrons collaborer à un projet plus ambitieux, entièrement dédié à votre grand-père. La science médico-légale lui doit beaucoup.

Cover photograph: Dr. Edmond Locard at his microscope. Permission granted for publication: 99PH, fonds Denise Locard Stagnara, Archives municipales de Lyon.

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This text was compiled on 04/23/2026

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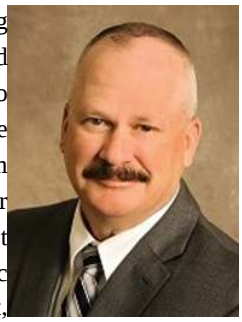
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About the Author



Investigator David J. Doglietto, M.S., CSCSA began his career with the State of California in 1985 working for the Department of Consumer Affairs. He transferred to the California Department of Corrections and Rehabilitations in Sacramento in 1988 and was assigned to the Headquarters Unit. In 1993, he transferred to the Correctional Training Facility, Soledad State Prison in Monterey County, as a correctional officer. He spent the first five years working as a tier officer in a housing unit consisting of 312 medium-maximum security level inmates supervised by only two officers. In 1998, he was assigned as an investigative officer with the Investigative Services Unit (ISU) with the primary responsibility of narcotic investigations. His last assignment was as the senior investigative officer with ISU where he occasionally still worked narcotic investigations, but was also a senior crime scene analyst, latent print technician and comparison analyst, bloodstain pattern analyst, crime scene photographer, major crimes and homicide investigator, and he operated the forensic laboratory. He is a life member of the California Narcotic Officers' Association, a member of the International Association of Identification (IAI), California State Division of the International Association for Identification, and the International Association for Arson Investigators. He is currently a Certified Senior Crime Scene Analyst and has over 2000 formal hours of investigative training, with most of the training in the field of forensic sciences. He has presented workshops at the annual International Association for Identification Educational Conferences since 2012. He is the Chair of the IAI Crime Scene Certification Board and is a member of the IAI Forensic Certification Management Board. He has a Master of Science degree in Organizational Leadership and a Bachelor of Science degree in Criminal Justice Management, both degrees from Union Institute & University. He is an adjunct professor at Hartnell Community College, Administration of Justice Department, in Salinas, California and has developed an Introduction to Forensic Science course for the college. Investigator Doglietto retired from the California Department of Correction and Rehabilitation in 2016. He is now an investigator and senior forensic specialist with the Greenfield Police Department in California. He is the author of Crime Scene Processing for Correctional Facilities and Prisons (2024), CRC Press Taylor & Francis Group.

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CHAPTER OVERVIEW

1: The History of Forensics

> *'There is nothing more important than human life; there is no punishment greater than death. A murderer gives life for life: the law shows no mercy. But to obviate any regrets which might be occasioned by a wrong infliction of such punishment, the validity of a confession' and the sentence passed are made to depend on a satisfactory examination of the wounds.' - Song Ci (Song Dynasty)*

Learning Objectives

- To learn a brief history of the forensic sciences
- To discover an alternative to interviewing suspects and eyewitnesses to solve crimes
- To understand the foundations of scientific methodologies
- To meet some of the most influential figures in the early days of forensic sciences
- To understand the role of forensic associations and organizations to modern forensic science

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1.1: Forensics

When your author mentions the word “forensics” in conversation, he is generally asked the following three questions: What are forensics? How long have we been doing forensics? Is it like on TV? Allow me to answer each of those questions separately. First, the word forensics comes from the Latin word “forensis” which when translated as an adjective into English means ‘public.’ However, the word would be used most to mean to argue in a persuasive manner in the public forum. Today, we can say that we are arguing in a persuasive manner in the legal system, or the courts, using scientific methodology and logical conclusions drawn from observations and experimentations. Second, we have employed forensic investigative techniques for far longer than you would imagine. Finally, no, it is not like on television. Trust me, it is far less glamorous.

Returning to the question of how long we have been doing forensics, we know that Egyptian physicians performed what could be called “autopsies” as far back as 3000BC; however, these autopsies were more closely associated with religious practices than with the legal system. The first recorded autopsy could be said to have been performed by the Roman physician, Antistius, who conducted an internal examination of the body of First Citizen Julius Caeser following his assassination by stabbing in the Roman Senate in 44BC. Antistius recorded that although he counted 23 stab wounds, only one wound penetrated the chest of Caeser leading to his death. The physicist and mathematician Archimedes of Syracuse dabbled in forensic engineering in 265BC when a young general named Heiro won a battle against an enemy of Syracuse and was proclaimed as king by his soldiers. A crown made of gold was commissioned from a goldsmith. A quantity of gold was given to the goldsmith with which the crown was to be made. When the crown was presented to Heiro, he thought it to be a bit on the light side. He wanted to test his theory that the goldsmith had mixed silver with the gold in an effort to cheat the new king, but he did not wish to destroy the crown to answer this question. He presented his quandary to his cousin, Archimedes, then a 22-year-old young man. During his morning bath, Archimedes had his well-known Eureka! moment regarding the displacement of water when an object is immersed. Archimedes measured the displacement of water in a vessel when either a quantity of silver or a quantity of gold was immersed. He determined gold was denser than silver and therefore would displace more water. He then repeated the experiment with the crown and determined it displaced less water than the lump of gold from the previous experiment. Ergo, he proved through forensic engineering that the goldsmith did in fact mix the gold with silver and defrauded the king. No mention is made of the return policy of the goldsmith, or whether he kept his head. In 13th century China, during the Song Dynasty, the brilliant physician, forensic pathologist, judge, anthropologist, and perhaps the first forensic entomologist, Song Ci (also known as Sung T’zu) wrote a book entitled the *Hsi Yuan Lu*, a guide for coroners’ inquests (also called *The Collected Cases of Rectified Injustices* or *The Washing Away of Wrongs*). 13th century Chinese inquests were conducted either on those who had died or those who received a severe wound but survived. In many of the collected cases presented by Song Ci, it is apparent that the inquest concerned itself with not just wound pathology, but also with the weapons that caused the wounds. In this regard, your author will present the reader with the following story.

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1.2: The Washing Away of Wrongs

For the telling of this story, let us imagine the year is 1235AD and a man was murdered by a sharp-edged weapon in the Hunan Province of China. Fortunately, Song Ci was able to solve the crime, even without the presence of an eyewitness. Although documented in Song Ci's book *The Washing Away of Wrongs*, as translated into English by Joseph Needham and Lu Gwei-djen, the following is a fictitious account of the event, as it is not known when the inquest happened; some scholars saying the story may predate Song Ci. It should be noted that aside from that of Song Ci, all other names are fictitious.

Song Ci sat in his small reading room, studying a chart of a body upon which he was writing the names of various bones that lay below the skin, when a young government official, Jingmu Hu Ming of the Gold Bird Guards entered. Jingmu is a title given to government officials who act in the role similar to that of a police officer. "Yishi Song Ci, please forgive this intrusion of your studies, but a farmer has been murdered. His body was found on a trail near the road to Hengyang." "Robbery?" inquired the physician. "Yes, Yishi, we believe so," replied the officer. "Does this farmer have a name?" "Wang Shan Yi, of 39 years," responded the officer. "And the body?" "It was taken to Hengyang at the Shigu Academy, where it awaits your eminence," the officer said as he urged Song Ci to come quickly.

They first traveled by sedan chair and then by animal cart until they were able to take a water boat along the Xiang River, arriving in Hengyang the following morning. Wang Shan Yi was a small, but muscular man, who tended to his rice farm since he inherited the land from his father when he was only nine years old. He was married to his wife, Zhu, at the age of 16 when she was barely 14. The marriage brought additional farmlands and Wang Shan Yi was able to prosper and was blessed with two daughters and a son. He was well respected in his village and people sought his advice on farming techniques and how their own farms could be made more profitable. He was also known as a generous moneylender.

The body reclined on a stone table dressed only in the ku, open-crotch trousers commonly worn by farmers while tending their fields, and a black futou hat. His changpao robe had been removed by the officials prior to the arrival of Song Ci. Tucked in a hidden pocket was his hebao, a small purse for carrying money. Song Ci counted the lead coins and Jiaozi currency in the purse. It was not a fortune, but certainly enough to steal. He then examined the incised wounds on the body and noted there were ten long wounds that were consistent with the use of a sickle as the weapon. Song Ci thought for a moment and said, "Robbers merely want men to die so that they can take their valuables. Now, the personal effects are there, while the body bears many wounds. If this is not a case of being killed by a hateful enemy, then what is it?" He declared the farmer had died from a loss of blood sufficient to sustain life. Turning to Jingmu Hu Ming, he said, "Let us talk to the wife of this poor man. Have her summoned to me without haste." Wang Zhu, wearing a modest white sangfu representing her grief, came before Song Ci. The physician instructed the room to be cleared and sent Jingmu Hu Ming to the village to "secretly observe the neighbors." He then turned to Wang Zhu and inquired, "In the past what man was your husband's worst enemy?" She replied, "Hitherto my husband had no enemies. But only recently there was a certain man who came to borrow money. He did not get it. They had already fixed upon a definite date, and they discussed that. But no money was given and there were no bitter enemies." "Did your husband often lend money?" "Yes, great sir, he was happy in his farm and often provided the money to our neighbors to buy land or make repairs. His terms were greatly less than the piaohao." "And yet, he did not lend to this man," observed Song Ci. "My husband said he was a bad risk; a man who was more common to the jing bottle than the rice field." Song Ci thanked Wang Zhu for her testimony, and they sat for a tea ceremony, known as the Dian Cha. As Wang Zhu was leaving the room, Song Ci inquired, "And do you know the man's name?" "Li Yichen Xi," was the response.

Later that evening, JIngmu Hu Ming returned to the Academy and provided an update of his observations in the village to Song Ci. The villagers appeared to be in agreement with their grief and believed robbers, who were common to the main road, were to blame. He added, "But there were no witnesses to the crime." To which Song Ci replied, "Not one witness, but a thousand eyes saw the crime." He then instructed the officer to find Li Yichen Xi and to bring him before him as quickly as possible. Within a few hours, Li Yichen Xi was located and brought before Song Ci. Song Ci asked the man if his request for a loan was refused, and if he harbored ill-will against Wang Shan Yi. Li Yichen Xi replied, "Wang Shan Yi was my dearest friend. He did not lend me money because the money I needed was given to me by my brother-in-law. I did not need the loan after that." Before dismissing Li Yichen Xi, Song Ci asked, "Did you kill Wang Shan Yi?" "I did not!" demanded the man. Once alone, Song Ci turned to Hu Ming and said, "Go forth and make a proclamation that all farmers of the village must appear at noon in the village square. They are to bring every sickle they own."

The following morning, Jingmu Hu Ming and Song Ci stood in the village courtyard and observed approximately 70 farmers assemble, each carrying several sickles, and each looking as confused as his neighbor. Would it be possible for the officials to examine each sickle? Surely the blade of one sickle would resemble that of every sickle. To their surprise, Jingmu Hu Ming ordered them all to set their sickles on the ground in a row and to then back away by twenty paces. Hu MIng looked at Song Ci, whose eyes he could see were scanning each blade intently from a distance of ten paces. “What now, Yishi?” he inquired. “We wait for our witnesses to arrive,” responded Song Ci. With the heat of the mid-day sun and a slight breeze blowing from the direction of Hengyang, it took only a few minutes for the first eyewitness to arrive, a fly. The fly buzzed past Song Ci, circled the row of sickles, and landed on just one. The fly appeared content to remain on this sickle. Shortly after, dozens of flies had joined the content fly on the blade of the same sickle. Song Ci leaned towards Ming Hu, pointed in the direction of the sickles, and said, “See how content the flies are to remain on that one sickle. Those that landed on the other sickles quickly abandoned those for that one.” “Why is this so, Yishi?” asked the bewildered officer. “It is the blood of Wang Shan Yi on that blade that has made it their preference. There are your witnesses.” Song Ci’s eyes then scanned the line of farmers. He noticed that the eyes of the farmers were focused on the owner of the now fly-covered sickle. It was Li Yichen Xi. Song Ci pointed at Li Yichen Xi and stated,” Now, you have killed a man. There are traces of his blood on your sickle, so the flies gather. How can this be concealed?" For a moment the bystanders were speechless and then murmured with admiration. Li Yichen Xi fell to his knees, knocked his head on the ground, and confessed.

Whether Son Ci’s telling of the story was factual or a parable, we do not know. If factual, one would assume that Song Ci had previously performed experiments with flies to determine if they would prefer traces of dried blood as a food source over residues associated with the sheaving of grains. Of course, without the confession, the discovery of traces of blood on the blade of the sickle would be circumstantial at best. It is true that the sickle belonged to Li Yichen Xi, but that does not mean that he was the killer. Someone else could have taken the sickle, committed the crime, and returned it without having been detected. The blood may have also been that of an animal. Today, we would conduct presumptive and confirmatory testing of the blood discovered on the blade of the sickle, and to confirm through DNA analysis that the blood did in fact belong to Wang Shan Yi in the story. Furthermore, DNA swabs collected from the handle and latent print development would determine if anyone other than Li Yichen Xi had handled the sickle.

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1.3: Crime Scene Examination and the First Forensic Laboratories

The systematic processing of the scene of a crime following scientific methodologies is a product of the 20th century. Modern crime scene processing seeks to document the entirety of the scene, and adjacent areas, to preserve the evidence within the scene, to mitigate contamination, and to discover and collect evidence and observations that can later be used to identify the participants, reconstruct the series of events of the crime, conduct subsequent analysis of evidence collected from the scene, and for the presentation of factual evidence during courtroom procedures in a manner that is fair, objective, and unbiased. Crime scene processing as a scientific methodology did not just appear in the 20th century but was an evolution of a combination of two things: historical investigative efforts and modern technology.

One could say that there have always been clever investigators, like Song Ci, who have utilized some form of scene or evidence analysis to draw a conclusion as to the identity and guilt of a suspect. Perhaps the earliest investigation involving footwear analysis and comparison occurred in Kirkcudbright, Scotland, in 1786. A young girl by the name of Elizabeth Hughan was stabbed to death in a field. As the detectives were examining the body, one noted the impression of the outsole of a boot in the mud next to the body. The detective used a thin parchment to draw an outline of the impression, noting individual characteristics such as nicks in the heel, and noted the boot that made the impression was "Heavily nailed and patched." The detectives then ordered all the men of the nearby village to bring their boots for inspection. A comparison was conducted, and a matching boot, belonging to Richard Robertson, was found, thus solving the case. This evidence was presented against Richard Robertson at trial.

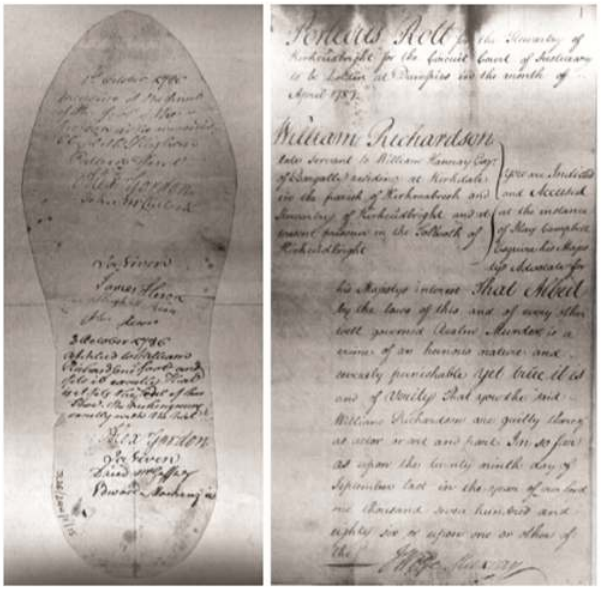


Figure **1.3.1**: With permission from the collection of William Bodziak

Of course, today the footwear impression would be photographed using a digital camera and a casting of the impression would be made using dental die stone.

From the moment Joseph Nicéphore Niépce had the idea of capturing a photographic image of his estate in La Gras, France, in 1826, using a camera obscura, your author believes somewhere lived a detective who thought to himself, "I wonder if I can photograph a crime scene with that thing." It, of course, would take another six decades before a plate camera was used to document the victims of the White Chapel murders in London, England. It would take another two decades before Alphonse Bertillon took the first photographs of the crime scene itself in Paris, France, in 1903, while documenting the murder scene of Madame Debeinche. The first hand-held camera was invented in 1912, making them more portable and convenient for crime scene photography. Today, full-frame and mirror-less digital cameras are the mainstay of every crime scene technician. Also today, every crime scene technician uses a camera to photographically document the crime scene with overall or scene-establishing photographs, medium-range or evidence establishing photographs, and close-up or evidentiary photographs.

In 1880, **Dr. Henry Faulds**, a Scottish physician and surgeon, is believed to be the first person to identify a patent greasy fingerprint on a bottle of medical alcohol, and then to match that print to a suspect. What Dr. Faulds did not do was to develop a

latent fingerprint, although he did develop a method of recording exemplar fingerprints using printers' ink. It would not be until the 1920s that granular powders were developed for dusting fingerprints that could not be detected by the human eye. Cyanoacrylate ester fuming (Super Glue) was not invented until the late 1970s. Today the crime scene technician has a vast array of development mediums that can be employed either at the crime scene or on recovered items of evidence in the laboratory.

Even the criminalistic laboratory is a product of one man in the 20th century; Edmond Locard, who created the first laboratory dedicated to the scientific examination of evidence from a crime scene in 1911, in Lyon, France. Locard attributed the creation of this laboratory to one influential fictional character, Sherlock Holmes.

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1.4: Sir Arthur Conan Doyle and Sherlock Holmes

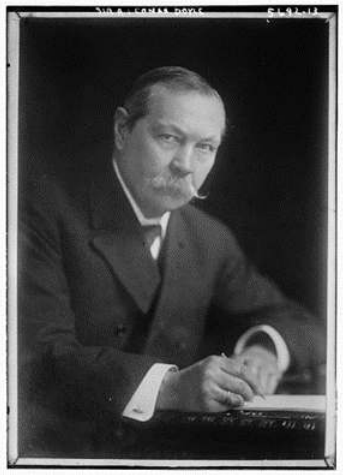


Figure 1.4.1:Sir Arthur Conan Doyle – US Library of Congress – Bains New Service 1920-1925 – Public Domain

Although your author does not believe that when **Sir Arthur Conan Doyle** first published the exploits of his fictional character Sherlock Holmes in *A Study in Scarlet* on the pages of The Strand Magazine in 1887, that he intended to change criminal investigations forever, but he most certainly did just that. Prior to the first use of a magnifying glass by Sherlock Holmes to reveal trace evidence in a crime scene, or his constant complaints regarding the inability of law enforcement to preserve the scene, which persists to this day, to his beakers and test tubes in his home laboratory at 221B Baker Street, police investigators relied upon eyewitnesses and rounding up the usual suspects to solve crimes. Even the way Sherlock Holmes approached a crime scene was novel and unique, as described by Dr. Watson at the death scene at 3, Lauriston Gardens:

> *"I had imagined that Sherlock Holmes would at once have hurried into the house and plunged into a study of the mystery. Nothing appeared to be further from his intention. With an air of nonchalance which, under the circumstances, seemed to me to border upon affectation, he lounged up and down the pavement, and gazed vacantly at the ground, the sky, the opposite houses and the line of railings. Having finished his scrutiny, he proceeded slowly down the path, or rather down the fringe of grass which flanked the path, keeping his eyes riveted upon the ground. Twice he stopped, and once I saw him smile, and heard him utter an exclamation of satisfaction. There were many marks of footsteps upon the wet clayey soil, but since the police had been coming and going over it, I was unable to see how my companion could hope to learn anything from it. Still, I had had such extraordinary evidence of the quickness of his perceptive faculties, that I had no doubt that he could see a great deal which was hidden from me." – Sir Arthur Conan Doyle, A Study in Scarlet, 1887*

Sir Arthur endowed Sherlock Holmes with a form of reasoning that later became known as Holmesian deduction, which was the ability to solve crimes using detailed observations and hypothesizing to solve crimes. In reality, the fictional detective utilized inductive reasoning, which is a method of logical hypothesis drawn from observations and then extracts general conclusions gathered from information revealed during the investigation.

Sir Arthur Conan Doyle, a physician who based the character Sherlock Holmes on John Bell, his Scottish professor who greatly influenced Sir Arthur by his diagnostic abilities, wrote nine books, four novels and a collection of short stories, between 1887 and 1927. The stories were well received at a time when forensic science was coming of age. The books certainly influenced French criminalists like Alphonse Bertillon and Edmond Locard, by their own admission, and, although there is no definitive proof, Hans Gross, the Austrian jurist, magistrate, and professor who was known as the Father of Criminal Investigations.

Edmond Locard gave praise to Sir Arthur when in 1929 he wrote in a paper published in the *Revue Internationale de Criminalistique* titled The Analysis of Dust Traces,

> *"I hold that a police expert, or an examining magistrate, would not find it a waste of his time to read Doyle's novels. For, in the adventures of Sherlock Holmes, the detective is repeatedly asked to diagnose the origin of a speck of mud, which is nothing but moist dust. The presence of a spot on a shoe or pair of trousers immediately made known to Holmes the particular quarter of London from which his visitor had come, or the road he had traveled in the suburbs. A spot of clay and chalk originated in Horsham, a peculiar reddish bit of mud could be found nowhere but at the entrance to the post office in Wigmore street."*

In the same paper, Edmond Locard credits Sir Arthur with the concepts of trace evidence detection and recovery that he employed at his laboratory in Lyon, France.

Your author recommends the reader conduct research into the case of George Ediji, who was convicted of animal mutilations, and George Slater, who was wrongfully convicted of murder. Sir Arthur was instrumental in the establishment of the British Court of Criminal Appeals.

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1.5: Hans Gross



Figure **1.5.1**: From the National Institute of Justice

Hans Gross was an Austrian jurist, or magistrate, who took up his posting in Upper Styria, an area of iron production near the Croatian border, in 1870. In those days, criminal investigators were not available in the small towns and villages, and law enforcement was left up to village officials, generally former military personnel, acting in the capacity of police officers. It was therefore the role of the jurist or “examining magistrate” to find practical solutions to incidents of criminal nature. Most examining magistrates would solve crimes using what the Austrians would call “Mutterwitz” or the common sense you would get from your mother. Whether influenced by the Sherlock Holmes stories or not, Hans Gross believed that a more thorough and systematic approach to investigating crimes was merited, and he set about an intensive campaign of study and self-enrichment to add to his vast experiences. According to Roland Grassberger in his 1957 paper entitled *Pioneers in Criminology,* “During many fertile years of intensive practical activity as an Examining Justice and later as a Public Prosecutor at Graz Hans Gross collected an enormous amount of experience. He very eagerly studied a great number of treatises on physics, psychology, medicine and science in general. He occupied himself with microscopy and photography and took great interest in the development of the X-rays which at that time was in its earliest stage. By studying all these subjects of physical and technical science he tried to find out to what extent they could assist the investigation of crime. Thus, Hans Gross founded the "Criminalistics" as a special police science.” In 1893, Hans Gross wrote his ground-breaking book the *Handbuch für Untersuchungsrichter als System der Kriminalistik* or *Handbook for Investigating Judges as a System of Criminalistics.* Although the book did not dispute the historical significance of “rounding up the usual suspects,” especially if they were gypsies, it did introduce the need for research, and for special attention to be paid to the scene of the crime, including an inspection of the area for trace evidence such as hairs, fibers, blood, and other bodily fluids. The book was translated into English in 1903, and Hans Gross earned the title of the Father of Criminal Investigations or the Father of Criminalistics. Hans Gross established the Institute of Criminology of Graz in 1898 where he taught criminal law and criminalistics until his death in 1915. He was also a professor at Chernivsti University (now in Western Ukraine) from 1897 to 1902, Prague University (now in the Czech Republic) from 1902 to 1905, and the University of Graz from 1905 to 1915.

Your author recommends Roland Grassberger’s paper on Hans Gross and a visit to the website of the Hans Gross Museum in Graz, Austria.

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1.6: Edmond Locard

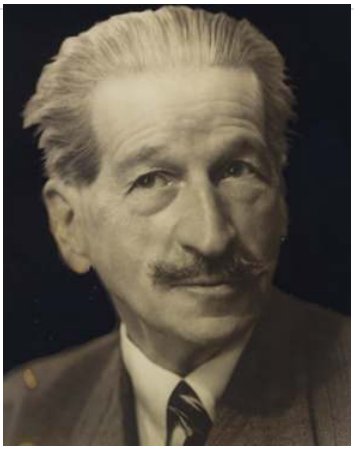


Figure **1.6.1**: Edmond Locard - Permission granted for publication: 99PH, fonds Denise Locard Stagnara, Archives municipales de Lyon.

It is your author's humble opinion that the person who had the most influence on the forensic sciences was **Edmond Locard**, so much so that in his lifetime he was called "The Sherlock Holmes of France." Dr. Locard studied both medicine and law and had a keen interest in combining medical science with legal matters. He studied under Dr. Alexandre Lacassagne, the French criminologist who founded the Lyon-based Lacassagne School of Criminology, and who famously wrote, "Every society gets the kind of criminal it deserves." In 1910, Dr. Locard approached the administration of the Lyon Police Department and offered his services as a criminalist for their forensic laboratory. The only problem was that they did not have one; no one did. He was able to convince the police officials to allow him to fund and operate a laboratory, likely modeled after the fictional laboratory found at 224B Baker Street, in two small rooms in the attic of the police station. The laboratory was officially recognized by the Lyon Police Department in 1912. This laboratory was the first known criminalistic laboratory in the world. It did not take Dr. Locard much time to put his forensic talents to work. In 1912, Dr. Locard was called to the murder scene of Marie Latelle, who was found shortly after midnight in a room of her parent's house. Her boyfriend, Emile Gourbin, was suspected of the murder by the Lyons Police Department. There was just one problem, Emile was playing cards with friends at his apartment when the crime was believed to have occurred. Dr. Locard was asked to make an examination of Emile, and with magnifying glass in hand, Dr. Locard discovered the residue of a reddish-pink powder underneath his fingernails. Dr. Locard collected this powder by scraping the fingernails into a pharmaceutical fold envelope. He then went to the crime scene. He noticed a jar containing a face powder that was sitting on the vanity of the victim, which he collected into evidence. He also noted the victim had bruising consistent with fingermarks on her neck. In the laboratory, Locard identified the components of the powder from the fingernail scrapings as bismuth, zinc oxide, magnesium stearate, and Venetian red, a reddish iron oxide pigment. The same components were found in the face powder he collected from the crime scene. He later discovered that the powder was sold to Marie Latelle by a Lyons druggist who made the formula specially for her. Faced with this information, Emile confessed to the crime. In order to have an alibi, he invited his friends to his house for a card game. Prior to their arrival, he set the clocks in the apartment back one hour. He insisted his friends leave the apartment at midnight, making it a point that they look at the clock to mark the time; however, it was only eleven. That is when he snuck out of the apartment from an upstairs window, climbed through the window of Marie's bedroom, and strangled her to death. In 1920, Dr. Locard published his theory of evidence exchange in which he surmised that when two objects come into contact with each other, a transfer of evidence will occur between the two objects. This is the primary theory associated with the forensic principles of trace and transfer. Your author believes the more violent the contact, the more likely evidence will be transferred from the suspect to the victim, the victim to suspect, and the suspect and victim to the crime scene. In the 1960's, the American criminalist Dr. Paul Kirk summed up Locard's Principle of Evidence Exchange as follows:

"Wherever he steps, wherever he touches, whatever he leaves, even without consciousness, will serve as a silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood he deposits or collects. All of these and more, bear mute witness against him. 'This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual

evidence. Physical evidence cannot be wrong, it cannot perjure itself, it cannot be wholly absent. Only human failure to find it, study and understand it, can diminish its value."

Just imagine that this concept was understood before the advent of deoxyribonucleic acid typing in criminal investigations.

Your author recommends a glance at the seven-volume *Traité de Criminalistique* (*Treaty of Criminalistics*) to see even more contributions Dr. Locard gave to the forensic sciences.

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1.7: Dr. Charles Norris and Alexander Gettler



Figure **1.7.1**:Dr. Norris (right) and Alexander Gettler (left) Courtesy the National Institute of Health

Dr. Charles Norris, born 1867 to a wealthy Philadelphia family, who had studied in Berlin and Vienna, was a physician in New York in the early part of the 20th century. He was keenly aware that the City of New York lacked a competent means by which deaths were investigated, autopsies were conducted, and the means, manner, and cause of death determined. In fact, there were no requirements that a coroner was a doctor of any kind or had any previous experience dealing with death and dead bodies. The only motivation for a person doing the job of coroner was the money they would be paid, and they were not above the occasional graft. Most often, in cases where death was not apparent, no investigation was conducted and therefore would be listed as unknown. This would be an ideal situation for the corruption that gripped New York politics at the time. Dr. Norris' time spent in Europe exposed him to the professional medical examiner systems there, and he knew it would work in New York as well. Upon his return to the United States, Dr. Norris convinced like-minded government officials who wanted to replace the current city coroner system with a professionally trained group of city personnel who could competently investigate cause of death. Therefore, in 1918, Dr. Norris was appointed as the Chief Medical Examiner at Bellevue Hospital in New York. He remained in this capacity until his death in 1935 in spite of the many obstacles and false accusations levied at him by various mayors of the City of New York who preferred the controllability of the previous city coroner system. There was no doubt that Mayor "Red Mike" Hylan preferred the more corruptible city coroner system who would continue to do "favors" for him. He found that Dr. Norris was incorruptible and a man who was driven by the desire to have a professional Medical Examiner's Office that would investigate deaths based solely on truth and science. Mayor Hylan therefore cut the budget for Dr. Norris' office in an effort to force the office to close. The major obstacle to this plan was the fact that Dr. Norris came from a wealthy family and he continued to run the office by funding it himself. Mayor "Jimmy" Walker did not oppose Dr. Norris' efforts, but he did nothing to restore funding to the office to make it viable. Finally, Mayor Fiorello LaGuardia, who erroneously believed Dr. Norris had embezzled nearly $200,000.00, initiated a criminal investigation of which Dr. Norris was exonerated.

Dr. Norris knew that he would need a good team to make his dream of having a truly professional and scientific agency hired **Alexander Gettler**, a brilliant chemist, to create the first toxicology laboratory in the country. Alexander Gettler was a Jewish immigrant from Poland who had studied chemistry at Columbia University. His many research papers are still being used in support of the science of forensic toxicology. Alexander Gettler remained with the New York Office of the Medical Examiner until 1959.

Dr. Norris' greatest triumph was in gaining the respect of the New York Police Department, who, at first being skeptical of the role of forensic science in solving crimes, began to see Dr. Norris and his staff as partners in solving crimes rather than rivals. With this association, the New York Police Department and the Office of the Medical Examiner not only solved current crimes but also solved cases that were previously listed as unsolvable.

Even though the pressure and stress placed upon Dr. Norris by the various mayors of the City of New York ultimately contributed to his death by heart failure in 1935, the work that he started, along with the convictions of a dedicated staff, gave this country the model of a professional Medical Examiners Office that is still followed today.

Your author highly recommends that documentary The Poisoners Handbook (2013) by the Public Broadcasting Service, based on the book by Deborah Blum. It is an exceptionally well-produced and highly informative documentary on Dr. Norris and Alexander

Gettler’s efforts to create the first professional Medical Examiner’s Office and the roadblocks they faced. The link to the documentary may be found in the reference section of this chapter.

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1.8: Henry Goddard and Calvin Goddard

Interestingly, although not related and separated by an expanse of ocean and more than a half-century, Henry Goddard of the London Bow Street Runners, the precursor of the London Metropolitan Police, and Calvin Goddard, one of the founders and head of the New York Bureau of Forensic Ballistics equally influenced the modern forensic science of ballistics.



Figure **1.8.1**: Henry Goddard. Courtesy of the National Institute of Justice

Henry Goddard, Principal Officer and investigator with the Bow Street Runners was tasked with the investigation of the murder of Mrs. Maxwell who was shot and killed in her home in Southampton, England, in 1835. Her butler, Joseph Randolph, claimed that burglars had entered the house, and Mrs. Maxwell was shot during a confrontation with the men. It was during this investigation that Henry Goddard conducted the first thorough examination of a bullet, which revealed a visible flaw, which he called a “pimple.” He determined this flaw was created when the bullet was made in a mold from the hole in which the lead was poured. He was able to find the mold amongst the supplies Joseph Randolph had for a hunting rifle he owned and to make comparison between the bullet from the murder to a bullet cast in this mold. He was also able to identify the paper patch that was used to seal the bullet against the powder charge within the barrel. He matched the paper to a torn portion of a newspaper found in the servants’ quarters. With this information, Joseph Randolph was arrested and charged with the murder of Mrs. Maxwell.



Figure **1.8.2**: Calvin Hooker Goddard. Courtesy of the National Institute of Justice

Calvin Hooker Goddard was born in Baltimore, Maryland in 1891 and developed a fascination with firearms. He pursued his education in medicine at Johns Hopkins University and earned his degree in 1915. He joined the United States Army and rose to the rank of Colonel. In 1925, he returned to his interest in firearms and co-founded the New York Bureau of Forensic Ballistics, which he was the head until it dissolved in 1929. In this time, Calvin Goddard worked with Philip O. Gravelle to develop the comparison microscope, which allowed the technician to microscopically examine two bullets side-by-side. In 1927, Calvin Goddard was called to help investigators with the Massachusetts robbery/murder case of Nicola Sacco and Bartolomeo Vanzetti, two Italian immigrant anarchists. By using the comparison microscope to analyze bullets from Sacco's revolver and those found at the crime scene, Goddard confirmed that Sacco's gun was used in the robbery. His conclusions were upheld in a re-examination thirty years later. Goddard was also involved in the 1929 investigation following the St. Valentine's Day Massacre in Chicago. The case revolved around the murder of seven gangsters by men dressed in Chicago police uniforms. It was unclear whether the killers were police officers or rival gang members dressed as police officers. Goddard, working as an independent investigator hired by the foreman of the grand jury, tested the machine guns used by the Chicago police and concluded that they were not used in the murders. Later that year, after a raid on the home of one of Al Capone's hit men, two machine guns were recovered. Goddard tested these weapons and proved that they were used in the murders. Calvin Goddard became the director of the Scientific Crime Detection Laboratory, which was affiliated with the Northwestern University School of Law near Chicago, and later the laboratory was transferred from the University to the Chicago Police Department. Your author uses a comparison microscope previously

operated by the Chicago Police Department from 1947 to 1978, which he hopes that Calvin Goddard once touched, which is quite unlikely to have happened.



Figure **1.8.3**: Comparison microscope. Author's collection

Your author recommends additional research into the 1915 Charles Stielow conviction and the efforts of Charles E. Waite and Dr. Max Poser to correct the misjustice caused by the erroneous conclusions of a “ballistics expert.”

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1.9: A Brief History of DNA Typing

The concept of DNA was first discovered in 1869 when a Swiss scientist by the name of Johann Friedrich Miescher discovered what he called the nuclein, a phosphorus-rich substance from the nuclei of a cell; however, other scientists were slow to understand or accept the importance of DNA in its fundamental role in inheritance. The work of Friedrich Miescher was largely forgotten or ignored, but in 1919, Russian biochemist Phoebus Levene published the rudimentary discovery of what he termed the tetranucleotide structure of DNA based on the Guanine, Cytosine, Adenine, and Thymine model (G-C-T-A-G-C-T-A etc.). In the 1940's, Austrian biochemist Erwin Chargraff conducted research to determine if there were any differences in the DNA of varying species. He discovered the nucleotides of different species were not in the same order as Levene had thought. He also concluded that almost all DNA maintains certain properties, no matter what organism it came from, even with varying composition. This led to the discoveries of James Watson and Francis Crick in the 1950's. They proposed the double-helix structure of DNA and discovered that it was an extraordinary molecule skillfully designed to carry out the task of controlling the genetic traits of all living cells, plants and animals.

A forensic application of DNA was not even considered until the discovery of two teenage girls who were found raped and murdered in the United Kingdom in 1983. The body of 15-year-old Lynda Mann, a schoolgirl from Narborough, a large village in Leicester, England, was found on a walking path. She had been strangled and raped. There were no witnesses or clues, and no investigative leads as to the identity of the suspect. Three years later, another teenage schoolgirl, Dawn Ashworth, was strangled and raped and her body found on a path in the woods less than a mile from where Lynda Mann's body was discovered. The constabulary was convinced the same person was responsible for both crimes, and they increased their efforts to find the person responsible for these hideous crimes. Richard Buckland, a 17-year-old-youth, was the prime suspect. During interrogation, he confessed to the murder of Dawn Ashworth, but not to the murder of Lynda Mann. This presented a problem for the investigation, and the police were determined to link both murders to the same suspect. The lead detective had heard of work being done at Leicester University by **Professor Alec Jeffreys** to determine if certain diseases on the human body could be linked to an error in the double-helix profile of a person's DNA. While doing this research, Professor Jeffreys had developed a blood test that resulted in far better genetic information than was previously available. The lead detective called Professor Jeffreys and asked if his test could identify a person using the DNA recovered from semen found in the clothing of both victims. Professor Jeffreys agreed to test this theory. He developed an enzyme from the semen that matched and determined the genetic profile matched only 10% of the male population. Interestingly, neither sample matched the genetic profile of Richard Buckland. His confession was false. It is remarkable to think that the very first application of DNA in a criminal investigation was to prove the innocence of a suspect who had confessed. In a call for compassionate support from the community, the Leicestershire Constabulary requested all 6,000 males in the three small villages surrounding the crime scenes to submit voluntary blood and saliva samples. Professor Jefferys and his team typed every sample for a genetic profile, but none matched the earlier samples recovered from the crime scenes. In 1987, Ian Kelly boasted to friends at his local pub that while working in a village near Leicester, he had been approached by a baker by the name of Colin Pitchfork and was paid 200 pounds to present Pitchfork's passport to the police and to provide his blood and saliva samples in place of those of Colin Pitchfork. A person who overheard the conversation reported this information to the police. Ian Kelly was brought in for questioning and he provided the same story. The police therefore arrested Colin Pitchfork for the deception and obtained blood and saliva samples. The DNA from these samples were matched to the semen samples recovered from both victims. He was tried and convicted of both murders and received two Life sentences. In 2025, Colin Pitchfork lost his bid for parole by a decision of the High Court and he remains in prison at the time of this writing. In his own words, Professor Jeffreys said that he had never envisioned the use of his research on the human genome to have such an influential impact on the culpability or innocence of persons who are accused of a crime. It was without a doubt the most fortuitous telephone conversation between a lead police detective and a professor perhaps in the history of the forensic sciences.

Your author recommends the reader conduct research into what compelled nearly 6,000 men to voluntarily submit their blood and saliva to law enforcement. It is an interesting example of community compassion, peer pressure, and honorable endeavor.

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1.10: Forensic Associations and Organizations

Your author greatly supports the many international associations and organizations that provide for industrial oversight, sponsored research, educational standards, ethics and integrity guidelines, and objective collaboration of forensic science professionals. The following is a brief list of some of these entities:

American Association of Forensic Sciences (AAFS)

Founded in 1948, the American Academy of Forensic Sciences (AAFS) is a professional organization that is dedicated to the advancement of the forensic sciences and its application to the legal system. The AAFS has a membership of over 6,000 representatives in the United States and 71 other countries. Members represent professional forensic pathologists, attorneys, dentists, toxicologists, anthropologists, document examiners, digital evidence experts, psychiatrists, engineers, physicists, chemists, criminalists, educators, researchers, and others. The AAFS is also instrumental in developing and maintaining up-to-date industrials standards in the forensic sciences and the training disciplines associated with the forensic sciences.

The International Association for Identification

The International Association for Identification (IAI) is the oldest and the largest association for forensic science practitioners with over 7,000 members. Founded in 1915, the association responsible for administering certification examinations for the following disciplines: Bloodstain Pattern Analysis, Crime Scene Investigations, Latent Print Examiner, Ten-Print Examiner, Forensic Photography, Forensic Art, Footwear Comparison, and Forensic Video. They also publish the Journal of Forensic Identification, a masterful work of forensic science research studies and educational papers.

The British Academy of Forensic Sciences

The British Academy of Forensic Sciences was found in 1995 in the United Kingdom. According to their website, www.bafs.org.uk, the BAFS is, “an interdisciplinary organisation that adds a breadth of understanding to the scientist as they engage with others in the forensic arena: lawyers, pathologists, clinicians and psychiatrists amongst others The Academy has a programme of world-renowned speakers and organises specialist technical meetings. Students are encouraged to attend and the meetings are normally free for those studying or in the early stages of their careers. The Academy also offers prizes annually in the three disciplines: medicine, science and the law, and publishes its own journal.”

The International Association of Bloodstain Pattern Analysts

The International Association of Bloodstain Pattern Analysts (IABPA) was founded in 1983 by Professor Herbert MacDonell, the Father of Modern Bloodstain Pattern Analysis, in Corning, New York. The IABPA has about 900 members representing bloodstain pattern analysts from around the world who are dedicated to the advancement of this forensic discipline.

The Association for Crime Scene Reconstruction

The Association for Crime Scene Reconstruction (ASCR) was established in 1991 by a group of professionals representing the forensic science that focuses on the forensic sciences and the examination of the documentation, analysis, preserved evidence, and the sequencing of events of crime scenes that allow them to reconstruct the circumstances related to the crime. The ASCR also publishes the Journal, a membership publication, focused on the forensic sciences.

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1.11: Test Questions

1. This ancient physician and criminalist wrote a book entitled called *The Collected Cases of Rectified Injustices* or *The Washing Away of Wrongs*, which was the first guide for forensic pathologist.
    1. Jing Yu Ma
    2. Song Ci
    3. Jing Hu
    4. Cho Jing Min
2. This Scottish physician and surgeon is believed to be the first person to identify a patent greasy fingerprint on a bottle of medical alcohol, and then to match that print to a suspect.
    a. Sir Robert Henry
    b. Sir Francis Galton
    c. Henry Faulds
    d. Hugh McGuiness
3. In what year was the first hand-held camera invented?
    a. 1985
    b. 1812
    c. 1826
    d. 1912
4. This person was instrumental in founding the first medical examiners office in the city of New York.
    1. Dr. Charles Norris
    2. Dr. Edmond Locard
    3. Dr. Henry Faulds
    4. Dr. Alexandre Lacassagne
5. The first criminalistic forensic laboratory was officially recognized in 1912 in what city?
    a. Graz, Austria
    b. Lyons, France
    c. New York City, New York
    d. Hengyang, China
6. This was the result of the first use of DNA-typing in the United Kingdom in 1983:
    a. A person of interest who had confessed to a crime was found innocent
    b. A suspect who had been convicted of a crime was released
    c. A victim of a crime was identified
    d. A witness to a crime was determined to be the suspect
7. The principle that every contact leaves a trace was first described by this forensic criminalist:
    a. Hans Gross
    b. Edmond Locard
    c. Calvin Goddard
    d. Alexander Gettler
8. This author created a fictional detective character who greatly influenced modern day forensic science:
    a. Sherlock Holmes
    b. Charles Dickens
    c. Sir Arthur Conan Doyle
    d. Edgar Allen Poe
9. This event resulted in a ballistic technician making a comparison with every Thompson sub machine gun in the inventory of the Chicago Police Department to determine if they were used in the crime:
    a. Black Friday

b. The St. Valentine's Day Massacre
c. The murder of "Big Jim" Collosimo
d. The Lindbergh Baby Kidnapping

10. This ballistic technician conducted a comparison analysis of the Thompson sub machine guns in the inventory of the Chicago Police Department following a notorious crime:
    a. Henry Goddard
    b. Calvin Goddard
    c. Alexander Gettler
    d. Sherlock Holmes

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1.12: Suggested Essay Topics

1. Write an essay on the importance of Edmond Locard's seven-volume *Traité de Criminalistique* (*Treaty of Criminalistics*), its importance to the forensic sciences in the early years of the 20th century, and its relevance to modern forensic science.
2. Write an essay on the novel *A Study in Scarlet* and discuss what future aspects of the forensic sciences did Sir Arthur Conan Doyle get correct, and what did he get wrong.
3. Write an essay about the 1915 Charles Stielow conviction and the efforts of Charles E. Waite and Dr. Max Poser to correct the misjustice caused by the erroneous conclusions of a "ballistics expert."
4. Write an essay about the case of George Ediji, who was convicted of animal mutilations, and George Slater, who was wrongfully convicted of murder. Sir Arthur was instrumental in the establishment of the British Court of Criminal Appeals.
5. Write an essay that explores what compelled nearly 6,000 men to voluntarily submit their blood and saliva to law enforcement in the small villages near Leicester, England, during the Lynda Mann and Dawn Ashworth homicide investigations during the 1980's. Would men in other countries have done the same in the 1980's and would this same request be honored in the 2020's?

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CHAPTER OVERVIEW

2: Scientific Methodology and Ethics in Forensics

Learning Objectives

- To learn definitions of scientific methodology
- To discover the various court cases that established the requirements of scientific methodology
- To be familiar with Federal Rules of Evidence, Section 702 (1975)
- To understand the role of the forensic science expert witness
- To understand the importance of moral and ethical integrity in forensic sciences

2.1: Scientific Methodology
2.2: Scientific Methodology and the Forensic Sciences
2.3: The Expert Forensic Science Witness
2.4: Ethics in Forensics
2.5: Test Questions
2.6: Suggested Essay Topics
2.7: References

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2.1: Scientific Methodology

A quick search of the internet will produce several good definitions of scientific methodology. Let us take a look at just a few:

- An empirical method for acquiring knowledge
- A systematic and rigorous process
- A method to discern activities by which success is achieved
- A method to discern activities by which success is achieved
- Experimentation used to explore observations and to answer questions

Your author thinks that all these definitions apply to some degree, but to truly understand scientific methodology for forensic sciences, one must understand the hallmark court cases that have been instrumental in forming the foundation of the methodologies as they apply to each discipline of the forensic sciences. Those cases are Frye v. United States 293 U.S. F.1013 (1923), Daubert v. Merrell Dow Pharmaceuticals 509 U.S. 579 (1993), and Kumho Tire Company v. Carmichael 526 U.S. 137 (1999). These court decisions shaped modern scientific methodology in the field of forensics because of the application of forensic science to assist the court with determining the innocence or guilt of a defendant who is accused of a crime.

Frye v. United States 293 U.S. F.1013 (1923)

In November 1920, Dr. R. W. Brown, a well-respected African American physician, and the President of the National Benefit Life Insurance Company, was shot through the head in his house in Washington D.C. A .45-calibe revolver was found next to the body of Dr. Brown. Although there were no witnesses to the crime, a house guest recalled allowing a male visitor into the house late in the evening before the sound of gunshots were heard. The house guest, Dr. Julian Dabney Jackson, described the man as being in his mid-20's, light brown skin, weighing approximately 135lbs. There were few clues as to the identity of the man, but instigators did find fingerprints on the exterior brick wall of the house. In August 1921, James Alphonzo Frye was arrested for forgery on a government compensation check. During an interrogation, Mr. Frye confessed to the forgery, a robbery of a salesman, and the murder of Dr. Brown, which he said was in self-defense after Dr. Brown hit him in the head. While awaiting trial, he was visited in jail by his court appointed attorneys, Richard Mattingly and Foster Wood. During the visit, Mr. Frye retracted his confession and said the only reason he had made the confession was to split a $1,000.00 reward, that had been offered by the family of Dr. Brown for the apprehension and conviction of the murder, with Sergeant Jones, the detective who conducted the interview. Mr. Frye also claimed that the detective had promised to drop the robbery charge if he confessed to the murder. Mr. Frye was charged with murder in the first degree with the prosecution seeking the death penalty.

The attorneys were convinced of his innocence, but they had a few problems: He matched the description provided by Dr. Jackson, he did not have an alibi for evening, and they could find no proof that Sergeant Jones had collected the reward money. They decided to turn to Dr. William Moulton Marston, a psychologist who in 1915 had discovered a means by which a person could be shown to be either lying or telling the truth based on their blood pressure. The device was called the systolic blood pressure deception test. The test was administered at the jail before the trial commenced. Dr. Marston was convinced that Mr. Frye was telling the truth that he had provided a false confession to the detective. A jury trial was held in 1922. At the trial, Presiding Justice McCoy excluded the results of the lie detector test, although it was well-known to the jury that the test had been performed. Justice McCoy had allowed the testimony of psychologists in previous trials, but the lie detector test was, "Not yet a matter of common knowledge," as reported by Ken Alder in his book The lie detectors: The history of an American obsession (2007). Mr. Frye was convicted of murder but, possibly owing to the knowledge of the lie detector test, the conviction was in the second degree, and he was sentenced to life in prison.

In 1923, the case was appealed to the District of Columbia Court of Appeals. At issue was the exclusion of the lie detector test at the jury trial. Associate Justice Van Orsdel demonstrated an understanding of the science behind the blood-pressure lie detector test and acknowledged the importance of testimony by persons who are experts in their field of study or have knowledge above that of the ordinary person; however, in his ruling he stated, " Somewhere in this twilight zone (between experimental and demonstrable stages of discovery) the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs." The appeal was denied, and the finding of the trial court was upheld. In this case, Justice Van Orsdel, while acknowledging the need for expert

witnesses, planted the seed for scientific methodology to separate a science that was generally accepted by the scientific community and a science that was not, and later to be called “Junk science.”

Your author recommends reading the entire appellate court decision in Frye v. United States 293 U.S. F11013

Federal Rules of Evidence, Section 70

In 1975, in an effort to refine and expand the admissibility of scientific expert witness testimony first established by the Frye v. United States (1923) standard, the United States Congress created Section 702 of the Federal Rules of Evidence. It should be noted that the Federal Rules of Evidence were created following the recommendations of a special advisory committee appointed by the United States Supreme Court in 1965. Rule 702 established that the testimony was admissible if it could ‘assist the trier of fact to understand or determine a fact in issue.’ Furthermore, the trial judge could qualify an expert witness by their knowledge, skill, experience, training, or education. Also, unlike Frye, an expert witness could testify to their opinion. Interestingly, the rule did not require a science to be generally accepted by the scientific community. Of course, Section 702 has been enhanced over the years, as recently as 2023, which have brought it closer to the United States Supreme Court ruling set forth in the Daubert Decision of 1993.

Your author recommends the reader to explore Rules of Evidence, Section 702 in its current iteration.

Daubert v. Dow Merrell Pharmaceuticals 509 U.S. 579 (1993)

In 1992, the parents of two infants, Jason Daubert and Eric Schuller, who were born with defects, sued Merrell Dow Pharmaceuticals, alleging that the prescription medication Bendectin, used to treat nausea and vomiting during pregnancy, had caused deformities. The civil lawsuit was held in a California District Court. During the trial, the petitioners provided expert witness testimony that reflected experiments conducted *in vivo* and *in vitro* using laboratory animals, and the subsequent supporting pharmacological research papers, linked the drug to the birth defects. Merrell Dow Pharmaceuticals presented their own research that was conducted on human volunteers, which proved the drug did not cause birth defects. Furthermore, Merrell Dow also successfully argued that the studies that were conducted on laboratory animals were not generally accepted by the scientific community. Merrell Dow Pharmaceuticals requested the case be transferred to the Federal courts and requested a summary judgement, which was granted. The petitioners appealed to the Ninth Circuit Court of Appeals, which upheld the lower court ruling using the Frye v. U.S. decision and Rule 702 standard. The Ninth Circuit Court of Appeal went further to suggest that the research conducted for the petitioner was done so solely for the purpose of litigation. Following this decision, the petitioners sought relief from the United States Supreme Court.

Following much deliberation regarding the acceptance of expert witness testimony, the Frye v U.S. decision versus Rule 702, the U.S. Supreme Court issued a unanimous ruling to remand the case back to the lower court to re-examine its finding using Rule 702 and not the Frye standard in what is now known as the landmark Daubert Decision. The lower court did so and upheld its decision in favor of Merrell Dow Pharmaceuticals. The significance of the Daubert Decision is that the highest court in the country supplanted the Frye ruling with Federal Rule 702 as the standard for the admission of expert witness testimony. The court went further to invest the trial judge with “gatekeeping responsibility” for allowing scientific expert witness testimony. The court provided guidelines by which the trial judges would determine the admissibility of expert scientific witness testimony.

First, remember that Federal Rule 702 requires that the evidence or testimony "assist the trier of fact to understand the evidence or to determine a fact in issue." Therefore, the testimony must be relevant to the crime being charged and must be an aid to understanding the facts of the case.

Second, in the unanimous opinion, Justice Blackmun wrote, ‘in order to qualify as "scientific knowledge," an inference or assertion must be derived by the scientific method. Proposed testimony must be supported by appropriate validation-i. e., "good grounds," based on what is known. In short, the requirement that an expert's testimony pertain to "scientific knowledge" establishes a standard of evidentiary reliability.’ Therefore, the science must follow an approved methodology.

Third, Justice Blackmun wrote, ‘Scientific methodology today is based on generating hypotheses and testing them to see if they can be falsified; indeed, this methodology is what distinguishes science from other fields of human inquiry.’ Thus, the science must be based on repeatable experimentation.

Fourth, Justice Blackmun wrote, ‘another pertinent consideration is whether the theory or technique has been subjected to peer review and publication.’ If you remember from Chapter 1 that your author mentioned the Journal of Forensic Identification by the

International Association for Identification and the Journal of the Association for Crime Scene Reconstruction. These are excellent sources where these scientific studies and experiments can be published. Furthermore, these, and other associations, maintain scientific principles and practices working groups where established and new experiments and methodologies are subjected to peer review.

Finally, the opinion states, 'Additionally, in the case of a particular scientific technique, the court ordinarily should consider the known or potential rate of error.' Fortunately, the court left some wiggle room on this requirement by not making it a mandatory requirement but instead chose the word 'ordinarily.' In the forensic sciences, it is often difficult to establish an error rate.

In summary, the rules that need to be followed for scientific testimony to be allowed are:

- The science must be relevant to the case being tried and must be helpful in understanding the facts
- The science must follow a methodology
- The science must be generally accepted by the scientific community
- The science must be based on repeatable experimentations
- The scientific experiments must be published and subject to peer review
- Ordinarily, the error rates of the experiments should be known

Daubert helped establish the rules for expert scientific courtroom testimony, but there were issues that needed to be resolved, which included a defense challenge that a forensic practitioner was not a scientist and therefore could not provide testimony on scientific matters. Fortunately, Kumho Tire v. Carmichael 626 U.S. 137 was not far away.

Your author recommends the reader listen to the oral arguments in Daubert v. Merrell Dow Pharmaceuticals 509 U.S. 579 (1993), which can be found on the internet.

Kumho Tire Company v. Carmichael 526 U.S. 137 (1999)

On July 6, 1993, Patrick Carmichael was driving his minivan when the right tire of the vehicle had a blow-out. Patrick lost control of the van, and it overturned causing death to one passenger and serious injuries to the others. Patrick Carmichael, the survivors of the accident, and the family of the decedent brought suit in the United States District Court for the Southern District of Alabama against the Kumho Tire Company alleging a defect in the tire caused the accident. The attorneys for the plaintiffs relied heavily on the testimony of Dennis Carlson, Jr., a tire failure specialist who was a former tire manufacturing engineer with ten years of experience at Michelin America Tire Company and who possessed a master's degree in mechanical engineering. Mr. Carlson intended to testify that a design defect in the tire had caused the accident based on a visual inspection he had made of tire, and upon his theory that the failure of the tire was due to the manufacturing design defect and not the result of improper maintenance or abuse of the tire. Attorneys for Kumho Tire argued that Mr. Carlson's analysis was incorrect and that his testimony failed to be supported by the Federal Rule of Evidence, Section 702. The trial court agreed, and the testimony was excluded, and summary judgement was given to the defendant, Kumho Tire Company. The plaintiffs appealed the decision to the Eleventh Circuit Court of Appeals, which reversed the decision of the district court based on the requirements set forth in the Daubert Decision.

Kumho Tire Company petitioned the United States Supreme Court to review the appellate court decision. Arguments were heard in 1998, and a decision was rendered the following year which overturned the appellate court decision and reinstated the district court ruling. The Supreme Court determined that the trial court appropriately upheld the roll of a "gatekeeper," as described in the Daubert Decision, and, most importantly, that this obligation applied towards all expert testimony, not just scientific testimony. The trial court's decision to exclude Mr. Carlon's testimony was appropriate with the discretion given to the trial judge.

Although the testimony of an expert witness, who had provided testimony in previous tort cases, was excluded by the ruling of the trial court and the United States Supreme Court, indirectly, the highest court in the country extended the responsibility of the trial judge to ensure all expert witness testimony remained relevant and reliable to the matter being litigated, and this responsibility included testimony that was 'technical' in nature, or was of 'other specialized knowledge,' and not just scientific in nature.

Your author recommends reading Karl Thorvold's *"Guarding the Gate to Expert Testimony: Kumho Tire Co. v. Carmichael and Statev. Council,"* South Carolina Law Review: Vol. 51 : Iss. 4 , Article 16.

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2.2: Scientific Methodology and the Forensic Sciences

In the aftermath of the Daubert and Kumho Tire Company decisions, one might ask how the various disciplines of the forensic sciences are deemed to be based on scientific methodology. To answer this question, we need only look at two disciplines: Fingerprint technology and crime scene reconstruction.

As you will soon learn, the science of fingerprint technology, which includes the development of latent fingerprints and the individualization of fingerprints during comparison, has a long history of research and study dating as far back as the 17th century through the efforts of Dr. Nehemiah Grew in Germany and Dr. Marcello Malphigi in Italy, who independently studied and recorded ridges on the hands and feet of humans. Dr. Henry Faulds and William Herschel argued in the late 19th century for the use of fingerprints in the identification of criminals and the use of fingerprints to solve crimes. Sir Francis Galton provided the unique detail or minutiae that existed within the fingerprint patterns in the late 19th century. Dr. H. H. Wilder and Dr. Inez Whipple conducted research on the development of fingerprint patterns during the volar stage of fetal development in the early 20th century. The Will and William West Case in 1903 in Leavenworth Prison discovered the flaws in the Bertillon System of Anthropometric Measurement. Sergeant Scott Ferrier from London's Scotland Yard encouraged the use fingerprint science to identify criminals and solve crimes in the United States of America during his attachment to guard the Crown Jewels at the Saint Louis World's Fair in 1904. Sir Edward Henry developed a system of cataloging and retrieving ten-print fingerprint cards between 1896 and 1925. The International Association for Identification was established in 1915 by Inspector Harry H. Caldwell, an identification specialist with the Oakland Police Department, Bureau of Identification, who wrote letters to "Criminal Identification Operators" in the United States of America asking them if they would like to gather to discuss and further develop the science of fingerprint development and comparison. The first meeting was held in that year when twenty-two analysts got together in San Francisco. Since that time the International Association for Identification has been instrumental in furthering not only the science of fingerprint technology, but also the other forensic disciplines. Fingerprint technology has been studied and researched, with a myriad of published studies, scientific papers, and books. These efforts have been discussed, debated, and peer reviewed. Experiments in latent fingerprint development have been conducted and successfully repeated. There is no doubt that fingerprint development and comparison is a forensic science that is respected and accepted by the scientific community. There is also no doubt that those who provide expert witness testimony regarding fingerprints greatly assist the trier of fact to understand a fact at issue involving the development or comparison of fingerprints associated with either criminal or civil litigation.

Crime scene reconstruction utilizes the documentation of a crime scene, as well as the evidence that was collected, to determine the sequence in which events associated with a crime occurred. Crime scene reconstructionists use logic, deduction, observations, and, interestingly, the principles of stratigraphy as provided by Nicholas Steno in the 17th century; in particular, the laws of superposition and continuity. By example, a lamp, which is free of bloodstains, is found on top of a pool of blood. It is logical to assume that the pooled blood was deposited first, which also means that a passive blood-letting event occurred before the pool of blood was formed. One could argue that the first application of crime scene reconstruction, although in a fictional sense, was performed by Sherlock Holmes in *The Adventure of the Norwood Builder*, published in 1903, when the bloodied thumb print of the young solicitor who was accused of the crime appeared in a hall closet. Upon inspecting the blood-print, Holmes knew the builder, who was thought to be murdered, was still alive. The deduction had been made based on observations by Holmes, who had carefully inspected the closet on the previous evening, and the blood-print was not present. The short story is also a prime example of crime scene staging. Dr. Edmond Locard's principle of evidence transfer is essential to crime scene reconstruction. In the 1930's and 1940's, Frances Glessner Lee, a New England forensic scientist, recreated miniature dioramas of actual crime scenes using dollhouse materials. This allowed her to visualize and manipulate sequential events. Paul Kirk and Professor Herbert MacDonell conducted reconstructive observations of crime scenes in the 1960's and 1970's. The Association for Crime Scene Reconstruction was founded in 1991, and it remains the primary association where studies and publications are subjected to discussion and peer review.

Your author recommends the reader conduct an internet search of the life and works of Frances Gessler Lee, and her contributions to the forensic discipline of crime scene reconstruction

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2.3: The Expert Forensic Science Witness

It is one thing to apply a scientific methodology to a forensic discipline, but that endeavor will be of little use if the information gathered from that effort cannot be introduced in courtroom proceedings. Thus enters the role of the expert forensic witness. First, as we have discussed, the expert forensic witness must be first qualified by the trier of fact to provide testimony. This qualification will be based on the demonstrable training, experience, and accomplishments of the witness, and the ability of the witness to assist the trier of fact to understand the significance of facts in question. Second, the expert witness must have an understanding of the science behind the methodology that was used, and that the methodology was accomplished in a manner that was objective and without bias. Third, the expert witness must provide written documentation of what process was used, what was done, how it was done, and how the conclusions were reached. Finally, the expert witness must be of the highest moral character and ethical integrity.

Your author is often approached by students who have an interest in pursuing a career in the forensic sciences, but believe they are far too shy to present testimony in court before a jury and audience. As with everything, comfort comes with experience, and the more one testifies, the easier it gets. Your author was once a shy young man. He got over this timidity by attending a college speech class and by joining a theatrical group and performing in college musicals. Embrace the challenge and you will overcome the fear that goes with shyness. It helps to have the ability to laugh at yourself. Your author does a lot of laughing.



Figure **2.3.1**: The Expert Witness chart

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2.4: Ethics in Forensics

In May 2025, during the retrial of Karen Reed, who was accused of the murder of her boyfriend John O'Keefe, an expert witness in digital forensics provided critical testimony for the prosecution regarding the time and position of the victim's last known use of his cellphone in relation to the last known movement of Karen Reed's SUV. During cross-examination, the attorney for the defense questioned the witness regarding false claims that he had made on some on-line resumes indicating he received a bachelor's degree, when he did not. The judge allowed the questioning despite the expert witness having presented the court with a curriculum vitae that did not list a college degree. The judge allowed this line of questioning as a means by which the jury could judge the integrity of the expert's testimony. Some readers may think the defense attorney was wrong to challenge resumes that were not introduced during testimony. However, your author believes that integrity goes to the core of an individual.

Your author defines ethics as always doing the correct thing, especially when the consequences of doing the correct thing are not favorable to your own position. Ethics are core principles that govern good conduct, or noble conduct in reference to law enforcement. In the forensic community, good ethics and moral character are those that conform to accepted standards of virtuous behavior. Virtuous testimony in court proceedings is that which is fair, unbiased, and objective. The forensic technician will never give testimony that is beyond the scope of their expertise, or upon anything that they have not given careful consideration. They will never mislead any of the parties involved in court proceedings regarding their education, training, experience, or area of expertise; nor will they misrepresent or falsify reports, or conclusions, or purposely withhold observations or documentation that might otherwise favor one side over another in court proceedings. They will not provide testimony in any case where they have a personal interest. They will conduct full and fair examinations and will offer conclusions based solely on the pertinent facts related to the evidence. They will never ignore exculpatory evidence. They will never bow to political pressure, favoritism, or other influences. They will support only forensic disciplines that are generally accepted by the forensic community, have been subject to peer review, and are based on sound scientific principles. A forensic technician will never misrepresent their qualifications by exaggerating or falsely embellishing their education, training, or experience, and will keep their professional and private lives unsullied. A forensic technician will never knowingly perjure themselves under oath. Perhaps the hardest dilemma faced by the ethical forensic technician is the duty to report illegal or unethical behavior by other law enforcement personnel of which they have direct knowledge to the proper authorities. A failure to do so may be tantamount to an inexcusable injustice to a person who is accused of a crime. Any violation of these core values and professional obligations may result in serious consequences that will tarnish the reputation of the technician, as well as the profession they represent.

In the landmark court decision in Pitchess v. Superior Court (1974) 11 Cal.3d 531, known in California as a Pitchess Motion, the California Legislature expanded upon the Brady v. Maryland (1963) 373 U.S. 83, stare decisis, which required the prosecution to provide as discovery to the defense any material evidence that is favorable to the defendant, to further allow criminal defendants to seek discovery from the court of potentially exculpatory information located in otherwise confidential peace officer personnel records. As you can imagine, any episode of professional dishonesty or violation of professional ethical conduct could result in an inability to provide future testimony in court proceedings.

A forensic technician should be bound to a solemn oath, generally voiced with venerable fealty included, which is a bond not only with the community, but also with the self. If you hold respect for yourself, your integrity, and your good character, you will hold true to an oath. If an oath was nothing more than a nuisance requirement to gain employment in law enforcement, let me be clear – you are in the wrong profession and have made a poor career choice. The oath and the badge are our links to a chivalrous past where knights on horseback were pure and noble. Your author holds his oaths quite dear these many decades after he first raised his right hand.

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2.5: Test Questions

1. This discipline of lie detection was prohibited from being demonstrated as a result of the Frye v. United States court ruling:
    a. Voice-Stress Analysis
    b. Systollic Blood-Pressure Deception
    c. Concealed Information Test
    d. Control Question Test
2. Frye v. United States 293 U.S. was decided in what year?
    a. 1919
    b. 1932
    c. 1923
    d. 1948
3. In what Supreme Court of the United States ruling required the trial judge to be a “gatekeeper”?
    a. Pitchess v. Superior Court (1974) 11 Cal.3d 531
    b. Frye v. United States 293 U.S. F11013
    c. Kumho Tire v. Carmichael 626 U.S. 137
    d. Daubert v. Merrell Dow Pharmaceuticals 509 U.S. 579
4. The Federal Rules of Evidence, Section 702 were initially adopted in what year?
    a. 1923
    b. 1941
    c. 1968
    d. 1975
5. The Supreme Court of the United States ruling allowed trial judges to admit the testimony of an expert witness that was ‘technical’ in nature, or was of ‘other specialized knowledge,’ and not just scientific in nature.
    a. Pitchess v. Superior Court (1974) 11 Cal.3d 531
    b. Frye v. United States 293 U.S. F11013
    c. Kumho Tire v. Carmichael 626 U.S. 137
    d. Daubert v. Merrell Dow Pharmaceuticals 509 U.S. 579
6. The Daubert Decision included an advisement to the trial court to ‘ordinarily’ establish this when considering scientific methodology:
    a. Error rates
    b. Exculpatory evidence
    c. Validation surveys
    d. Scopes
7. This forensic discipline relies on the laws of superposition and continuity:
    a. Fingerprint development and comparison
    b. Crime Scene Investigations
    c. Forensic photography
    d. Crime Scene Reconstruction
8. This association was founded in 1915 by Inspector Harry H. Caldwell, an identification specialist with the Oakland Police Department, Bureau of Identification:
    a. Association for Crime Scene Reconstruction
    b. International Association for Bloodstain Pattern Analysts
    c. International Association for Identification
    d. International Association for Arson Investigators
9. This forensic scientist conducted crime scene reconstruction by recreating dioramas of actual crime scenes using dollhouses miniatures:

b. Dr. Edmond Locard
b. Paul Kirk
c. Professor Herbert L. MacDonell
d. Frances Glessner Lee

10. This landmark court ruling required the prosecution to provide as discovery to the defense any material evidence that is favorable to the defendant, to further allow criminal defendants to seek discovery from the court of potentially exculpatory information located in otherwise confidential peace officer personnel records:
    a. Pitchess v. Superior Court (1974) 11 Cal.3d 531
    b. Frye v. United States 293 U.S. F11013
    c. Kumho Tire v. Carmichael 626 U.S. 137
    d. Daubert v. Merrell Dow Pharmaceuticals 509 U.S. 579

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2.6: Suggested Essay Topics

1. Write an essay on the role of the forensic science expert witness in courtroom proceedings.
2. Select a forensic science discipline and write an essay regarding the scientific methodology that is used by practitioners of that discipline.
3. Write an essay about the achievements of Frances Glessner Lee and her contributions to the forensic sciences.
4. Write an essay about the responsibilities of the trial judge to be a “gatekeeper” in regards to expert witness testimony, and the rules by which the judge must follow as established by the Daubert and Kumho Tire Company Supreme Court rulings.
5. Write an essay about what ethics and morality mean to you and the importance of integrity in the forensic sciences.

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CHAPTER OVERVIEW

3: The History of Fingerprint Comparison

Learning Objectives

- To learn about the history of fingerprint identification
- To discover important figures in the history of fingerprint identification
- To understand the role Sir Francis Galton played in providing a methodology
- To explore the development of the Henry Classification System
- To learn about the Bertillon system and why it was replaced by fingerprint identification

3.1: Early investigators

3.1.1: Nehemiah Grew

3.1.2: Dr. Marcello Malphigi

3.1.3: Ian Evangelista Purkynje

3.1.4: Sir William James Herschel

3.1.5: Dr. Henry Faulds

3.1.6: Sir Francis Galton

3.1.7: Sir Edward Richard Henry

3.1.8: Sir William James Herschel - The Origin of Finger Printing

3.2: Fingerprints – The King of Identification

3.3: The Will West Case

3.4: Sergeant John Kenneth Ferrier, Scotland Yard

3.5: Test Questions

3.6: Suggested Essay Topics

3.7: References

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SECTION OVERVIEW

3.1: Early investigators

Have you ever wondered why we have ridges on the bottoms of our hands and feet? Have you ever looked at your fingerprints and thought what evolutionary trickery is this? Indeed, evolution is the culprit as it was not sufficient that humanoids decided two legs were better than four legs, but now two of those legs were freed up to hold and use tools, mostly sticks and rocks at first, and humanoids needed a way to tightly grasp those items. Ridges therefore provide the friction necessary to grasp sticks and stones and perhaps help Og from slipping off the edge of the boulder to Og's doom. So, like the chicken and the egg arguments, which came first, the standing or the ridges? I suppose we shall never know, but your author does firmly believe that having ridged skin where it mattered is one of those things that helped humanoids jump to the top of the ladder. We also likely will not know exactly when humans noticed the individual characteristics of those ridges, especially the ridges on the tips of the fingers, the distal phalanx. We do have examples of fingerprints being used as a form of signatures recorded on clay tablets and on the bottoms of clay pots in China, Persia, and Babylon around 1000 B.C. Our written history of fingerprint identification begins in the 17th century and continues to this day.

3.1.1: Nehemiah Grew

3.1.2: Dr. Marcello Malphigi

3.1.3: Ian Evangelista Purkynje

3.1.4: Sir William James Herschel

3.1.5: Dr. Henry Faulds

3.1.6: Sir Francis Galton

3.1.7: Sir Edward Richard Henry

3.1.8: Sir William James Herschel - The Origin of Finger Printing

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3.1.1: Nehemiah Grew



Figure **3.1.1.1**: Nehemiah Grew - Public Domain

Nehemiah Grew was a 17th century English botanist and microscopist who studied the structure of ridges in the epidermis and dermis of the hands and feet using a microscope. He made accurate drawings of these ridges, furrows, and pores, which he published in 1684. Nehemiah Grew was aware of the uniqueness of these ridged surfaces, which could be used for identification purposes, which makes him one of the founding fathers of dactyloscopy or the science of using fingerprints as a means of identification.

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3.1.2: Dr. Marcello Malphigi



Figure **3.1.2.1**:Dr. Marcello Malphigi - Public Domain

Italian physician and biologist **Marcello Malphigi**, and the founder of the science of microscopic anatomy, also conducted microscopic examinations of ridges, furrows, and pores in human skin during the 17th century. Dr. Malphigi was the first to discover that common patterns existed in human fingerprints. These patterns were loops, whorls, and arches, which he suggested would be useful in identification.

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3.1.3: Ian Evangelista Purkynje



Figure **3.1.3.1**: Jan Evangelista Purkynje - Smithsonian Public Domain

Jan Evangelista Purkynje was a physiologist and anatomist in Czechoslovakia, who studied the patterns of the human ridges, and published a study in 1823 that recognized nine different types of patterns in the pads of the fingertips, or distal phalanx, by which humans could be identified. His works were not generally recognized outside of Czechoslovakia, but he did eventually have a great influence on future research into dactyloscopy

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3.1.4: Sir William James Herschel

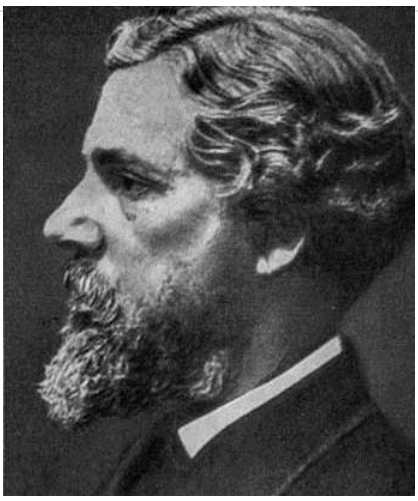


Figure **3.1.4.1**: Sir William Herschel - Public Domain

Sir William Herschel was the British Chief Administrative Officer for the Hooghly District of Bengal India. In 1858, Sir William Herschel began the extensive use of fingerprints by recording them on contracts with native vendors.



Figure **3.1.4.2**: The palm print of a vendor, Rajyadhar Konai, as recorded by Sir Wm. J. Herschel in 1858 - Gutenberg Press

Sir William Herschel requested permission from the British Home Office to use a fingerprint system in the jails in India for the identification of prisoners, but his request was denied. However, Sir William applied the system extensively within his own province. After almost twenty years of observations of his own fingerprints, and those of prisoners who had been fingerprinted over a period of years, Sir Wiliam noticed that ridge formations did not change during the lifetime of an individual. At the end of this section, your author included an excerpt from Sir William Herschel's book, *The Origin of Finger-Printing* published in 1916. This will allow the reader to experience that exact moment when Sir William envisioned using fingerprints as a means of identification.

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3.1.5: Dr. Henry Faulds



Figure **3.1.5.1**: Dr. Henry Faulds - 1905 - Public Domain

If you were to ask anyone in Scotland the name of the founder of fingerprint identification, they will proudly exclaim, “It was Doctor Henry Faulds and no other!” Far be it for your author to disagree. **Henry Faulds** studied medicine at what is now the University of Strathclyde, Scotland. Upon becoming a doctor, Henry Faulds became a missionary of the Church of Scotland and travelled to Japan where he established his ministry at the Tsukiji Hospital in Tokyo in 1874. While visiting an archeological dig with a friend, Dr. Faulds became fascinated by finger marks impressed into ancient clay tablets. He surmised this was a form of identification used in antiquity. This began a life-long interest in fingerprints and the marks they leave behind. Dr. Faulds also had an opportunity to put his interest into real-world use when the laboratory at the hospital was burgled, and the person suspected of the crime was a young colleague. Dr. Faulds found a broken beaker that had a greasy fingerprint deposited on the side. He compared this patent, or observable, fingerprint to the fingerprints of his colleague and determined that he did not deposit the greasy print, thus proving his innocence. He wrote articles which were published in the English journal Nature in which he described his observations of fingerprints and advocated their use in criminal detection. He proposed using printers’ ink as a medium by which a person’s fingerprints could be recorded. It should be noted that Dr. Faulds wrote an article describing individual characteristics within the patterns of fingerprints in 1905, but this was after the publications of our next hero of fingerprint comparison, Sir Francis Galton.

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3.1.6: Sir Francis Galton

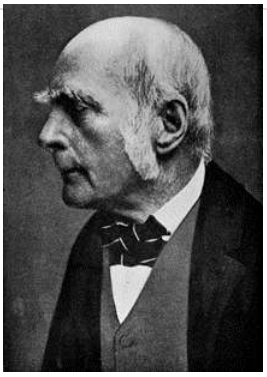


Figure 3.1.6.1: Sir Francis Galton - Public Domain

Sir Francis Galton was an English biologist, anthropologist, explorer, applied mathematician, and the cousin to Charles Darwin, who began making fingerprint observations in the 1880's. In his book *Fingerprints*, published in 1892, he supported Sir William Herschel's claims that fingerprints are never duplicated and that they remain unchanged during an individual's lifetime. Most importantly, Sir Francis noticed something that made fingerprint comparison a scientific methodology: minutiae. Fingerprint patterns, which were established as loops whorls, and arches, were already defined. What Sir Francis gave us was a method of classification inside of the patterns that are based on natural formations of the ridges. These formations are bifurcations, end ridges, short ridges, enclosures, spurs, bridges, and dots. The position of these formations within the pattern are what make the finger marks unique and individual. We will explore these minutiae in a subsequent chapter. The discovery of this minutiae was so important to the science of fingerprint comparison that we named the minutiae "Galton's detail." Also, in recognition of the importance of this discovery, in 1915, the official logo of the International Association for Identification adopted the print of the right fore finger of Sir Francis as their official logo.

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3.1.7: Sir Edward Richard Henry



Figure 3.1.7.1: Sir Edward Richard Henry - Public Domain

In 1891, **Sir Edward Richard Henry** was assigned as Inspector General of Police in Bengal, India, and later became Commissioner of London's Metropolitan Police. He was familiar with the efforts of Sir William Herschel and adopted an identification system for the identification of criminals that was not based on fingerprint identification. This system was based on anthropometric measurements, a system created by Alphonse Bertillon, who the reader will learn about shortly. Sir Edward was keenly aware of the deficiencies of this system and believed the use of fingerprints as a method of identification would be a superior model. He corresponded regularly with Sir Francis Galton on this very topic. In 1896, Sir Edward implemented a system of recording the fingerprints of convicts using what is called the ten-print card, which records all ten fingerprints on a card using printer's ink. The problem became apparent quite quickly that it was one thing to have the convict's fingerprint cards at hand when you know the identity of the person with whom you would like to compare the fingerprints, but not when you have a fingerprint and an unknown contributor. Therefore, Sir Edward created a system by which fingerprint cards could be sorted using a classification system based on the patterns of the distal pads of the phalanges. This system divided fingerprints into two categories based on the presence of loops, whorls, and arches with a value being assigned to each finger based on the presence or absence of a whorl pattern. Using this system, ten-print cards could be grouped by category. This system, often called the Henry Classification System, was eventually adopted by almost every country, and remained in use until the advent of computerized systems like the Automated Fingerprint Identification System in the late 1980's.

In 1898, Sir Edward was instrumental in solving the murder and robbery of a tea garden manager as belonging to an ex-convict named Kangali Charan. The following is a transcript of the official report:

> *"The manager of a tea garden situated in the district of Julpaiguri on the Bhutan frontier was found lying on his bed with his throat cut, his despatch box and safe having been rifled and several hundred rupees carried away. It was suggested that one of the coolies employed on the garden had committed the deed, as the deceased had the reputation of being a hard taskmaster, or that his cook, upon whose clothes were some blood spots, might be the culprit. There was suspicion also against the relatives of a woman with whom the murdered man had a liaison, also against a wandering gang of Kabulis of criminal propensities who had lately encamped in the neighbourhood. A representation was also made that the deceased had an enemy in an ex-servant whom he had caused to be imprisoned for theft. Inquiry, however, satisfied the police that there was no evidence to incriminate the coolies or the relatives of the woman or the Kabulis, and it was ascertained that the ex-servant had been released from jail some weeks before, and no one could say that he had since been seen in the district. The cook's statement that the marks*

> *on his clot lies were stains from a pigeon's blood which he had killed for his master's dinner was supported by the Chemical Analyst's report. Fortunately amongst the papers in the despatch box was found a calendar in book form, printed in the Bengali character, with an outside cover of light-blue paper on which were noticed two faint brown smudges. Under a magnifying glass one smudge was decipherable as a portion of the impression of one of the digits of some person's right hand. In the Central Office of the Bengal Police, the finger impressions of all persons convicted of certain offences are classified and registered, and the impression on the calendar when compared there was found to correspond exactly with the right thumb impression of Kangali Charan, the ex-servant above referred to. He, in consequence, was arrested in Birbhum, a district some hundreds of miles away, and brought to Calcutta, where his right thumb impression was again taken, and the police in the meantime set about collecting corroborative evidence. The Chemical Examiner to Government certified that the brown marks on the calendar were mammalian blood, the inference: being that the actual murderer or some associate had knocked his blood - stained thumb against the calendar when rummaging amongst the papers in the despatch box for the key of the safe. The accused was committed to stand his trial before a judge and assessors, charged with murder and theft, and finally was convicted of having stolen the missing property of the deceased, the assessors holding that it would be unsafe to convict him of murder, as no one had seen the deed committed, but recording their opinion that the charge of theft had been conclusively established against him. This conviction was upheld by the judges of the Supreme Court, to which the case was taken on appeal."*

So important were the contributions of Sir Edward Richard Henry to the advancement of fingerprint identification that Sir William James Herschel offered the following dedication to Sir Edward in his 1916 book *The Origin of Finger Printing*:

> *'I am offering you this old story of the beginnings of Finger-printing, by way of expressing my warm and continuous admiration of those masterly developments of its original applications, whereby, first in Bengal and the Transvaal, and then in England, you have fashioned a weapon of penetrating certainty for the sterner needs of Justice.'*

Sir Edward made many other contributions to law enforcement as the Commissioner of the London Metropolitan Police between 1903 and 1915. He advanced the use of dogs in law enforcement, he standardized the training of the constables, adopted a city-wide system of telephone call boxes, and increased the size of the police force.

Your author recommends the reader conduct research into the contributions of Juan Vucetich, Harold Cummings, and Edmon Locard to the forensic science of fingerprint comparison.

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3.1.8: Sir William James Herschel - The Origin of Finger Printing

In 1858, after five years' service, as an Assistant under the old East India Company, in the interior of Bengal, I was in charge of my first subdivision, the head-quarters of which were then at Jungipoor, on the upper reaches of the Hooghly river. My executive and magisterial experience had by that time forced on me that distrust of all evidence tendered in Court which did so much to cloud our faith in the people around us. We cannot be too thankful that things have greatly improved in India in the last sixty years, but the time of which I am speaking was the very worst time of my life in this respect. I remember only too well writing in great despondency to one of the best and soberest-minded of my senior companions at Haileybury[1] about my despair of any good coming from orders and decisions based on such slippery facts, and the comfort I found in his sensible reply.

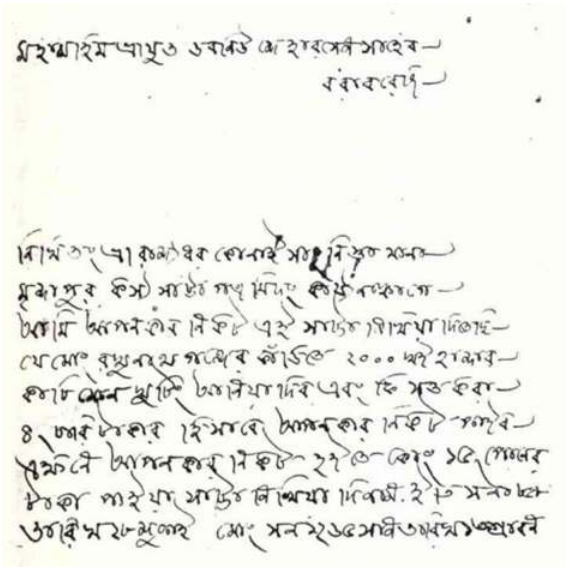


Figure 3.1.8.1: Contract for 2,000 maunds of road-metaling, between W. J. Herschel and Rajyadhar Konai, in Konai's handwriting - Public Domain

It happened, in July of that year, that I was starting the first bit of road metaling(sic) at Jungipoor, and invited tenders for a supply of 'ghooting' (a good binding material for light roads). A native named Rājyadhar Kōnāi, of the village of Nistā, came to terms with me, and at my desire drew up our agreement in his own hand, in true commercial style. He was about to sign it in the usual way, at the upper right-hand corner, when I stopped him in order to read it myself; and it then occurred to me to try an experiment by taking the stamp of his hand, by way of signature instead of writing. There was nothing very original about that, as an idea. Many must have heard of some such use of a man's hand; and the correspondence that has taken place has brought to light old instances of the hand, or the nail of a finger, or the teeth in one's mouth, being used to certify a man's act, or a woman's. But these have all been isolated instances. Sir Francis Galton, however, has pointed out[2] that in our own times the engraver Bewick had a fancy for engraving his thumb-mark, with his name attached, as vignettes, or as colophons, in books which he published.[3] As a boy I had loved Bewick on Birds: I regret that it is not now to be found in our library. Galton's remark has reminded me that I used to see the thumb-mark there, as well as I recollect, in an ornamental title-page. I mention this because I dare say it had something to do with my fascination over Kōnāi's hand-markings. If so, the influence was unknown to me. The absorbing interests of manhood had blotted out, not Bewick, but his thumb-mark, from my memory. However that may be, I was only wishing to frighten Kōnāi out of all thought of repudiating his signature hereafter. He, of course, had never dreamt of such an attestation, but fell in readily enough. I dabbed his palm and fingers over with the home-made oil-ink used for my official seal, and pressed the whole hand on the back of the contract, and we studied it together, with a good deal of chaff about palmistry, comparing his palm with mine on another impression. Here is a facsimile of the whole document, made by the Clarendon Press. I was so pleased with the experiment that, having to make a second contract with Kōnāi, I made him attest it in the same way. One of these contracts I gave to Sir Francis (then Mr.) Galton for his celebrated paper read before the Royal Society, November 1890, to which body he presented it; the other lies before me now. Trials with my own fingers soon showed the advantage of using them instead of the whole hand for the purpose then in view, i.e. for securing a signature which the writer would obviously hesitate to disown. That he might be infallibly convicted of perjury, if he did, is a very different matter. That was not settled, and could not have been settled, to the satisfaction of

Courts of Justice, till, after many years, abundant agreement had been reached among ordinary people. The very possibility of such a 'sanction' (to use a technical expression) to the use of a finger-print did not dawn upon me till after long experience, and even then it became no more than a personal conviction for many years more. The decisiveness of a finger-print is now one of the most powerful aids to Justice. Our possession of it derives from the impression of Kōnāi's hand in 1858.

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3.2: Fingerprints – The King of Identification

From what you have learned, you would think that it was apparent that fingerprints were the ideal method of identification known since at least the 1860's, but there was a reluctance in government officials to adopt a system based on the ridges, furrows, and patterns of human skin. Instead, in 1879, a system of identifying criminal offenders based on a collection of the measurements of bones in the body was developed by the Frensch criminalist Alphonse Bertillon. This system was first adopted by the Parisian police in 1883 and called it the Bertillonage system. The formal name was the Bertillon System of Anthropometric Measurements.

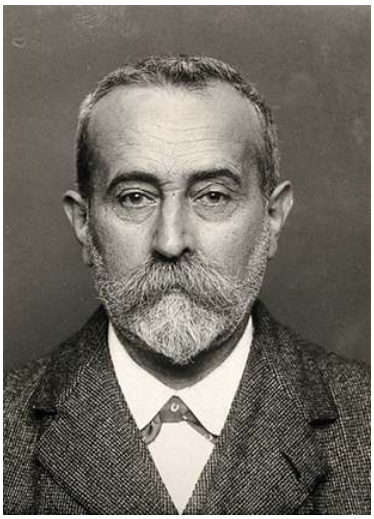


Figure **3.2.1**: Alphonse Bertillon – Public Domain

Alphonse Bertillon was a French criminalist and anthropologist who believed once a person reached adulthood, the bones of the body would remain the same size. He therefore developed a system that recorded the measurements of a person convicted of a crime. These measurements included the head, ears, nose, arms, legs, and feet, which would be recorded on a card. Included on this card would be distinguishing characteristics like scars, tattoos, deformities, eye color, and any other individual traits. Along with the measurements, the Bertillon system, or Anthropometric Measurement, included a photograph of the offender.



Figure **3.2.2**: Bertillonage - Public Domain - Bertillon – Identification Anthropometrique – 1893

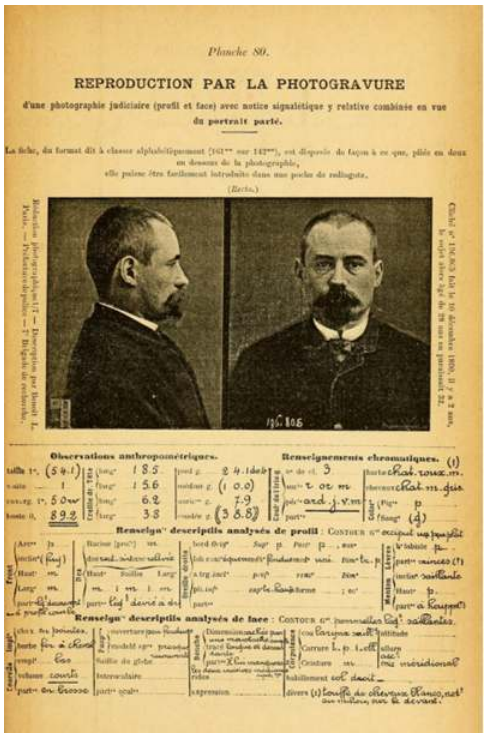


Figure **3.2.3**: Bertillon Card - Public Domain - Bertillon - Identification Anthropometrique 1893

The problem inherent in the Bertillon System was that it was overly complicated, the measurement devices needed constant recalibration, it took a long time to train measurement technicians, and conducting the measurements was laborious and time consuming. It was also based on the premise that the body remains relatively unchanged in adulthood. We know this now to be incorrect. The good part of the system was it was the first to incorporate photography into an identification system. The photograph appeared as side and face portraits that are still the basis for modern mugshot photography. In spite of the drawbacks, the Bertillon system was widely adopted throughout the world, propelling Alphonse Bertillon to fame for a decade. In fact, California Penal Code Section 11102 still reads, “The department (Department of Justice) may use the following systems of identification: the Bertillon, the fingerprint system, and any system of measurement that may be adopted by law in various penal institutions of the state.”

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3.3: The Will West Case

In 1903, at Leavenworth Prison in Kansas, the Bertillon clerk, while collecting the measurements of Will West, a recent arrival at the prison after having been sentenced to life for manslaughter, asked the young man if he had been previously incarcerated. Will West responded that it was his first time in prison. The clerk finished the measurements but believed that he had collected the same measurements for a person with the same name before and believed that Will West was not being truthful about his incarceration. Thus, the clerk consulted the Bertillon system filing cards where he found the near identical measurements having been recorded for William West, an inmate who had left the prison in 1901. When challenged by the clerk, Will West stated, “That’s my picture, but I don’t know where you got it, for I know I have never been here before.”

When the discrepancy was pointed out to the Warden, M.W. McClaughry, he is known to have said, “This is the death of the Bertillon system,” and the very next day he signed an order replacing the anthropometric system with a system based on fingerprints. By 1905, fingerprints surpassed the Bertillon System as the king of identification.

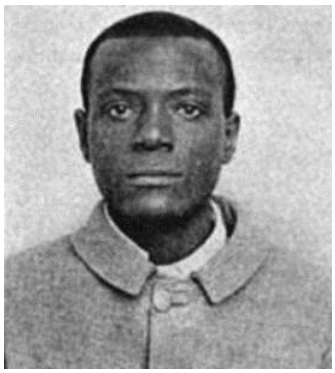


Figure **3.3.1*a***:- Will West - Courtesy of the FBI



Figure **3.3.1*b***: William West - Courtesy of the FBI

In later years, the fingerprints of Will West and William West were recorded and compared. They did not match



Figure **3.3.2**:William and Will West - Courtesy of the National Law Enforcement Museum, Washington D.C. 1960

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3.4: Sergeant John Kenneth Ferrier, Scotland Yard



Figure **3.4.1**:Sergeant John Kenneth Ferrier - Photograph Courtesy of the NY State Division of Criminal Justice

As it happened, in 1904 **Sergeant John Kenneth Ferrier** of the London Metropolitan Police Department was assigned to guard the Crown Jewels Exhibition at the World's Fair in Saint Louis. Sergeant Ferrier had worked with Sir Edward Henry to implement the Henry Classification System for fingerprint card retrieval in London. While awaiting the arrival of the jewels, Sergeant Ferrier, who was a skilled fingerprint technician, provided instruction to police agencies in the United States. He set up a booth at the World's Fair and it is said that his eagerness and enthusiasm for the use of fingerprints as a means of identification convinced anyone who spent time talking to him. It should also be noted that Sergeant Ferrier recorded the first known fingerprint card at the Saint Louis Police Department when he assisted with the arrest of a British expatriate, Percy Ogilvie, who was caught running a fraud scheme with an advertisement that promised well-paying security guard positions to protect the crown jewels at the exhibition in exchange for a $10.00 application fee. Percy Ogilvie interviewed over 400 people from whom the application fee was collected. It was determined that Percy had no authority to advertise the jobs, nor were any of those who were interviewed given employment. While Sergeant Ferrier recorded his fingerprints, Percy confessed to the crime.

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3.5: Test Questions

1. This person was a 17th century English botanist and microscopist who studied the structure of ridges in the epidermis and dermis of the hands and feet using a microscope
    a. Dr. Marcello Malphigi
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Nehemiah Grew
2. This person was the first to discover that common patterns existed in human fingerprints. These patterns were loops, whorls, and arches, which he suggested would be useful in identification.
    a. Dr. Marcello Malphigi
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Nehemiah Grew
3. This person was a physiologist and anatomist in Czechoslovakia, who studied the patterns of the human ridges and published a study in 1823 that recognized nine different types of patterns in the pads of the fingertips, or distal phalanx, by which humans could be identifie
    a. Dr. Marcello Malphigi
    b. Jan Evangelista Purkynje
    c. Sir Francis Galton
    d. Dr. Henry Faulds
4. This person proposed using printers' ink as a medium by which a person's fingerprints could be recorded.
    a. Dr. Marcello Malphigi
    b. Jan Evangelista Purkynje
    c. Alphonse Bertillon
    d. Dr. Henry Faulds
5. This person provided the methodology of fingerprint comparison by describing unique formations called minutiae in ridge-print skin.
    a. Dr. Marcello Malphigi
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Nehemiah Grew
6. This person requested permission from the British Home Office to use fingerprints as a means to identify convicts within the jails he supervised. The request was denied.
    a. Dr. Marcello Malphigi
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Nehemiah Grew
7. This person devised a method for the retrieval of ten-print fingerprint cards that divided fingerprints into two categories based on the presence of loops, whorls, and arches with a value being assigned to each finger based on the presence or absence of a whorl pattern.
    a. Sir Edward Richard Henry
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Dr. Henry Faulds
8. This system of identification was based on the belief that once a person reached adulthood, the bones of the body would remain the same size:
    a. Automated Fingerprint Identification System

a. Automated Fingerprint Identification System
b. Anthropometric Measurement System
c. Bellflower System of Identification
d. Craniological Measurement System

9. This famous case in 1903 signaled the demise of the Bertillonage system of identification:
    a. Klaus Von Beulow case
    b. William Frick case
    c. Will West case
    d. Stielow case
10. Which of the following was a drawback for the Bertillonage system of identification:
    a. The desk was made of wood and would warp with time
    b. The calipers used to measure the head were sharp and pointy
    c. The system was overly complex and required a lot of training to perform
    d. The person being measured would often fall to the ground

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3.6: Suggested Essay Topics

1. Write an essay on what makes fingerprint identification better than a system based on anthropometric measurements.
2. Write an essay on Alphonse Bertillon's testimony during the trial of Captain Alfred Dreyfus and how it led to a miscarriage of justice.
3. Write an essay about the impact of the Will West case on the manner in which the identification of a person is confirmed.
4. Write an essay about the reasons why it is important to know a person's proper identity.
5. Write an essay about other achievements Sir Edward Richard Henry contributed to law enforcement.

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CHAPTER OVERVIEW

4: Fingerprint Comparison

Learning Objectives

- To learn the proper terminology for the science fingerprint comparison
- To discover important figures in the history of fingerprint comparison
- To understand fingerprint patterns
- To understand fingerprint minutiae or Galton's detail
- To learn fingerprint comparison techniques
- To understand the Automated Fingerprint Identification System

4.1: Introduction
4.2: The finger
4.3: The palm
4.4: Ridges and furrows
4.5: Fingerprint patterns
4.6: Ridges
4.7: Professor Inez Whipple and Dr. H. H Wilder
4.8: LOOPS
4.9: ARCHES
4.10: WHORLS
4.11: Double Classified
4.12: MINUTIAE
4.13: POROSCOPY
4.14: RIDGEOLOGY
4.15: Acceptable Tolerances and Elastic Deformation
4.16: OTHER CONSIDERATIONS
4.17: AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM
4.18: Test Questions
4.19: Suggested Essay Topics
4.20: References

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4.1: Introduction

In this chapter, the reader will learn about the science of fingerprint comparison. That is to say, the comparison of an inked, known or exemplar fingerprint, with an unknown fingerprint that is either inked or developed. The reader will learn the proper terminology and the methodologies used by fingerprint analysts to identify a ridge-print or fingerprint. These analysts are generally grouped into two categories: latent print examiners, who are skilled in the examination of ridge-print skin from anywhere on the palms and phalanges (fingers) of the hands or the toes and soles of the feet; or ten-print examiners, who have the primary responsibility of comparing only the fingerprints of the phalanges. This chapter will focus primarily on ten-print examinations, and in particular, the ridge-print skin of the finger pad known as the volar pad or distal phalanx. The first terms that the reader will learn are the composition and characteristics of the fingerprint in question, and that is whether the impression left from the finger can be seen (patent or molded) or cannot be seen (latent) and therefore needs to be developed.

Latent Print – The deposition of a fingerprint that cannot be seen by the human eye and therefore needs to be developed

Patent Print – The deposition of a fingerprint by a medium that can be seen by the human eye, such as a fingerprint composed of blood, dirt, grease, ink, or dust

Molded Print – The deposition of a fingerprint that is impressed into a surface such as candle wax, mud, or other soft material

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4.2: The finger

Next, we need to learn the terminology of the phalanx (finger) and palmar (palm) surfaces:

Proximal phalanx – The area of the finger closest to the palm

Distal phalanx – The area of the finger furthest from the palm

Medial phalanx – The are of the finger between the proximal phalanx and the distal phalanx

Proximal crease – The flexion line of the joint between the palm and the proximal phalanx

Distal crease – The flexion line of the joint between the distal phalanx and the medial phalanx

Medial crease – The flexion line of the joint between the medial phalanx and the proximal phalanx

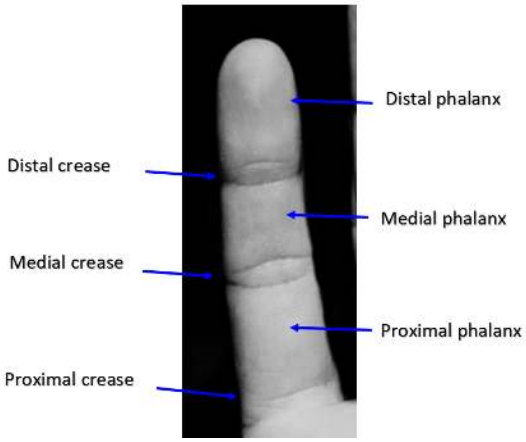


Figure 4.2.1: Left index finger

What about the thumb? The thumb only has a distal phalanx/crease and a proximal phalanx/crease. It should be noted that the distal phalanx is also called the volar pad, but more on that a bit later.

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4.3: The palm

Although the focus of this chapter will be the ridges and furrows of the fingers, we can take a brief look at the terminology associated with the palmar surface.

Thenar – The fleshy part of the palm associated with the thumb.

Hypothenar – The fleshy part of the palm at the base of the little finger

Ulnar palm – The aspect of the palm that is on the side of the ulna bone

Radial palm – The aspect of the palm that is on the side of the radius bone

Metacarpal region/Interdigital region – The area of the palm below the proximal creases of the phalanges

Midpalmar space – The lower center of the palm

Longitudinal thenar crease – The vertical crease between the thenar and the midpalmar space'

Proximal palmar crease – The horizontal crease closest to the midpalmar space

Distal palmar crease – The horizontal crease furthest from the midpalmar space

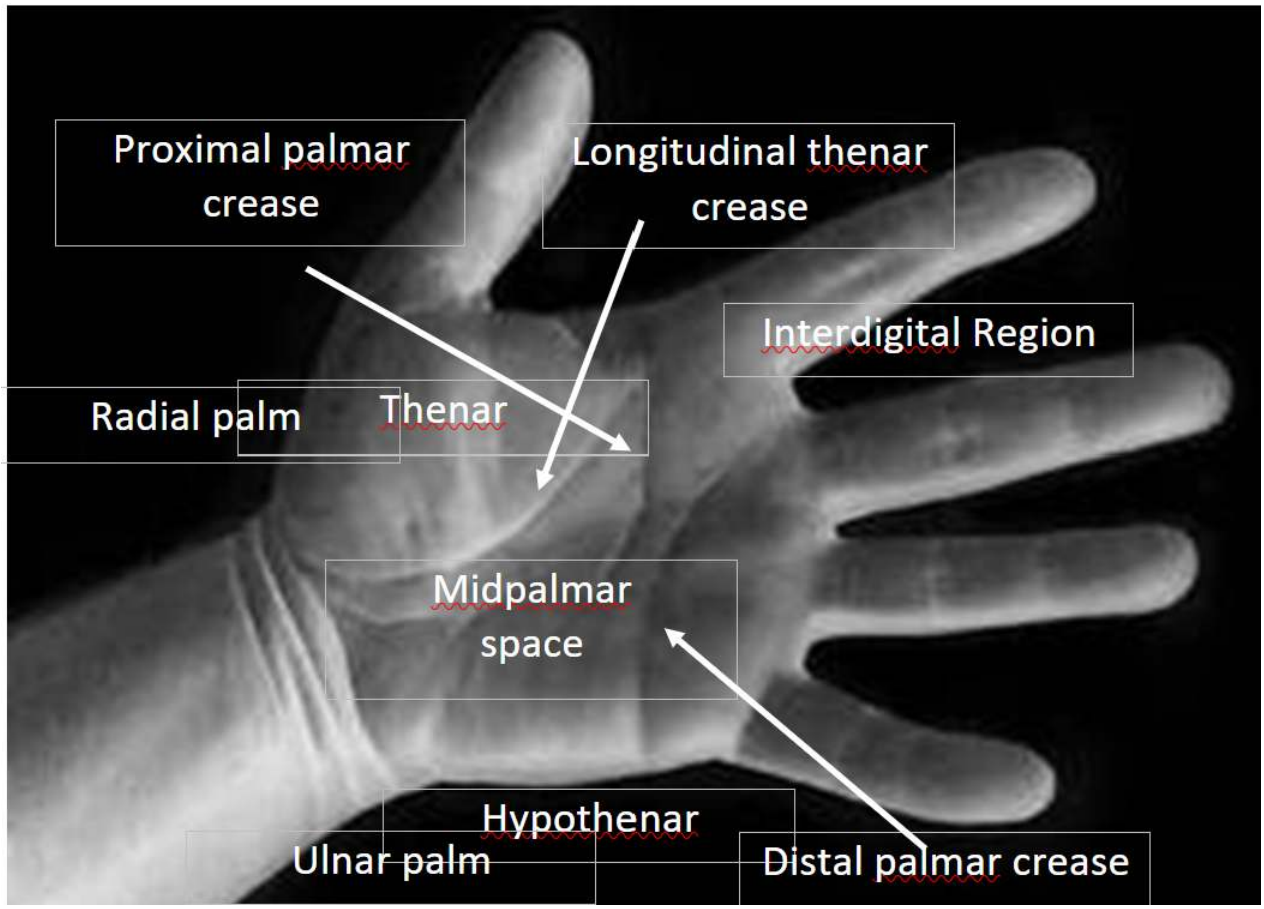


Figure **4.3.1**: Palmar surface

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4.4: Ridges and furrows

Imagine if you will poor caveman Og sliding down the face of a boulder, relying on his friction ridge skin to save him, but suddenly his fingertips become glassy and smooth by the rough surface of the rock. Og would need a plan B, perhaps landing on a plump woolly mammoth. This would be the case if Og's finger surfaces were not flexible. How do we therefore keep the surface of our fingers flexible? To answer this question, we must look at the formation of friction ridge skin, which is composed of a raised area, known as the ridge, and a depressed area, known as the furrow. Think of a field that has just been plowed with the planting area having been raised above a channel for watering. The epidermis is that plowed field. It is the surface layer of our skin. The dermis is the bottom layer of the skin. The two layers are held together by the papillae by interlocking papillae pegs.

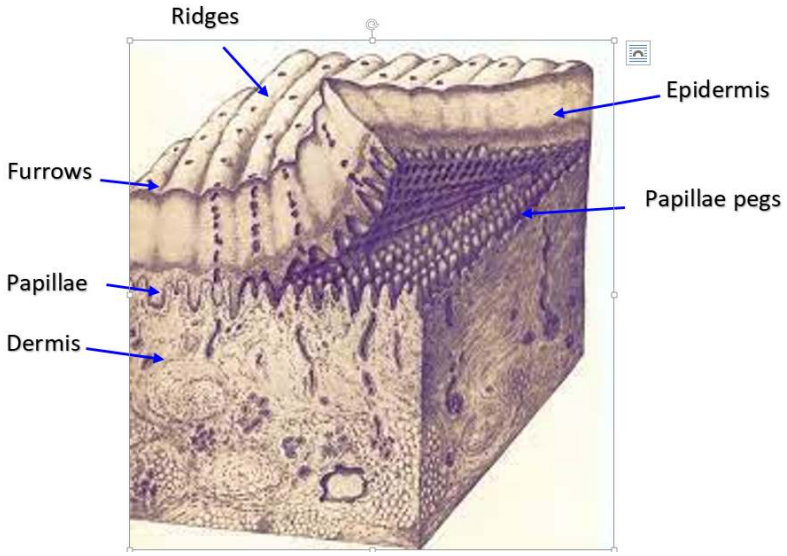


Figure **4.4.1**: Epidermis and dermis - modified from Babler 2005

In friction ridge skin, sweat glands provide secretions that allow the skin to be flexible and moist, and to facilitate grip without constantly wearing smooth. The sweat glands exit the epidermis at the pores.

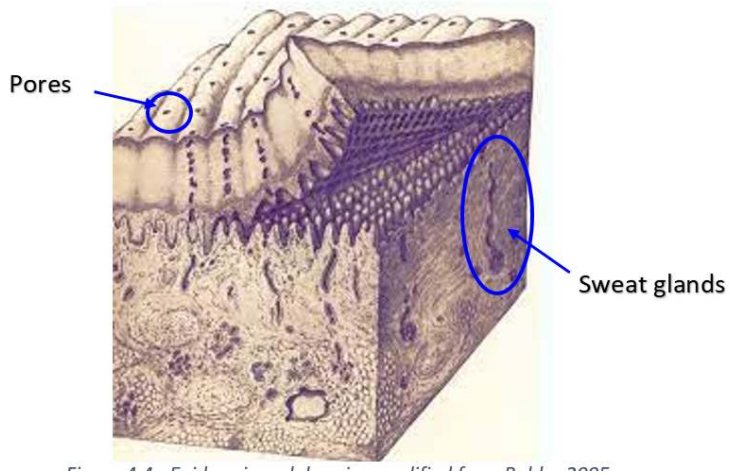


Figure **4.4.2**:- Epidermis and dermis - modified from Babler 2005

It is the secretions from the sweat glands that deposit a latent mirrored image of the ridges of the finger. What are these secretions? The technical answer is that secretions are composed of fatty acids, amino acids, lipids, sodium, chloride, potassium, inorganic salts, sebum, proteins, cholesterol, carbohydrates, and organic and inorganic environmental contaminants. The easy answer is as follows:

Eccrine – Secreted by the eccrine gland and consists of approximately 98% water, electrolytes, and organic and inorganic solids.

Apocrine – Secreted by the apocrine gland and consists of water, protein, carbohydrates, sodium chloride, carbohydrates, and other organic compounds

Sebaceous oils – Generally associated with hair follicles, sebaceous oils contain sebum, the waxy and oily secretion that keeps hair and skin flexible. Sebum consists of triglycerides, wax esters, and squalene, a polyunsaturated hydrocarbon. Other components include cholesterol esters, cholesterol, and free fatty acids.

Yuck – Organic and inorganic environmental compounds make up the last category. These include anything that your hands have contacted throughout the day including hamburgers, cosmetics, grease, dirt, etc.

Take the first letter from each word and you find this is an **EASY** way to learn the basic secretions in a ridge print impression. Just be sure to say “contaminants” instead of “yuck” when testifying in court.

It is interesting to note that even latent fingerprints can be seen by the human eye when deposited on non-porous (hard) surfaces like glass or metal because of an inherent luminescent or “glistening” quality of the secretions or contaminants. You may have to turn the object slightly or use a flashlight at an oblique angle to see them, but it may provide a helpful hint as to what development medium to use.

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4.5: Fingerprint patterns

As you learned in the previous chapter, there are only three basic patterns of fingerprints, although there are subcategories within each pattern. Those patterns are loops, arches, and whorls. You must first understand the development of the fingerprint during the fetal cycle known as the volar development stage. This is the stage of development of skin and skin structure between eight and 18 weeks of gestation. By the 18th week of gestation, a person’s fingerprints, the unique manner of identification, are firmly developed, and will remain the same throughout that person's life.

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4.6: Ridges

The reader must remember that the fingerprint seen of an exemplar (known) fingerprint recorded in ink or a latent fingerprint developed using a dark medium will be a mirrored image of that on the hand. Therefore, the ridges will appear dark, and the furrows will appear white or blank.

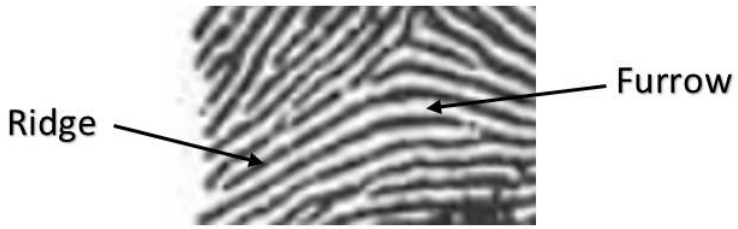


Figure **4.6.1**: Ridge and Furrow - FBI Science of Fingerprints - Public Domain

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4.7: Professor Inez Whipple and Dr. H. H Wilder

At the turn of the 20th century, Professor Inez Whipple and Dr. Harris Hawthorne Wilder collaborated on research into friction ridge evolution, pattern and individual ridge structure during the volar stage of fetal development. Professor Whipple published this research in 1904 in her book entitled *The Ventral Surface of the Mammalian Chiridium.*



Figure 4.7.1:By Unknown author - Smith Alumnae Quarterly, Volume XX, Number 3, May 1929, page 269, Public Domain,

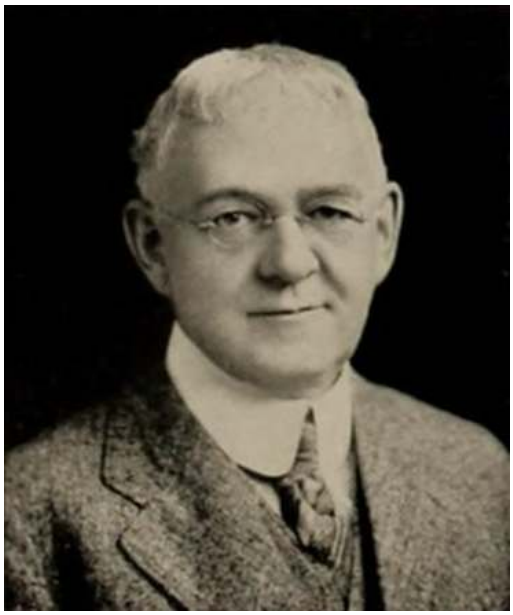


Figure 4.7.2: Harris Hawthorne Wilder - Unknown author, Public Domain

In their research, they discovered that when the volar pad of the distal phalanx forms in the middle (intermedial) and to the left or right, the pattern would be a left-slant or right-slant loop. If the pad forms low and to the center, the pattern would be an arch. If the pad forms high and to the center, the pattern would be an arch. As a side note, they married in 1906.

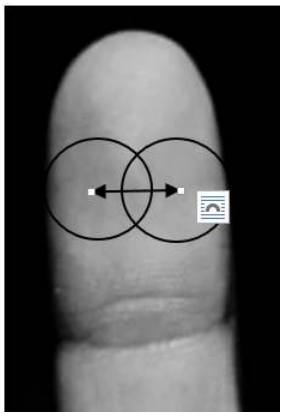


Figure 4.7.3a:
Volar pad - Intermediate left or right



Figure 4.7.3b: Right slant loop -FBI Science of Fingerprints - Public Domain

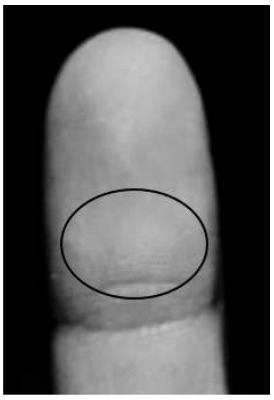


Figure 4.7.3c:

Volar pad low and center



Figure 4.7.3d:

Plain arch - FBI Science of Fingerprints
- Public Domain

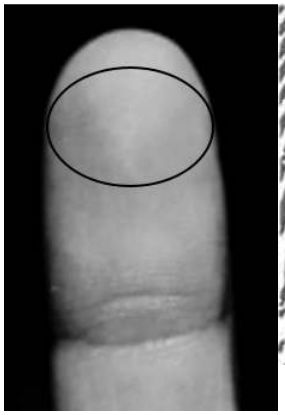


Figure 4.7.3d:

Volar pad - high and center



Figure 4.7.3e:Plain arch Whorl -FBI Science of Fingerprints -
Public Domain

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4.8: LOOPS

A **loop**, simply defined, is a fingerprint pattern consisting of a ridge or ridges that enter from one side of an impression, re-curve (or loop) and exit (or tend to exit) on the same side of the impression from which they entered. There must be only one **delta**, and at least one ridge between the delta and the core of the print. To understand the delta, you must first understand the **pattern area** and **type-lines**.

The pattern area is that part of a loop or whorl in which appear the cores, deltas, and ridges.

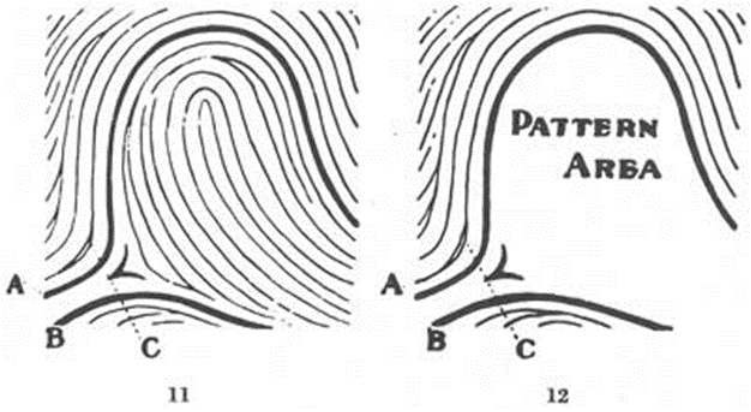


Figure 4.8.1: Pattern area - FBI Science of Fingerprints - Public Domain

Type lines are the two innermost ridges, which start parallel, diverge, and surround (or tend to surround) the pattern area. The delta is that point on a ridge at or in front of and nearest the center of the divergence of the type lines. Think of the delta as that sand bar that is usually found where a river flows out to a larger body of water. The three ridges that you will see surrounding the pattern area and the delta are called the tri-radius.

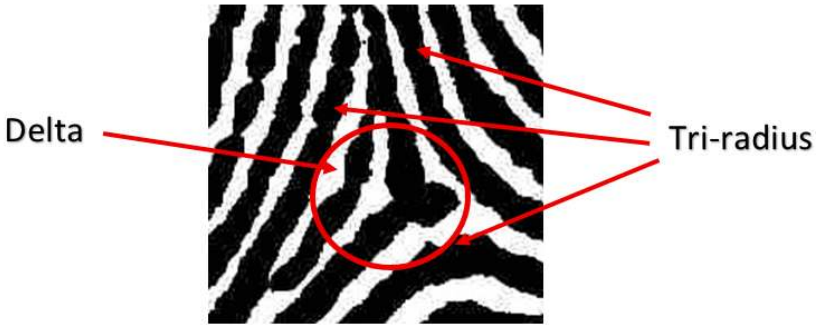


Figure 4.8.2: Delta and Tri-radius - FBI Science of Fingerprints - Public Domain

The **core** is the approximate center of the fingerprint impression. The **ridge count** is the number of ridges intervening between the delta and the core is known as the ridge count.

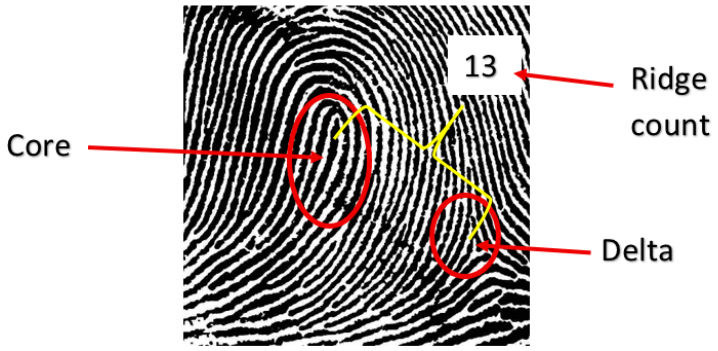


Figure 4.8.3:Core, Delta, and Ridge counting - FBI Science of Fingerprints - Public Domain

Ulnar loop vs. Radial loop

The classification of loops is based on the way the loops flow on the hand (not the fingerprint card or developed latent print), so that on the fingerprint card for the left hand, loops flowing toward the thumb impression are ulnar, and loops flowing toward the little finger impression are radial, and the same for the right hand. Of course, the examiner will not know if the fingerprint is an ulnar or radial loop until they have determined from which hand the print was deposited. Until that is determined, the prints are referenced as left-slant or right-slant loops. Many years ago, your author was taught this handy way of remembering ulnar from radial loops by a method called “URL” as follows:

Ulnar – Right – Left

Ulnar Loops Slant Right on Left Fingers

Opposite for the right

Ulnar Loops Slant Left on Right Fingers

Unfortunately, it did not help your author much so instead this handy chart was always near to hand:

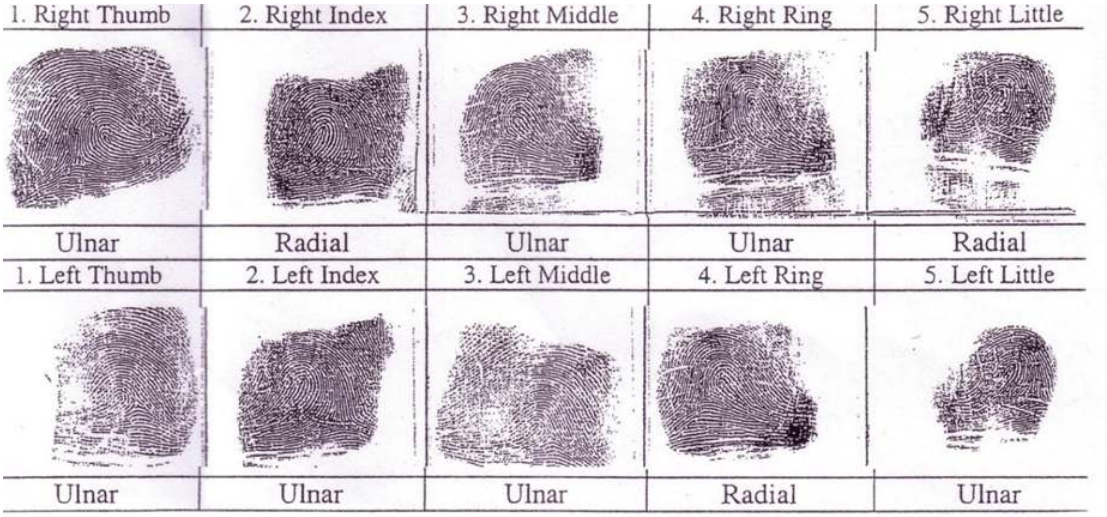


Figure 4.8.4: Ulnar - Radial chart - FBI Science of Fingerprints - Public Domain

Rods

In the event that the center of the fingerprint has two ending ridges instead of a recurve, these ridges are called rods. The rod that is furthest from the delta is determined to be the core when doing a ridge-count.

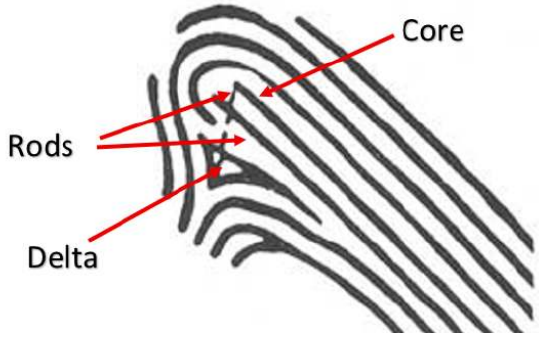


Figure 4.8.5: Rods - FBI Science of Fingerprints - Public Domain

Elements of a Loop

Things to remember for the loop pattern:

- Enters from one side and exits (or tends to exit) the same side

- Must have a recurve
- Must have only one delta
- Must have at least one ridge count between the delta and the core

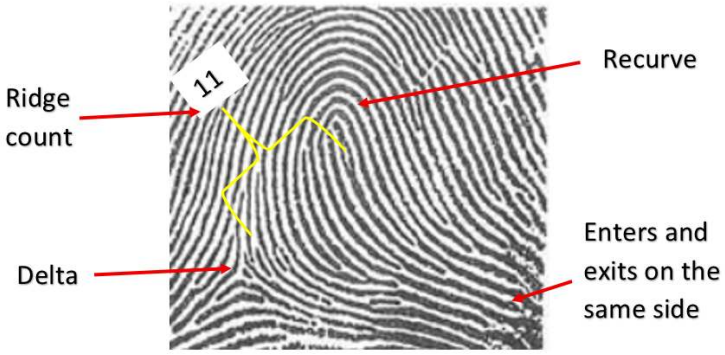


Figure **4.8.6**: Elements of a Loop - FBI Science of Fingerprints - Public Domain

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4.9: ARCHES

Arches are boring. The ridges enter from one side of the finger, rise slightly in the center, and exit out (or tend to exit) on the opposite side. There are two varieties of arches: the **plain** arch and the **tented** arch.

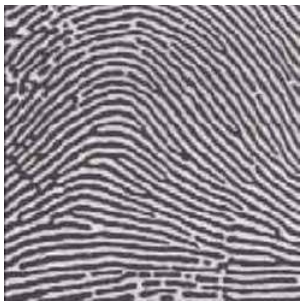


Figure **4.9.1**: Plain arch - FBI Science of Fingerprints - Public Domain

In the tented arch, most of the ridges enter from one side of the impression and flow (or tend to flow) out the other side, as in the plain arch; however, the ridge or ridges at the center do not. The most common form of tented arch has a ridge or ridges that thrust upward at or near the center of the print.

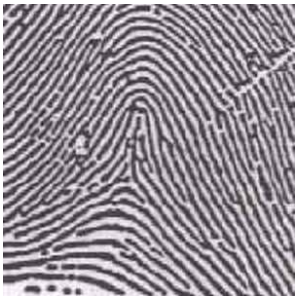


Figure **4.9.1**: Tented arch - FBI Science of Fingerprints - Public Domain

Elements of an Arch

Things to remember for the arch pattern:

- The ridges flow in from one side of the print and flow out (or tend to flow out) the other side of the print with either a slight upward curve in the center (plain arch) or with an upward thrust in the center (tented arch)
- There is either an absence of a delta or there is less than one ridge-count between the delta and the core

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4.10: WHORLS

Unlike boring arches, **whorls** are exciting. A whorl is a fingerprint pattern in which the ridge formations are spiral, elliptical or oval shapes, or have variations of these formations, and at least two deltas are present with a re-curve in front of each. There are four types of whorls: the **plain whorl**, the **central pocket** whorl, the **double-loop** whorl, and the **accidental** whorl.

Plain Whorl

A **plain whorl** has two deltas and at least one ridge making a complete circuit, which may spiral, oval, circle or have any variant of a circle. If you drew an imaginary line drawn between the two deltas, the line must touch or cross one of the re-curving ridges within the inner pattern area.

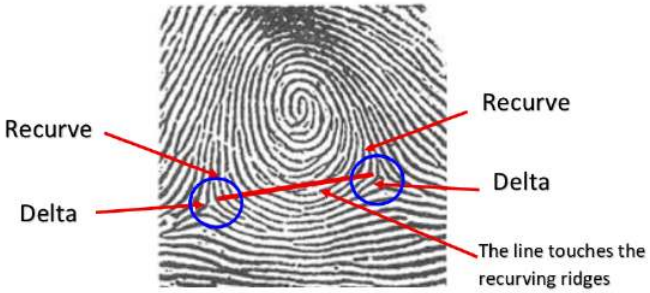


Figure 4.10.1: Plain Whorl - FBI Science of Fingerprints - Public Domain

Central Pocket Whorl

A **central pocket whorl** has two deltas and at least one ridge making a complete circuit, which may form a spiral, oval, circle or any variant of a circle. An imaginary line drawn between the two deltas must not touch or cross one of the re-curving ridges within the inner pattern area.

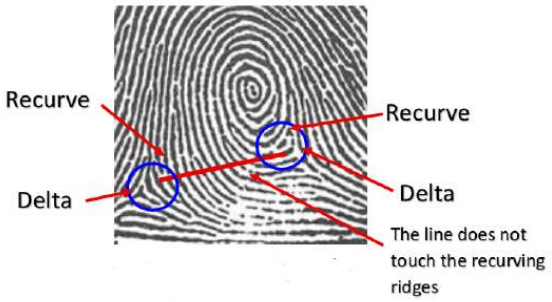


Figure 4.10.2: Central Pocket Whorl - FBI Science of Fingerprints - Public Domain

Double-Loop Whorl

Double-loop whorls are fun. They consist of two separate loop formations with two deltas and two distinct sets of recurving ridges called **shoulders**. Shoulders are the points on a loop at which the re-curving ridge definitely turns inward or curves. You may ask why this is a whorl pattern and not a loop pattern. The answer is that there are two deltas.

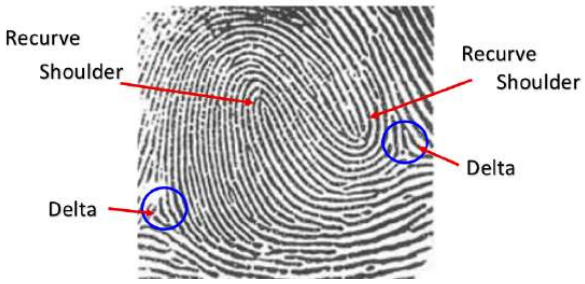


Figure **4.10.3**: Double-Loop Whorl - FBI Science of Fingerprints - Public Domain

Accidental Whorl

Accidental Whorls are fun too, but not as fun as the double-loop whorl. Your author prefers to call this category of whorls the dumpster for whorls because this pattern consists of a combination of patterns, excluding the arches, with two or more deltas; or a pattern that possesses some of the requirements for two or more different types; or a pattern that conforms to none of the standard definitions of other patterns.



Figure **4.10.4**:Accidental Whorl - FBI Science of Fingerprints - Public Domain



Figure **4.10.5**:Accidental Whorl - FBI Science of Fingerprints - Public Domain

Elements of a Whorl

Things to remember for the whorl pattern:

- The ridge formations are spiral, elliptical or oval shapes, or have variations of these formations
- There are at least two deltas present with a re-curve in front of each

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4.11: Double Classified

Sometimes a fingerprint pattern just does not fit into one category, or it is just on the cusp between two different patterns. In cases such as this, it is acceptable to **double-classify** the print.

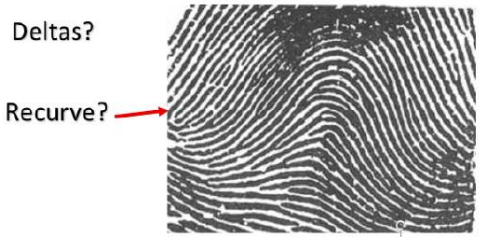


Figure **4.11.1**:How would you classify this print? FBI Science of Fingerprints - Public Domain

The FBI classified this pattern as an accidental whorl. Your author likely would double-classify it as a loop or arch.

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4.12: MINUTIAE

As previously mentioned in Chapter 3, Sir Francis Galton provided for us a method of classification inside of the patterns that are based on natural formations of the ridges. These formations, called **minutiae** or **Galton's Detail,** are bifurcations, end ridges, short ridges, enclosures, spurs, bridges, and dots. The position of these formations within the pattern are what make the finger marks unique and individual. The following are descriptions of fingerprint minutiae:

- **Ridge endings** = a ridge that ends abruptly
- **Ridge bifurcation** = a single ridge that divides into two ridges
- **Short ridges, island or independent ridge** = a ridge that commences, travels a short distance and then ends
- **Ridge enclosures** = a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge
- **Spur** = a bifurcation with a short ridge branching off a longer ridge
- **Bridge** = a short ridge that runs between two parallel ridges

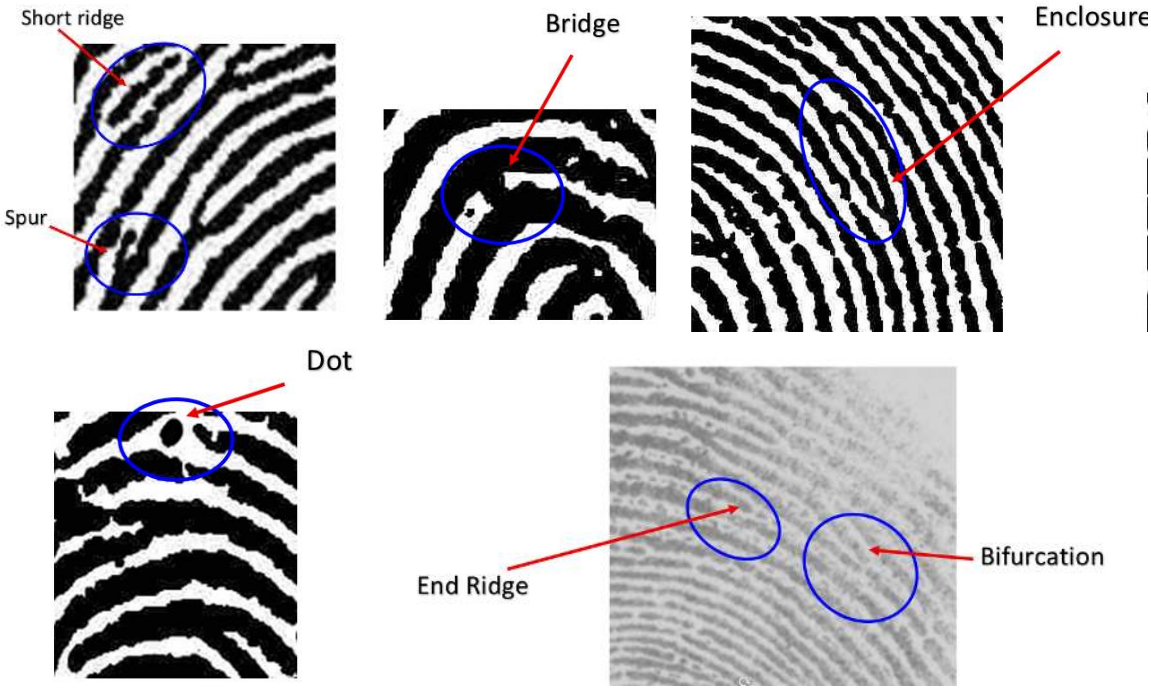


Figure 4.12.1: Galton's Detail - Author's collection

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4.13: POROSCOPY

In 1914, Edmond Locard suggested the use of pores within the ridges as minutiae in his study called the ‘Tripartite Rules for Fingerprint Comparison’. These rules are as follows:

1. If more than 12 concurring points are present and the fingerprint is sharp, then certainty of identity is beyond debate.
    - Points are ridge characteristics.
    - Sharpness = clarity.
    - Therefore, the number of points of comparison are likely very high.
2. If 8 to 12 points are involved, then the case is borderline, and the certainty of identity will depend on:
    - The sharpness of the fingerprint
    - The rarity of its type
    - The presence of the center of the fingerprint and the triangle in the exploitable part of the print
    - **The presence of pores**
    - The perfect and obvious identity regarding the width of the papillary ridges and valleys, the direction of the lines, and the angular value of the bifurcations
    - In these instances, certainty can only be established following discussion of the case by at least two competent and experienced specialists
3. If a limited number of characteristic points are present, the fingerprint cannot provide certainty for an identification, but only a presumption for identification, and only a presumption proportional to the number of points available and their clarity.

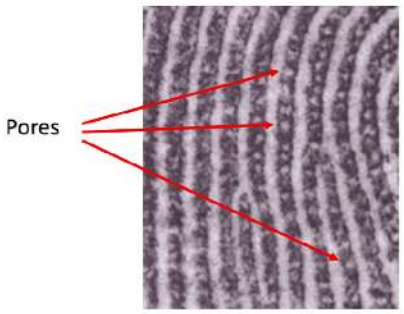


Figure **4.13.1**: Pores - Author's collection

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4.14: RIDGEOLOGY

In 1912, Alphonse Bertillon, who was warming to the science of fingerprint comparison, published a study that presented this latent print comparison and determined that 16 points were required for positive identification. This standard was adopted worldwide, most notably by Scotland Yard. Posters were printed bearing these “identified” fingerprints.

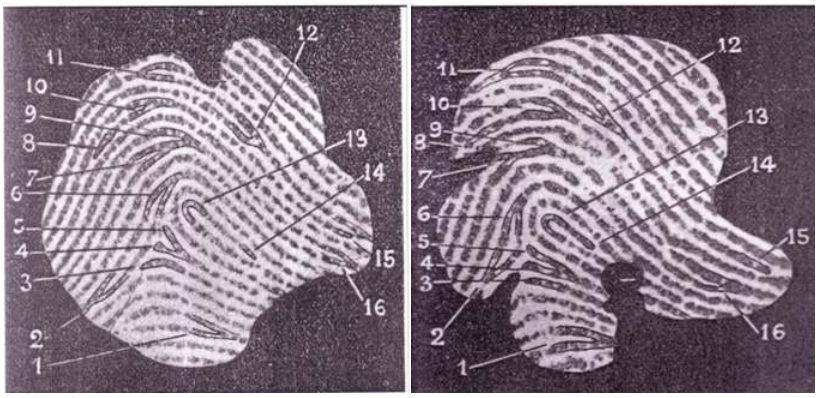


Figure **4.14.1**: Bertillon's 16-point comparison - Public Domain

In 1986, **Staff Sergeant David R. Ashbaugh**, of the Royal Canadian Mounted Police, examined this poster while on assignment in London, England, at Scotland Yard. As he stared at the poster, he noticed something interesting – the prints did not match. Bertillon had altered the prints, removing anything that did not match, and minutiae were outside of acceptable tolerances. The poster that hung on the wall of a prestigious identification bureau for 60 years was a fraud. It was then, however, that Sergeant Ashbaugh discovered what he later called “**Ridgeology**.” He understood that it was not sufficient for minutiae to be in the same position on the known and questioned fingerprints; rather, they had to be in agreement with their position on the ridge structure, that distortions, if present, had to be within acceptable tolerances, and that the special relationship and ridge sequence between ridges had to be in agreement as well. Further, he developed what he called the ACE-V methodology of comparison: Analyze, Compare (always the unknown to the known, and not vice-a-versa), Examine, and Verify (always a blind verification). A blind verification means that the second analyst is unaware of the findings of the original analyst.

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4.15: Acceptable Tolerances and Elastic Deformation

Every time friction-ridge skin comes into contact with a hard, fixed surface, it undergoes a distinctive type of deformation called **elastic deformation**. Elastic deformation occurs when a flexible material returns to its natural shape once the pressure or stress is removed. In the next two figures, you will see I the first figure what appears to be wavy ridges in the distal left portion of the fingerprint. This occurred when pressure and a slight twist were applied during the inking process. The second figure is a pressed fingerprint that was recorded with minimal pressure. You will see that although some of the ridges in the first figure are wavy, the actual ridges remain the same, as do the minutiae within those ridges. They are just a bit wavy, but well within acceptable tolerances. **Lateral** and **deposition** pressures may also be noted within a fingerprint that is either recorded using ink or a digital method or developed as a latent print.

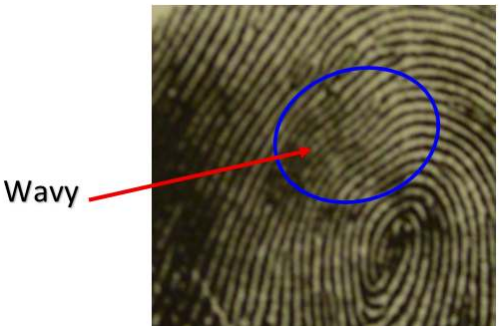


Figure **4.15.1**: Elastic deformation distal left
Author's collection

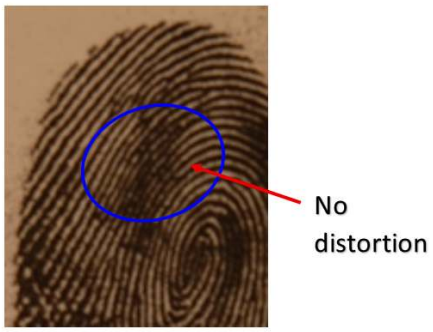


Figure **4.15.2**: Pressed print without distortion
Author's collection

Lateral pressure occurs when there is side-to-side movement while grasping an object or during the recording process. **Deposition pressure** is the downward force applied in the same manner. Lateral pressure may result in a portion of the fingerprint being either lighter or darker, or smudged, than the rest of the print on one side or the other. Deposition pressure will result in ridges that appear wider than normal or may also be smudged. Both types of pressure affect the quality of the print.



Figure **4.15.3**:Developed print exhibiting deposition pressure - Author's collection

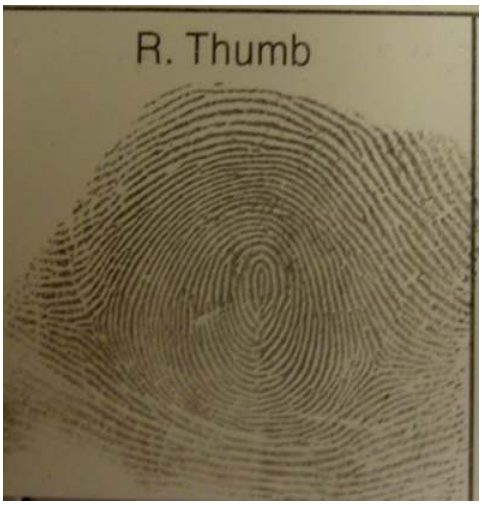


Figure **4.15.4**: Rolled impression using ink - Author's collection

Your author recommends the reader press their thumb onto a mirror or glass, and while applying pressure, twist their thumb left and right. Remove the thumb and then lightly press the thumb next to the first thumb print. Use a magnifying glass to examine the resulting prints.

Now let us take another look at the fingerprints provided by Masseur Bertillon.

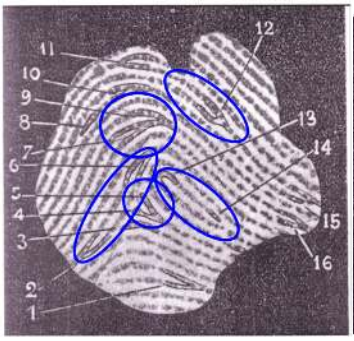


Figure 4.15.5:Unknown print

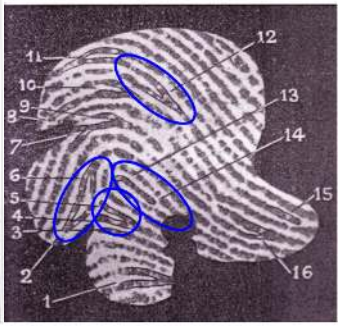


Figure 4.15.6:Exemplar or known print

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4.16: OTHER CONSIDERATIONS

Comparing unknown to know

As previously mentioned, it is advisable to always compare the unknown print to the exemplar print, and not the other way around. This is because the brain is capable of capturing a brief memory of the known print, which will then transpose that memory to unknown print. Although it is possible to happen when comparing the unknown print to the known, that feature on the unknown print will likely not be transposed onto the known print without the analyst noting the discrepancy.

Scars

Scars are exceptionally unique identifiers in a fingerprint. It would be exceedingly unlikely that two people with the same fingerprint pattern and notable minutiae could cut themselves deeply enough in the exact same place on the finger to leave a scar. If a person cuts themselves only at the epidermal layer of ridge-print skin, the ridges grow back exactly as before. However, if a person cuts themselves deep into the dermal layer of ridge-print skin, the ridges do not grow back, and the scar becomes a distinguishing feature. The scar is notable by an inward “puckering” where the ridges appeared to be falling into the furrow created by the scar. This is how scars are differentiated from creases.



Figure **4.16.1**: Scar. Notice how the ridges appear to be falling into the furrow of the scar. Author's collection

Adermatoglyphia

There is a rare genetic skin condition where ridge-print skin does not develop during the volar stage of fetal development. This condition is called **adermatoglyphia.** Depending on the degree of adermatoglyphia, the individual may not be identified using fingerprints and therefore DNA would be the best alternative method of identification. However, many years ago, your author was tasked with identifying an adermatoglyphic person by the ridge impressions in figure **4.16.2**. In this case, your author was able to create a transparency of the print and then over the transparency with the exemplar print. Each **dot** that matched the overlay was one point of minutiae, and an identification was able to be made.



Figure **4.16.2**: Adermatoglyphic print - Author's collection

Incipient Ridges

Another very unique identifier within the ridge pattern is the **incipient** ridge. Incipient ridges, also called nascent ridges, are immature ridges that began development, but for some reason never fully developed. These ridges are often found between two ridges, and appear as very small or thin ridges, as in figure **4.16.3**.

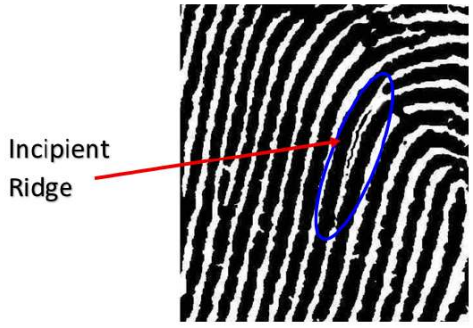


Figure **4.16.3**: Incipient Ridge - Author's collection

Is it a dot or dirt?

Your author maintains there is no such thing as a perfect fingerprint. Often, latent print examiners will ask themselves, “Is this an end ridge or a bifurcation that did not develop or ink, or is it a dot or dirt?” The answer to these questions can be found by examining the ridges above and below the ridge in question. If you look at the ridges above and below the short ridge in Figure 4.40, you will notice that the ridges tend to bow away from the short ridge. The same will occur with a dot or end ridge. Therefore, if it looks like an end ridge that is leaning towards another ridge, and the ridge above or below does not bow away from the ridge, it is likely that the ridge is a bifurcation with an undeveloped or recorded connecting ridge.

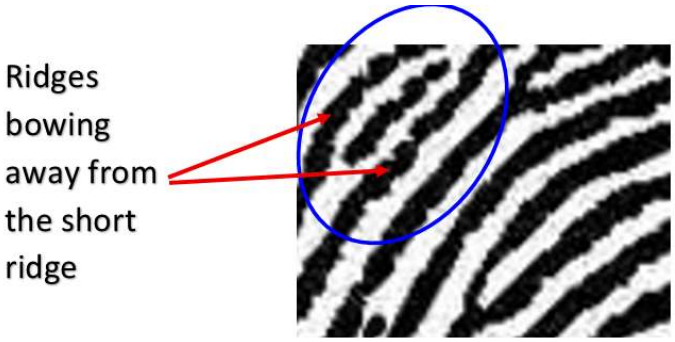


Figure **4.16.4**: Ridges bowing away from short ridge - Author's collection

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4.17: AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM

By the early 1980's, the Federal Bureau of Investigations had developed an algorithm-based computer system capable of replacing the Henry Classification System as the primary fingerprint card storage and retrieval system. This system was the Automated Fingerprint Identification System (AFIS). Before this development, fingerprint cards had to be stored in physical form at each jail, prison, or the justice departments of each state. AFIS allows for the collaborative storage of these cards in digital form in one centralized storage and retrieval database.



Figure **4.17.1**:FBI Fingerprint Storage Facility – 1944 – Public Domain

The fingerprint comparison analyst will input a scanned digital image of the unknown fingerprint into the AFIS database, plotting minutiae in a digital format. The analyst will request a certain number of potential matches and allow AFIS to search through as many as 500,000 digital ten-print cards in .08 of a second. The analyst then conducts the comparison and confirms or rejects the possible matches provided by the computer.

Altered Fingerprints

One benefit of AFIS is that it can detect and match altered fingerprints by reconstructing the original fingerprint on file using algorithms.



Figure **4.17.2**: Altered fingerprint reconstructed to the original print - Author's collection

Of course, once the ridge-print skin of the finger has been surgically altered, the resulting alteration becomes a very distinctive and uniquely identifiable fingerprint.

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4.18: Test Questions

1. The part of the finger that is furthest from the palm is called the:
    a. Medial phalanx
    b. Distal phalanx
    c. Proximal phalanx
    d. Interdigital region
2. Professor Inez Whipple and Dr. H. H. Wilder conducted research into the development of finger pads in the womb. What was the name of the book they wrote together?
    a. The Origin of Fingerprints
    b. FBI Science of Fingerprints
    c. The Ventral Surfaces of the Mammalian Chiridium
    d. Fingerprints – They are Good for Something
3. Fingerprints develop during the volar stage of fetal development and are fixed and permanent by this week of gestation:
    a. 28th week
    b. 14th week
    c. 22nd week
    d. 18th week
4. This fingerprint pattern is characterized by a ridge or pair of ridges that enter the pattern area from one side, recurves, and exits, or tends to exit, out the same side.
    a. A whorl pattern
    b. A loop pattern
    c. A double-loop whorl
    d. dAn arch
5. This fingerprint pattern is characterized by ridge formations that are spiral, elliptical or oval shapes, or have variations of these formations, and at least two deltas are present with a re-curve in front of each.
    a. A whorl pattern
    b. A loop pattern
    c. A tented arch
    d. An arch
6. This fingerprint pattern is characterized by ridges that enter from one side of the pattern, rise slightly in the center, and exit out (or tend to exit) on the opposite side.
    a. A whorl pattern
    b. A loop pattern
    c. A double-loop whorl
    d. An arch
7. This person devised a method for the classification of fingerprints based on a comparison of the minutiae found within the pattern area:
    a. Sir Edward Richard Henry
    b. Sir William James Herschel
    c. Sir Francis Galton
    d. Dr. Henry Faulds
8. This type of minutiae is characterized by a single ridge that is divided into two ridges:
    a. A short ridge
    b. An end ridge
    c. A bifurcation
    d. An enclosure

9. This type of minutiae is characterized by a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge
    a. A short ridge
    b. An end ridge
    c. A bifurcation
    d. An enclosure
10. This digital database used to store, sort, retrieve and query fingerprints is called the:
    a. Automated Fingerprint Identification System
    b. Automated Latent Prints System
    c. Biometric Storage and Retrieval System
    d. Automatic Fingerprint Database System

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4.19: Suggested Essay Topics

1. Write an essay on the contributions of Edmond Locard to the science of fingerprint comparison.
2. Write an essay on the first use of fingerprints to identify a criminal in the United States of America.
3. Write an essay about the impact of Ridgeology on the science of fingerprint comparison.
4. Write an essay on the contributions of Harold Cummings on the science of fingerprint comparison.
5. Write an essay about the 1911 theft of the Mona Lisa from the Louvre Museum and the efforts of the Paris police to find the painting.

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4.20: References

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CHAPTER OVERVIEW

5: Latent Fingerprint Development

Learning Objectives

- To learn the historical development of the means employed to visualize latent fingerprint evidence
- To understand the uses of fingerprint powders to develop latent fingerprint evidence
- To understand the types of brushes, documentation, and lifting techniques used to record developed latent fingerprint evidence
- To understand chemical development mediums for latent fingerprint evidence
- To learn how to enhance blood print evidence in a crime scene

5.1: Introduction
5.2: POWDERS
5.3: CHEMICALS
5.4: Fingerprint Scenario
5.5: Test Questions
5.6: Suggested Essay Topics
5.7: References

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5.1: Introduction

The first fingerprint development techniques utilized to develop latent fingerprints likely involved holding a non-porous item in the soot produced by the wick of a lit kerosene lamp. Camphor fuming is a very old technique first introduced in India in the late 19th century, which gained popularity again in the early 2000's for developing fingerprints on un-fired firearm cartridges. A few camphor crystals were placed in a metal spoon and set alight. The item was held above the smoke rising from the spoon until a layer of carbon atoms interacted with excreted sebaceous oils and the aqueous deposits of the fingerprint, producing a dark developed print. Excess carbon could be removed using a camel-hair brush, or with the application of a gentle stream of cold running water. If the developed print was too faint, the process could be repeated. The developed print can be easily lifted using standard tape-lifting methods. The only drawback of the camphor method is that it produces a lot of smoke. It does, however, have a very pleasant odor. At any rate, it is a development medium best completed in an area with a lot of ventilation, and not in a laboratory with a sensitive fire alarm or sprinkler system.

Fingerprint development methods can be divided into two categories: powder development and chemical development. They can also be broken down into practical applications of those methods that can be used in the field (crime scene) and those that can be used in the laboratory; although any method used in the field can also be used in the laboratory. Development mediums can also be grouped by the surface upon which the latent fingerprint is deposited: porous and non-porous. A **porous** surface is a material that will absorb excretions, like paper or paper products. A **non-porous** surface is a material that is solid and impervious to excretions, like metal, glass, or plastics.

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5.2: POWDERS

The first fingerprint powders were developed in the early 1920's and used lampblack as a base. Lampblack is a finely powdered black soot deposited in incomplete combustion of carbonaceous materials, collected from fireplace chimneys or oil lamps, and used chiefly as a coloring agent in paints and inks. Since that time, fingerprints powders are made using resin, ferric oxide, lampblack, lead, mercury, cadmium copper, silicon titanium, and bismuth.

Powders are the old faithful partner of the fingerprint technician, and they can be used in the field and in the laboratory. Sometimes it is just the easiest solution to throw some powder. Fingerprint powders adhere to eccrine, apocrine, sebaceous oils, and contaminants. Most technicians in the field only use two colors of powder, black and silver, or bi-chromatic powders that have the unique quality of appearing black on light colored surfaces and silver on dark surfaces. White powders are good for developing fingerprints on dark surfaces. White powders photograph well but the developed prints are almost impossible to lift. Magnetic powders come in various colors and are great for developing prints on non-metallic surfaces. Application of magnetic powders is done with the use of a magnetic brush, which will be discussed in a later section of this chapter. Fluorescent powders have properties that allow the powder to fluoresce with the application of an Alternate Light Source, which will be explained in a subsequent chapter. They are incredibly bright and are useful on dark or multi-colored surfaces. Be forewarned, however, that a very tiny amount of fluorescent powder goes a very long way.

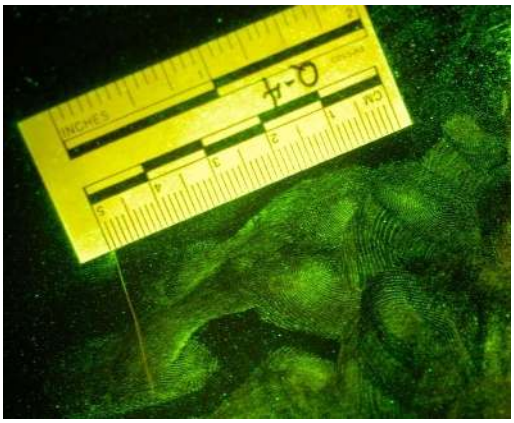


Figure **5.2.1**: Fluorescent green fingerprint powder on a television screen - Author's collection

Brushes

There are two options for the application of regular fingerprint powders: ostrich feather or fiberglass brushes. Your author prefers an ostrich feather brush with a light, twirling touch, and a camel hair (or squirrel hair) brush for finishing. Fiberglass brushes are a bit less expensive than ostrich feather brushes, but they tend to get heavy with powder and there is less control, in your author's opinion. Whatever technique or brush the technician finds that works best is fine, but practice, practice, practice. Be sure not to mix your brushes and to have one brush designated for each type of powder. Be careful of the surface you are using the brush on, and if the brush gets wet, throw it away.



Figure 5.2.2: Ostrich feather brush and regular black powder - Author's collection

Magnetic brushes are used to apply magnetic powders to non-metallic surfaces. They are very useful when the technician really does not want to make a tremendous mess, which will happen with regular powders. Also, magnetic powders can be used on porous surfaces because the powders are picked up by the action of the magnet and therefore do not smear the inks from the powder across the surface. The magnetic end of the brush will attract the magnetic powder to form a cluster of powder at the head. The powder can either be applied with the powder held in place by the magnet, or it can be retracted causing the powder to fall onto the area to be dusted. The powder is then pulled back to the magnetic head when the magnet is returned to its original position.



Figure 5.2.3: Magnetic brush and powder - Author's collection

Photographing and Lifting

Once a fingerprint is developed, it is essential to document the print using photography. The image must be photographed with the film plane at a 90-degree angle to the print to avoid distortion. There must be a scale in the image as well. Fingerprints developed

with powders can be “lifted” from the surface of non-porous items using clear fingerprint tape or a hinge-lifter. Once the lift has been applied to a backing card, it is important to document the essential information relative to the crime being charged, and to document the direction of the lift using an arrow. It is also recommended that the technician provide a drawing of the item being fingerprinted with an arrow depicting the direction of fingerprint deposition. This card now becomes an item of evidence and must be treated as such.

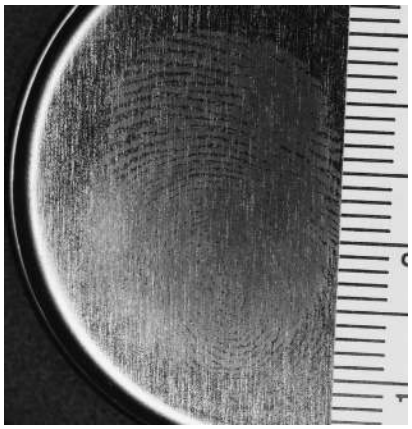


Figure 5.2.4: Latent print developed on pill tin - Author's collection



Figure 5.2.5: Developing print being "lifted" with a hinge lifter. Fingerprint lifting tape is nearby. - Author's collection



Figure 5.2.6: The lifted developed fingerprint - Author's collection

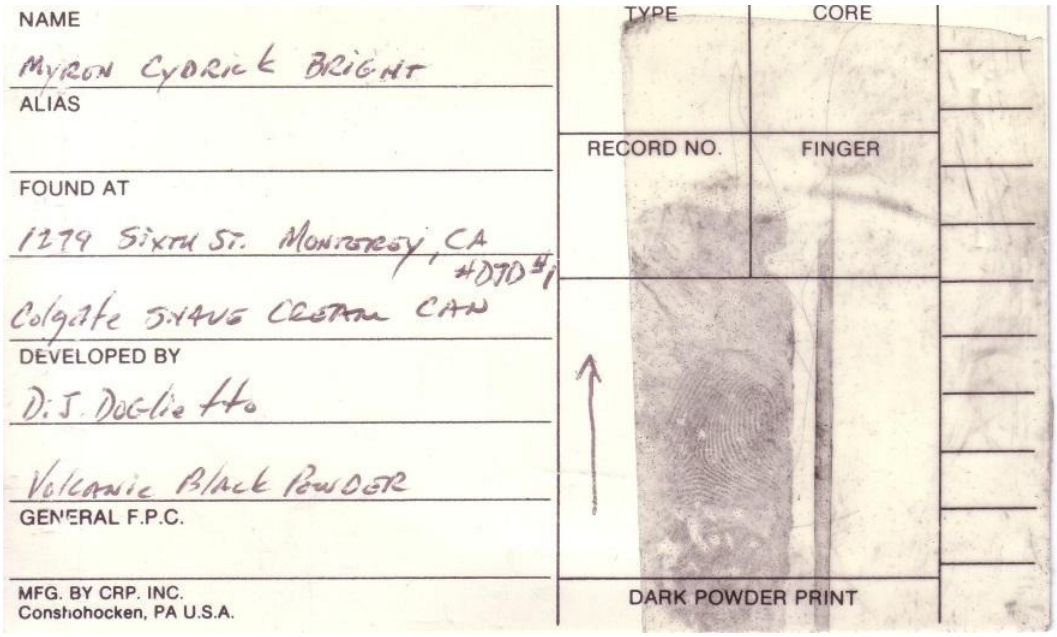


Figure 5.2.7: Fingerprint backing card. Note the arrow depicting the direction of the lift. - Author's collection



Figure 5.2.8: Drawing of item being lifted with an arrow depicting the direction of the fingerprint. - Author's collection

To Lift or Swab

The dilemma faced by latent print technicians is always, is it better to develop a latent fingerprint impression or to swab the area for DNA. A developed fingerprint can be identified in a manner of minutes, whereas a DNA specimen might take months to get the results. Is it possible to do both? Yes, particularly in the laboratory following strict sterilization protocols of the equipment needed to process the item for latent prints. In the field, the technician can use sterile powders and brushes. These are single-use items that are manufactured and sterilized before being packaged in containers. The application devices are available either as single-use fiberglass brushes or sterile sheaths that are placed over magnetic brushes. Sterile powders are packaged and sold in small containers providing usually one ounce of powder. Other methods of sterile development will be discussed in the chemical section of this chapter.

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controlled environment, the need for water and a basin, or the specialized equipment needed to complete the process; although some equipment can be acquired that are smaller, more portable versions of their laboratory-based kin.

Ninhydrin

Ninhydrin is a chemical reagent used to visualize latent prints on porous items, such as paper, through a reaction with the amino acids present in sweat secretions, which turn the prints a violet color called **Ruhemann's Purple**. The technician will either spray the ninhydrin on a surface using a pre-mixed solution, available from any forensic supply company, in a spray bottle or by brushing or dipping the item with the solution in a pan that contains the solution, which is the preferred method by your author, and then hanging the item to dry. The best results can be achieved using a fuming cabinet heated to 175-degree Fahrenheit with an attached humidifier. Using this method, prints will begin to develop in five to ten minutes. Without the chamber, prints will begin to develop in about an hour. The chamber is invaluable to the technician, who is constantly harried by administrators who are anxious to know if a print was developed on a death threat, forged document, or bank robber's note, as the reaction time is greatly reduced. The technician will allow the item to hang dry for up to 24 hours to allow faint prints to fully develop. It is not recommend using ninhydrin sold in aerosol cans unless the laboratory is equipped with a good breathing apparatus and a well-ventilated fuming chamber. Even with these precautions, the technician will still have some exposure to the invasive fumes. It is imperative that the technician wears several layers of latex gloves and a respirator when working with ninhydrin; and that the laboratory is well ventilated to an area that will not inconvenience people passing by.

Remember that any uncovered part of the technician's skin will stain purple when it comes in contact with the chemical, and it might remain that way for a few hours regardless of washing. So, if you do not want to have purple streaks on your cheeks and forehead, do not scratch until you have discarded your gloves and washed your hands. Be careful when using pre-mixed ninhydrin that also contains acetone, as this chemical may obliterate some soluble inks. The same can be said for some fixatives. It is always best to experiment before processing the actual item of evidence. It is also advisable to the document before processing and again immediately after. Using a green colored filter will help correct the purple color if you find it difficult to analyze. You may also use the Alternate Light Source at 535 nm without a barrier filter or 485 nm (450 nm for Manila envelopes) with an orange filter to visualize.

With some experience, the technician will also become an expert at determining which prints belong to the writer of the note and which belongs to people who have handled the document with their bare hands. These prints tend to be partial prints on the extreme corners of the document or thumb prints on the margins about one-third of the way up from the bottom of the page, with corresponding index finger impressions opposing. Suspects who wear latex gloves while drafting their machinations will seldom wear them while carrying the note to the mailbox or delivering the note to a bank teller. Therefore, do not forget to treat the envelope that housed the offensive document. It should be noted that the chemical formula for ninhydrin will likely be banned in the near future. Fear not, technology will replace the current form of ninhydrin with pellet-based vacuum chamber ninhydrin that will provide for the safe use of the development medium well into the future.

Special formulations are available for developing prints on thermal paper. Bear in mind that papers that have been coated in wax, like milk cartons, do not lend themselves to ninhydrin processing. For this type of evidence, it is best to use powders, cyano-acrylate fuming or Sudan Black.

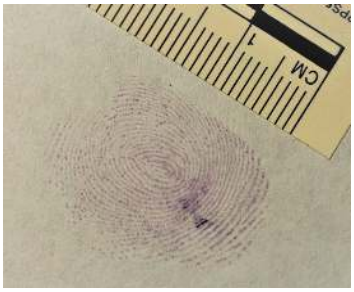


Figure **5.3.1**: Ninhydrin developed print. Author's collection

Another great thing about ninhydrin is that even if you only develop partials or smudged impressions, the ninhydrin process does not interfere with DNA typing.

Cyanoacrylate Ester

Cyanoacrylate ester fuming has replaced powders as the work horse of the fingerprint laboratory. With the advent of easy-to-use fuming kits, the ever-popular and inexpensive cotton-ball method, and fuming wands there is no reason for a laboratory not to be equipped with a fuming chamber or to take cyanoacrylate into the crime scene. The technician will place the item of evidence in the fuming chamber and place either the laboratory grade super glue on a foil tray on top of a heating plate with a humidity source or will introduce a fuming kit, such as Sirchie's Cyano-Shot™ or Lynn Peavey's Hot Shot™, by placing the activator canister into the jar containing the activator solution and emptying the glue vial on top of the activator canister. It is best to have a fan in the chamber for the circulation of the fumes evenly onto the items being fumed. Cyanoacrylate esters react with the amino acids, fatty acids, and proteins in the latent fingerprint to create a visible print that is white along the ridge lines and absent on the furrows. Cyanoacrylate also will not degrade DNA, so if you only get partials, you can still submit the item for DNA typing. Fuming chambers can be made from any cabinet, fish tank, or can be commercially purchased. The technician should keep a constant eye on the fuming process to make sure that the items of evidence are not over-fumed. To reduce the chance of over-fuming, Placing a black fingerprint backing card with a nice greasy nose-oil thumb print prominently in the center on a string in the chamber where a keen eye can be kept is a good way to know when to stop the fuming process. The best method for documenting the visualized print is with digital photography using a format that is acceptable to the agency that administers the automated fingerprint database. Do not forget to add a metric scale to the frame. The California Department of Justice recommends either JPEG-Fine or TIFF. The experienced fingerprint comparison analyst usually has no difficulty matching the white ridges on the developed print to the black ridges of the inked exemplar. However, when making exhibits for the jury, it is always best to color-reverse the image, with an explanation of the steps taken, and a reason for the enhancement, so that the jury will not be confused by the color contradiction.

So, what happens if the surface upon which you want to develop the print is of a white color? There's a dye for that. Treat the item as normal and examine it under magnification. If you detect only partials or fragments, submit the item for DNA typing, should the investigation warrant. If you detect good impressions under magnification, you can treat the item with Ardrox, Basic Yellow, Basic Red or Rhodamine 6G. If a laboratory does not have dyes on hand, the technician can try using a fluorescent medium and an Alternate Light Source. Small Particle Reagent can also be used to dye the ridges black; providing the surface is washable.







Figure 5.3.2:

Latent fingerprint developed with cyanoacrylate fuming. Color-reversed image. Exemplar fingerprint. Author's collection

Sticky-Side Tape

The sticky-side (or adhesive-side) tape formula method is another staple of the fingerprint technician in the jail or prison setting owing to the abundance of inmate manufactured weapons with tape-wrapped handles. There are several formulations on the market including Forensics Source Sticky-Side Powder™ kit, and Wet Wop™, and Evident's Wet Powder™ that are extremely easy to use. The technician merely paints the adhesive side of the tape with the formula using a brush, waits a few minutes, gently rinses the tape using tap water or a Nalgene wash bottle, and allows the tape to dry. The resulting developed prints will appear on the tape. The trickiest part of using sticky-side tape formula is pulling the tape apart from itself and the object. Pulling the tape steadily and slowly is the best method. The other tricky part is holding the tape down while you apply the formula. A pair of forceps and an old ridge pick are handy for taming the wild sticky tape, especially when the technician is wearing latex gloves. Sticky-side tape formula will also recover lip impressions if tape is used to cover a victim's mouth. Think how great it would be to have the suspect's fingerprints and the victim's lip print on the same item of evidence.

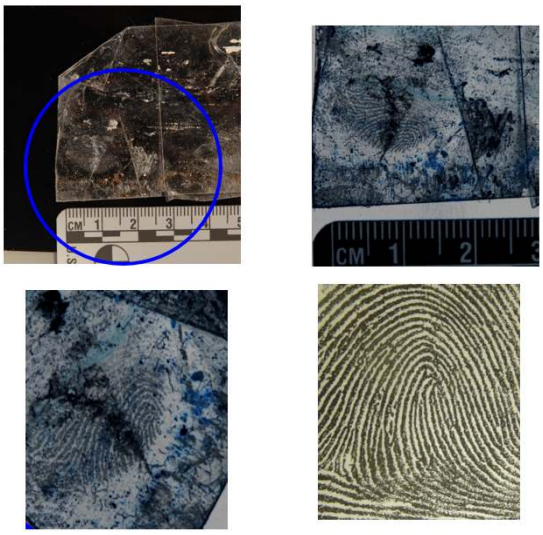


Figure 5.3.3: A latent fingerprint developed with the Sticky-Side tape method. Color-reversed court exhibits. Exemplar print. Author's collection

Skin Print Black

Doje's Skin Print Black™ is a product that is kept in the laboratory for those "just in case" events. It is a magnetic powder that is formulated to have less ink than normal magnetic powders. The technician inserts a small dowel into a roll of clean cotton cash register tape (do not use thermal paper) and rolls it, with some pressure, on the skin of a victim as a means to transfer the impressions to the paper. The technician then dusts the paper with the powder. This product is great if the technician can get to the victim before they wash or rub the area that was grasped. Thus, if a person is strangled or grabbed hard upon the arm, this method may well recover either fingerprint impressions or other sweat transfers like those produced by the assailant's inner arm. Even if the technician develops an impression on the paper that does not yield significant ridge detail for identification purposes, the technician will still be able to see where the victim was grabbed or strangled and therefore, they can vigorously swab that particular

area for a DNA specimen. This is the least obtrusive examination of a decedent person, with the least amount of contamination, a technician can make while awaiting personnel from the coroner's office to arrive.

Small Particle Reagent

Small Particle Reagent, or SPR, is a chemical reagent that is extremely useful in developing fingerprint impressions on difficult surfaces like vehicles that are wet with dew, cold soda cans, surfaces that are covered in oils or dirt, and glass. SPR is easy to use and inexpensive. The technician can either use a pre-mixed solution, available from all of the forensic supply companies, or can purchase the individual vials (containing Molybdenum disulfide) and mix them with water, shaking vigorously. The solution is then sprayed on the surface with a gentle misting spray. Wait a few minutes and then spray the area again with clean water from another spray bottle. The prints will appear as the excess SPR washes away. The process can be repeated for faint impressions. Once the surface has dried completely, the impressions can be photographed and lifted using common lifting methods. One thing to remember is to be sure that the technician has black and white reagent on hand as there is nothing worse than being called out to a vehicle crime scene with a dark colored car and all that the technician has brought is black SPR. A quick look at some of the forensic supply sources reflect a fluorescent SPR is now also available.



Figure **5.3.4**: Fingerprint developed on a soda can fresh from the vending machine using SPR. Author's collection

Enhancing ridge print impressions in blood

On occasion, the technician will come across a faint impression deposited on a surface in blood, whether ridge print or footwear impression, and the hope is that the impression can be enhanced in a manner in which it can be visualized and documented using photography. Coomassie Blue is an enhancement chemical used to dye blood-contaminated fingerprints on porous or non-porous surfaces, which produce bright blue visible prints. Amido black is commonly used for the same purpose and will produce a dark blue stained impression. Amido black is sprayed onto the area of interest and then rinsed with a destaining product. Acid fuchsin, also known as Hungarian red, is an aqueous solution used to enhance fingerprint deposits in blood but must be used with an Alternate Light Source with a wavelength between 520nm-560nm. Your author prefers Leuco-Crystal Violet because of its ease of use, safety, versatility, and ability to find impressions in large scenes that were previously unseen. Leuco-Crystal Violet (LCV), also known as Aqueous LCV, is a reduced form of gentian violet; it is a highly sensitive formula to visually enhance blood prints and the reaction to blood will produce a vibrant violet result.

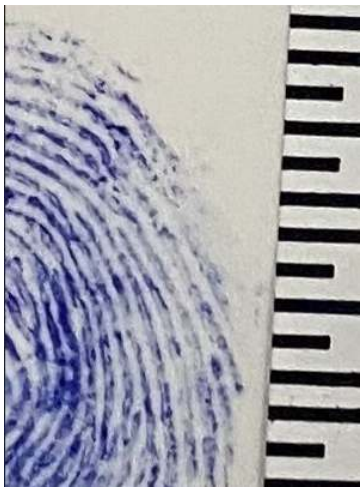


Figure **5.3.1**: Blood print enhanced with LCV. Author's collection

Of course, all the above listed latent print development techniques are all for naught if the items being processed were not collected in a manner that preserved the fragile deposited evidence. The technician should tirelessly impress upon first responders, crime scene investigators, and civilian employees that fingerprints are delicate and easily obliterated. The technician should instruct all personnel that wearing latex gloves while handling evidence is essential; however, they are not sufficient to prevent the destruction of latent fingerprints, which are composed, depending on the source, from 80% to 90% water. Items of evidence must be handled in a way to preserve the latent print impressions. In other words, you do not pick up a knife by the handle and expect the prints on the handle to be intact. You must pick up the item in a manner that is not instinctive, such as by the end, hilt, or the very edges of the blade near the handle. Once the item is in an evidence envelope or paper bag, hold the bag or envelope so that you do not press the inside against the object. In other words, hold it by the top or the bottom, but not with your hand grasping the item as the impression may be absorbed into the paper or smudged beyond individualization. Be sure to get that evidence into the lab as soon as possible. The less handled and the fresher the evidence, the better the chance of recovering prints.

Vacuum Metal Deposition

Vacuum Metal Deposition or VMD is an advanced latent fingerprint development technology that works by depositing very thin layers of atomized metal on to the surface of an item of evidence inside a vacuum chamber to visualize latent fingerprints. The benefits of VMD is that it can develop latent fingerprints on aged items of evidence that have been exposed to adverse environments and conditions. The process does not interfere with subsequent DNA analysis. It can develop fingerprints on fabrics, fired cartridge casings, thermal receipt paper, positive and negative sides of adhesive tape, and unfired and fired cartridge casings. VMD is also non-destructive to electronic devices and electronic digital storage media. It can also develop latent transfer impressions of body surfaces like faces, ears, lips, hands, feet, and arms, which provide target areas for DNA collection. It works on porous, semi-porous, and non-porous surfaces. The vacuum removes air, moisture, and solvents from the evidence and chamber environment to allow the metal atoms to travel through the chamber without interference to the evidence item surface and to condense onto the surface thus providing a smooth, even coating. The metals used during the VMD process are gold, silver, sterling silver, zinc, and copper. Your author believes that VMD will be the go-to latent fingerprint development method in the future.

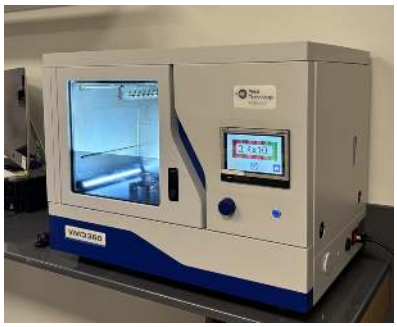


Figure **5.3.6**: West Technology Model VMD360. Author's collection



Figure **5.3.7**:Fired rifle cartridge casings developed with VMD. Author's collection

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5.4: Fingerprint Scenario

One of your author's favorite fingerprint development stories involved mutual aid to a neighboring city. The local police were experiencing a repeated crime involving a young man who was on State parole, wherein the parolee would stand on a corner near his residence and point a handgun at the motorists while shouting gang slogans. Upon hearing the sirens of responding police cars, the suspect would sprint back to his house and hide. After three days of this cat-and-mouse game, the local police formulated a plan to catch the culprit. They stationed marked and unmarked police vehicles strategically around the block. They also had officers hiding nearby on foot. When the suspect repeated his daily shenanigans, the officers were in quick pursuit. Unfortunately, the suspect was fleet-footed and ducked behind an abandoned vehicle parked in the driveway of his house. Officers arrived just as he locked and closed the door to the vehicle. The deputy chief of the agency arrived on scene, looked through the dirty front passenger door window, and saw what he believed to be the butt of a handgun protruding from under the driver's seat. Therefore, the vehicle was seized as evidence, towed to the station, and a search warrant petitioned. Once the warrant was approved, the deputy chief called to see if your author was available to process the vehicle for the suspected handgun. Upon your author's arrival, he photographed the vehicle in its entirety and worked his magic to unlock the locked door. He then went to his vehicle to prepare for the task of recovering the suspected handgun and collecting DNA evidence. As he did this, he noticed that four of the police officers, along with one sergeant, had gathered in the parking lot. Not to his surprise, sadly, he observed the sergeant don a pair of gloves, and advanced one step towards the suspect vehicle. Your author knew that he would have to stop them from contaminating the evidence, but before he had a chance to move, the deputy chief appeared and scolded them most harshly. "But D.C., we just want to see if the gun is stolen." Knowing this, your author cut a sheet of clean butcher's paper and laid it on the front footwell of the vehicle. He carefully moved the gun onto the shiny side of the paper, and photographed the serial number, which he provided to the gathered curious personnel. Vindicated that the gun was indeed stolen, they retreated into the station, and your author was left to finish processing the gun. Carefully, your author swabbed the gun for touch-DNA, and then gently removed the stainless-steel magazine. It was then that he observed the glistening inherent luminescence of a left thumb print, in fact, the suspect's left thumb print. No development was needed, as the print was patent. Your author is confident, had the sergeant manipulated the handgun to "render it safe" or to copy the serial number, the thumb print may not have survived. As it was, the print was enough to send the suspect back to prison for three additional years.



Figure 5.4.1: The suspect's left thumbprint on a pistol magazine. - Author's collection

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5.5: Test Questions

1. This early latent fingerprint development technique was widely used in India and involved the use of soot to adhere to excreted sebaceous oils and aqueous components of the fingerprint impression.
    a. Cyanoacrylate ester fuming method
    b. Camphor fuming method
    c. Black powder
    d. Small Particle Reagent
2. Early black fingerprint powders were composed primarily of this:
    a. Camphor
    b. Silicone
    c. Lampblack
    d. Sand
3. Fingerprint powders were first developed in which decade?
    a. 1910's
    b. 1880's
    c. 1920's
    d. 1930's
4. Fingerprint powder brushes are made from ostrich feathers, fiberglass, and _____.
    a. magnets
    b. bamboo
    c. goose down
    d. mole hair
5. For fluorescent powders to fluoresce, the technician must use a:
    a. A strong flashlight
    b. A laser
    c. An Alternate Light Source
    d. Outdoor lighting
6. This latent fingerprint developing medium uses a laboratory grade version of super glue:
    a. Camphor ester fuming
    b. Cyanoacrylate ester fuming
    c. Ninhydrin
    d. Ardrox
7. This latent fingerprint development medium is sprayed on to wet non-porous surfaces and then gently washed off to review developed prints:
    a. Camphor ester fuming
    b. Cyanoacrylate ester fuming
    c. Ardrox
    d. Small Particle Reagent
8. This is the color of developed latent fingerprints when using ninhydrin:
    a. Ruhemann's Purple
    b. Orndorff's Red
    c. Sulemaan's Silver
    d. Grecian Grey
9. When developing latent fingerprints using the cyanoacrylate ester fuming method, it may be necessary to do this for the court exhibit for the benefit of the jury:
    a. Apply contrast to the recorded image

b. Color-reverse the recorded image
c. Nothing
d. Make a sketch of the ridges and furrows

10. The author recommends this chemical for enhancing fingerprint deposits left in blood:
    a. Ardrox
    b. Fluorescent powders
    c. Leuco-Crystal Violet
    d. Skin-Print Black

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5.6: Suggested Essay Topics

1. Write an essay on the development of cyanoacrylate ester fuming beginning with the Sega Prefecture Crime Laboratory in Japan in 1977, and how it revolutionized latent fingerprint development.
2. Write an essay about the considerations of DNA contamination when processing latent fingerprint evidence, and the benefits or drawbacks of each method of identification.
3. Write an essay exploring the various methods of developing fingerprints on porous surfaces like papers, currency, and cardboard.
4. Write an essay about the various methods of recovering latent fingerprints from human skin; especially the research conducted by Brian Dalrymple using the iodine fuming and silver plate transfer method.

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5.7: References

Doglietto, D. (2025). *Crime Scene Processing in Correctional Facilities and Prisons*. CRC Press, Taylor & Francis Group.

Sturelle, V., et Al (2006). The Use of Camphor in the Development of Latent Prints on Unfired Cartrdiges. Journal for Identification, 2006 (56), 694-705

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CHAPTER OVERVIEW

6: Forensic Photography

Learning Objectives

- To learn about the different kinds of cameras used, and not used, in forensic photography
- To understand the important role of depth of field in forensic photography
- To understand the methodology of photographing a crime scene
- To learn about the role of the camera in photographing injuries
- To understand the difference between prejudicial and clinical photographs
- To understand close-up, evidentiary, and comparison quality photography

6.1: Introduction
6.2: The Camera
6.3: PHOTOGRAPHY
6.4: CRIME SCENE PHOTOGRAPHY
6.5: WOUND PHOTOGRAPHY
6.6: EXTREME CLOSE-UP OR MACRO-PHOTOGRAPHY
6.7: Things to Remember
6.8: Final Thought
6.9: Test Questions
6.10: Suggested Essay Topics
6.11: References

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6.1: Introduction

As noted in previous chapters, cameras have been used to document aspects of crime scenes or the faces of people convicted of crimes since the 1880's. As photography was a very specialized science, or art depending on your perspective, in the late 19th and early 20th centuries, the photographs themselves were precious and few. The cameras were bulky, heavy, and required a large tripod. The photographs taken were generally an overall view of the scene, and there is no guarantee that the scenes were not staged or posed to get the entire scene into one frame. Because early cameras were so difficult to maneuver around a crime scene, hand-drawn sketches and drawings were more common to the courtroom than a photograph. Photographs of that time could easily be altered as the plate negatives provided large canvases for manipulation in the darkroom; and thus, the resulting photograph itself was no guarantee that it was an accurate representation of the scene or object having been photographed.



Figure **6.1.1**: Photographer A. W. Leanord with Large Format Plate Camera of the early 1900's – Library of Congress

As cameras evolved into the convenient size that they are today, the role of the camera became more important to modern forensic sciences. Today, cameras are used to fully document crime scenes, capture accurate images of important items of trace and transfer evidence for comparative purposes, are useful in the analysis of bullet trajectories and bloodstain patterns, record injuries before metamorphic or surgical change have occurred, and many other forensic applications.

For this chapter, we will divide the topic of forensic photography into three parts: crime scene photography, wound photography, and comparison quality photography. First, however, we will start with the camera itself.

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6.2: The Camera

According to a 2024 Pew Research study, 98% of Americans own a cellular telephone. 91% of those telephones are smart phones with cameras. In effect, over 300 million people have a camera in their pockets or on their belts. Most of these cameras take great incidental photographs; however, these cameras are neither appropriate nor approved for forensic photography. The reason for this will be explored later in this chapter but is primarily a result of the way the cell phone camera artificially corrects depth of field and the manner in which the image is stored. For the better part of the 20th century, 35mm film cameras were the mainstays of the forensic technician. 35mm silver halide crystal film was cut into strips and loaded into a canister. The canister was easily loaded into the back of a camera, generally a **single-lens reflex** camera that allowed the photographer to view the image through the lens by a mirror and prism system, and either manually or automatically fed the film roll past a shutter arrangement. When the shutter was opened, a photon of light would react with the silver halide on the film strip forming a tiny speck of solid silver. The more light that interacted with the silver halide, the more specks of solid silver would be created. Of course, the image that was captured could not be observed by the human eye until after it had been developed. Since there were about 86,400,000,000 silver halide crystals on the film, the resulting photographic images were of great quality. This is the reason why most law enforcement agencies did not abandon their beloved 35mm cameras for digital cameras until the mid-2000's or even later. Finally, photographs that did not need to be developed to be seen, having the ability to replay the photograph that was just taken, and the improvement of pixel quality of the captured images led to the adoption of **digital single-lens reflex** or DSLR cameras being the standard for law enforcement agencies.



Figure **6.2.1**: 35mm Film Emulsion SLR Camera - Courtesy Brian A. DeLucia

Digital imaging utilizes a light-sensitive sensor to replace film to capture an image. The sensor is made of millions of minuscule **photosites**, which collect photons of light and converts them into electrical (digital) signals. These signals are gathered as numbers, which the camera's processor uses to collect the information received by the sensor and to store it in its memory device. We rely on **pixels** or picture elements to visualize the data. Pixels are the smallest unit of a digital image, essentially one point of color or shade of grey. Your camera arranges pixels in a grid. Each position of a pixel on this grid corresponds with the location of that pixel on the digital image. The more pixels a digital camera can place on the grid, the higher the image resolution. Typically, digital cameras are inferior to the image resolution provided by silver halide film with one exception: **full-frame digital cameras**. The full-frame digital camera uses a sensor that is the same size as the 35mm film format. This provides for a higher quality image that more closely matches the quality of the 35mm film camera. It also provides better performance in low-light conditions than the smaller **crop sensor** found in the DSLR. The drawback of the full-frame camera is their price, which is generally outside of the means of anything but the largest police agencies. The current trend in digital imagery is the **mirror-less digital camera**, which replaces the prism and mirror arrangement of the SLR and DSLR with a sensor called an **electric viewfinder** or EVF. The benefits of the mirror-less camera is that by removing the prism and mirror arrangement, the cameras can be lighter, will have a fast-shooting speed, and may have better autofocusing properties. It should be noted that the best benefit of the DSLR camera is the ability to change lenses for the different responsibilities which with the forensic camera is tasked.



Figure **6.2.2**: Your author's forensic camera

The reason cellular telephone cameras are not appropriate for forensic use is owing to the problem the camera has in dealing with depth of field, which is something you will learn about later in this chapter. Cellular telephone cameras lack the ability to physically adjust the aperture of the lens and lack the distance between the lens and the sensor, as in larger cameras. Therefore, in order to make corrections for depth of field, the cellular telephone camera uses software-based artificial adjustments to blur the background. This technique is called the **bokeh effect.** This makes the background appear as if it is further away from the principal subject of the photograph. This can also be accomplished using a process called **depth map generation** which uses depth-sensing technology, such as dual-pixel autofocus, to map the scene and artificially blur certain aspects to give the perception of depth. Another method used to correct depth of field problems is a process called **multiple exposure** whereby the camera takes two simultaneous photographs and layers the images on top of each other. Finally, most people leave their cellular telephone cameras set on **portrait mode** that require the camera to focus on the primary subject and to artificially create a shallow depth of field.

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6.3: PHOTOGRAPHY

In this chapter, you will be learning about **still** photography, which means a photograph that is not moving as in a motion picture or video. Consider a motion picture that is made of many frames of individual photographs. The sequential movement of these frames provides for the seamless movement associated with a movie. The individual frame of the movie is called a still photograph. Although video cameras play a significant role in crime scene and forensic documentation, it is the still camera that provides the factual representation of the crime scene and the evidence located within the scene. Photography is the creation of an image of an object using the action of radiant light on a light-sensitive surface. Cameras record light. They do not record motion, unless we manipulate their functions in order to record motion; and by this, your author means to stop motion. Light is provided either by the sun or by electric lights or electronic flash. It is important to understand that every photograph taken at a crime scene is subject to **discovery** in courtroom proceedings. Therefore, no photographic image should ever be deleted. It also means that any photograph captured by any law enforcement official either in the crime scene or on the perimeter of the crime scene must provide that image to the court. It is essential that the only photographs of a crime scene must be captured by trained professionals who have the primary responsibility of processing the crime scene.

Depth of Field

Depth of field is likely the most important aspect of forensic photography because depth of field provides sharpness to the image being captured. Depth of field is the distance between the objects that are closest to camera's lens and those that are furthest away. In other words, depth of field determines how much of the image is sharply in focus. Depth of field is controlled by the aperture of the camera, the focal length of the lens, and the distance between the lens and the object. The aperture of the camera can be found within the lens. Just like the human eye, the aperture of the camera widens or narrows to allow more or less light into the lens. The aperture is measured by focal lengths called **F-stops**. Here is where things get complicated. The higher the F-stop number, the narrower the aperture, and therefore the less light is being let in to reach the sensor. You might ask, wait a minute, if there is less light being allowed into the camera, how does this create a sharper image? The answer is **shutter speed**. When the **shutter release button** is pressed, the shutter opens for a specific amount of time to allow the light to enter the lens and to interact with the sensor. If the aperture is wide open, the speed at which the shutter must be left open must be very fast or too much light would come through the lens and the resulting image would be greatly over-exposed. If the aperture is very small, the shutter must remain open longer, and therefore more light is allowed to interact with the sensor. The drawback of a slow shutter speed is that the photographer likely would not be able to hold the camera steady enough to allow the image to remain in focus, and therefore the camera would need to be mounted on a stable platform like a tripod or copy stand. You will notice the importance of depth of field in the next series of photographs. You will also notice how important it is for fingerprint comparison purposes.



Figure **6.3.1**: Aperture f4.2 - Shutter speed 1/10th of a second - Author's collection



Figure **6.3.2**: Aperture f22 - Shutter speed 4/5th of a second - +0.03 exposure - Author's collection



Figure **6.3.3**: Aperture f5.6 - Shutter speed 1/400th of a second - Author's collection



Figure **6.3.4**: Aperture f22 - Shutter speed 1/25th of a second - Author's collection

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6.4: CRIME SCENE PHOTOGRAPHY

The following is a list of objectives of crime scene photography:

- To record the condition of the scene before alterations occur
- To record the location and position of evidence items before being collected
- To document the point of view of the responding officers, investigators, suspects and witnesses
- To document the spatial relationships of pertinent items.

Photographs provide visual images and have the distinct advantage of showing physical objects in a way similar to what the human eye sees if they are properly composed and focused. Photographs of the crime scene capture the visual aspects of the scene, which are needed to convey the look of the scene, and the items of evidence it contained, to investigators, analysts, attorneys, judges and jurors. It is important to understand that photography is not a substitute for notes and sketches prepared by the trained crime scene investigator because photographs are two-dimensional. Scene sketches, although also are generally two-dimensional, the measurements recorded on the sketches can provide the necessary information to create a three-dimensional understanding of the scene.

Photographs are also a crucial visual record of the conditions at the scene for investigators, during follow-up investigations and for investigators and analysts who are reconstructing various aspects of the crime. When combined with notes and sketches, the photographs will assist the crime scene specialist in painting an accurate picture of the crime scene during courtroom testimony. This contributes to the credibility, memory and testimony of the person giving testimony.

There is no set number of photographs that must be taken at any crime scene. Every scene will present itself differently and additional information will need to be documented as the investigation progresses. The best policy is to always take too many photographs rather than too few as the opportunity to take photographs is usually limited to the time and conditions at the scene. The position of items of evidence can never be reproduced to exactly how they were found in the scene; therefore photographs must be taken before anything is moved or disturbed.

The crime scene may be as small as the interior of a vehicle or cover an area as large as a prison exercise yard. The photographic conditions at the scene vary considerably depending on the weather, time of day and lighting. These conditions will determine what photography technique to use, whether it is painting with light, bulb exposure, flash photography or using ambient or artificial light. Always ask yourself the following questions before determining which technique to use. These questions will help obtain the best photo-documentation of the crime scene:

- What is the purpose of photographing this scene?
- Does the item have any relationship to the overall scene?
- Does the item have any relationship to the other items in the scene?
- Will the item be properly exposed, focused and composed?
- Will there be any reflections off windows or mirrors that will wash the photograph, or will reflect the image of personnel, or create a hot spot from a flash or artificial light?
- Is there sufficient lighting to take the photograph?
- Can the camera be placed in a position that will make it possible to take the photograph?
- Can the photograph be explained to a jury?
- Is the correct equipment being used for the scene?

Crime Scene Photography Methodology

Crime scene photography must be an accurate representation of the crime scene and the items of evidence it contains. The photographs must be considered an accurate representation of what the photographer, responding officers, and crime scene investigators observed and documented. These photographs must be correctly exposed and have maximum depth of field. The photographs must be composed, free of distortion, and in focus.

Overview or Scene Establishing Photography

The purpose of overview photographs is to establish the location of crime scene and enable others to be able to visualize the scene as it was found. Overview photographs must not be taken from a distance that is too far to accurately visualize the area but should

be from a distance that will include avenues of ingress and egress. Remember that all photographs are considered official record of how the scene was at the time of the investigation. Do not allow anyone to move anything prior to or during the photographic process. Do not allow anyone to introduce items to these areas either. Never photograph crime scene processing equipment inside of the scene, unless it is necessary to accurately reflect a technique used to enhance, visualize or collect the item of evidence. Prior to taking the photographs, make a mental plan of the photographs you are going to take, the method in which you are going to take them and the possible problems you might encounter while taking the photographs. Be sure to use a methodical approach to taking the photographs that will include all aspects of the scene. Take overall photographs without evidence markers being placed in the crime scene first. Then take the same photographs again after the markers have been placed. This will prevent the allegation that the markers are covering vital pieces of evidence in subsequent courtroom proceedings.

When it comes down to it, there are only two stages of crime scene photography: that which is outside of the perimeter, or overview photography, and that which is inside of the perimeter of the crime scene, or mid-range and close-up photography.

Outside and Inside Perimeter

In the next chapter, you will learn about crime scene perimeters. For now, just think of the primary perimeter of the crime scene is that area immediately surrounding the area where the crime occurred. Later you will learn about the secondary crime scene and the staging area.

First, take photographs to establish the location of the scene. This could include a street sign, a building name or some type of identifying landmark or all the above. It is important when taking a photograph of a street sign, especially at an intersection, to take the photograph with the street name where the crime scene is located being the represented image. When photographing an outdoor scene, it is important to take photographs towards the scene using the **four compass directions**. It may be necessary also to take photographs away from the scene itself to record avenues of ingress and egress

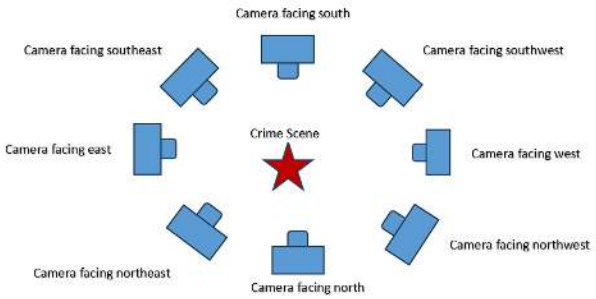


Figure **6.4.1**: Photographing the four compass points and in between

Photographing the four corners of the compass, and the points in between, provide for a complete representation of the crime scene, and quite often captrure aspects of the crime scene that might not be noticed if only captured from one or two directions. The same technique applies to photographing vehicles.

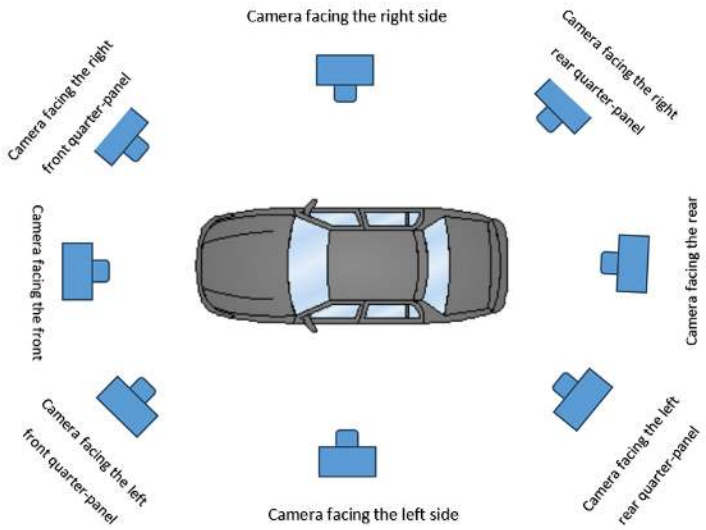


Figure **6.4.2**: Photographing the compass points and in between of a vehicle - Vehicle created with ScenePD 6

Indoor Overview Photography

Indoor overview photography is done much the same way as outdoor overview photography; except instead of photographing the points of the compass, photograph **the corners and the flats**. The same thing applies when photographing the exterior of a building. When photographing the corners, it is best to turn your camera on its side with the shutter release button on the top, and your support hand holding camera and operating the focus of the lens. For large rooms or buildings, it may be necessary to stand in the middle of the room and take photographs outwards towards the walls in a circle.

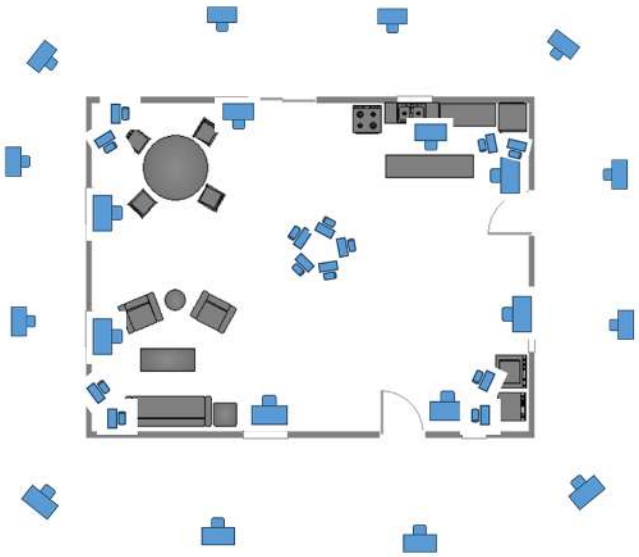


Figure **6.4.3**: Photographing the interior and exterior of a building – Building interior created with ScenePD 6

Compose your photographs in a manner that they would overlap each other if laid out on a table. In other words, be certain to capture at least one-third of the ceiling and floor in each photograph, and to capture four to six feet of the previous image taken. As always, be extra careful not to disturb any items of evidence, bloodstains, or impression evidence during the photography process. The best way to avoid destroying evidence is to first use a clean white light flashlight held at an oblique angle to the floor to visualize evidence that is difficult to see. The light will create small shadows that will make the evidence appear larger.

Medium-view or Evidence Establishing Photography

When the overall photographs are completed, photographs should be taken from closer range to show the layout of the smaller areas of the scene. These photographs also allow for the relationship between items of evidence to be established. Therefore, it is very important to capture an image containing as many items of evidence within each frame while still being able to clearly identify the items of evidence being captured.

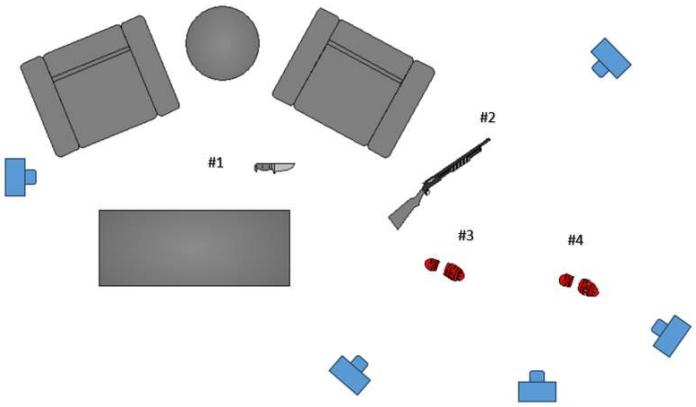


Figure **6.4.4**: Medium-view photographs of items of evidence - Furniture and evidence created with ScenePD 6

Again, aside from placing clean evidence markers to identify the items of evidence, nothing should be disturbed or added to the scene at this time.



Figure **6.4.5**: Medium-view photograph of two fired cartridge casings with markers - Author's collection

Close-Up or Evidentiary Photographs

Close-up photographs of items of evidence taken at the crime scene depict the item as it looked at the time it was discovered, documented, and recovered. However, **evidentiary quality** or **comparison quality** photographs should be taken in the laboratory under ideal conditions. In both instances, the item should be photographed first without a scale or marker and then with a scale or marker in place. The scale or marker should never touch the item of evidence. When using a scale, it should be placed on the same plane as the item of evidence whenever possible. In the field, the camera must be mounted to a tripod for close-up photography. It is best to use a copy stand in the laboratory.

The camera must then be adjusted so that it is parallel and perpendicular to the surface of the item being photographed. Make sure a ruler or scale is included in the photograph. Remember to photograph the scale on the same plane as the item of evidence. You may have to raise the scale to be at the same level as the item of evidence or furrow a depression if photographing impression evidence.

Also place a photograph identifier label in the photograph if possible. This contains information such as the incident number, date, victim or suspect names and evidence item number. It is best to fill the frame with the object, scale and photograph identifier.



Figure **6.4.6**: Comparison quality photograph of bloodstained footwear impression - Author's collection



Figure **6.4.7**: Evidentiary quality photograph of the headstamp of a fired cartridge casing. - Author's collection.

Comparison quality photographs are photographs taken where an item of impression evidence is in the center of the frame, is in focus, has good depth of field, and lack distortion. These photographs are used by comparison analysts to compare the item in the image with an object suspected of having contributed the impression. Evidentiary quality photographs are high resolution close-up images that are often on a 1:1 scale. It should be noted that a measurement scale is necessary to accurately determine the size of the object being photographed.

Scales and Markers

Using a scale in the photograph eliminates any speculation as to the size of the object. However, it is imperative that the item is photographed with the camera parallel and perpendicular to the object as any deviation may alter the perception of the object's size through distortion. Only scales, rulers and markers that are appropriate for the purpose of photography should be used. Never use a ruler that is broken, bent or has writing upon its surface that is not relative to the item being photographed. It is best to use an American Board of Forensic Odontology (ABFO) L-scale for the documentation of injuries or small items of evidence.

Larger photographic L-scales should be used for footwear or tire tread impressions, or other impressions in snow, dust, dirt or mud. These scales include the appropriate markings to facilitate enlargement and comparison. They also include photographic circles that indicate whether or not the camera is parallel and perpendicular to the item being photographed. Metal scales and rulers may not be suitable when using a camera mounted flash as they may reflect the flash back towards the camera. Adhesive scales are useful when photographing fingerprints or items being swabbed for DNA. Not only are they on the same plane as the object, they remain in the scene following collection and therefore are a reference for measuring, sketching or mapping.

Perspective Photographs

Often times the photographer will be required to take a series of photographs that are to represent the perspective of eyewitnesses, victims, first responders or investigators. This form of forensic photography is called **perspective photography**. When doing this, you should always use a tripod or monopod set to the height of the eyes of the observer to be documented. The photographer should use a good depth of field and set the focal length between 38mm to 50mm, depending on the brand of camera being used, which is closest to what the normal eye sees. You may have to use a tripod that allows you to position the camera at the proper level of a car door window frame or steering wheel, to replicate the position of the witness' eyes. **Natural perspective photography**, however, requires the photographer to stand at full height with the same focal setting.

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6.5: WOUND PHOTOGRAPHY

Most people do not consider that there is a methodology for how to photograph injuries to people or animals. It is important to photograph injuries before they have been bandaged. This is not always possible as victims of violent assault are often whisked away from the scene by the emergency services. In times like these, it is important to photograph the bandaged or sutured injuries in order to document the location of the injuries on the body. If the injuries are on sensitive areas of the body, it is best to photograph the injuries while still maintaining the decorum of the victim. Emergency room personnel are usually experienced in this and will help the forensic photograph in a manner that records only the injuries. If it is necessary to photograph genitalia, it is best to use close-up photography so that only the injury is depicted in the image. It is very important in overview injury photographs where the face of the victim is depicted that the photographer instruct the victim not to smile or laugh. It is very hard to convince a jury that the injury is painful when the subject of the photograph is smiling or laughing. The next consideration in wound photography is the admissibility of the photograph at trial. The five basic rules for the admissibility of evidence, including photographic evidence, are as follows:

- The evidence must relate to the charges being filed by the prosecutor
- It must be legally obtained
- It must be properly collected
- It must have a proper chain of custody
- It cannot be overwhelming to play on the emotions of the judge or jury

It is the last rule that will determine if a photograph may be entered as evidence during courtroom proceedings. Take a look at the photograph below. Would this photograph play on the emotions of the judge or jury?



Figure **6.5.1**: Prejudicial photograph - Author's collection

Clearly the victim of the slashing assault is grimacing in pain and blood appears on his face, shirt, and bandage. The jury would understand that the victim is in pain. They might feel bad for the victim and render a verdict to punish the suspect. This photograph would be considered **prejudicial** and would likely not be introduced during the trial. However, the next photograph would be allowed.



Figure 6.5.2: Clinical photograph - Author's collection

In this photograph, the victim is no longer grimacing in pain, most of the blood has been wiped away, and the incised wounds are clearly visible. This photograph is called a **clinical photograph**. By the way, did anyone notice the orange deposits on the victim's shirt in the first photograph? Those deposits are courtesy of the Mark IX Oleoresin Capsicum spray canister, which was discharged by an alert officer at the suspect of the crime. Unfortunately, the victim was also hit by the spray, and that is likely the source of the pain characterized by the grimacing. So, not only would the photograph be prejudicial in nature, but also an unfair representation of the event for the suspect. The question is then would you still take a prejudicial photograph if it is not admissible during a trial. Yes, because it could be used during the sentencing phase of the trial.

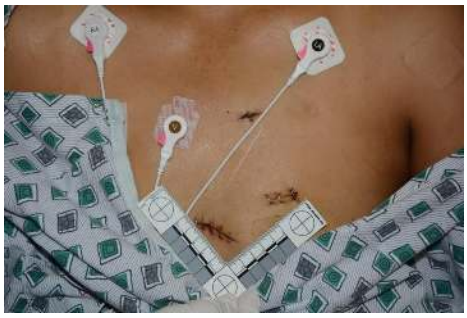


Figure 6.5.3: Sutured stab wounds on the chest of a female victim. Note how the photographs capture the injuries but preserve the modesty of the victim. Author's collection

It is equally important to photograph injuries that are not present. If a person claims that they were injured, but no injuries are apparent, it is important to photograph the absence of injuries. Also, if a person claims to have been harmed by a law enforcement official, but there are no visible injuries, it is important to document the lack of injuries, but to remember to revisit the victim the following day as sometimes bruising does not appear for several hours.

It is important to photograph the injuries without a scale first and then to add the scale to the image. The ABFO #2 L-scale is the best scale to use for injuries.

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6.6: EXTREME CLOSE-UP OR MACRO-PHOTOGRAPHY

As previously mentioned, close-up or evidentiary photography is important to capture images of individual items of evidence. These images can either be evidentiary photographs, where a sharp image of the item of evidence is required for identification or demonstration purposes during court proceedings, or comparison quality photographs needed by an analyst to compare the item of evidence with a known exemplar, such as fingerprint or other impression evidence. In this second category of close-up photographs is the macro-photograph, which is a highly detailed image that creates an image of a very small object that appears to be larger in comparison to the original object. Macro-photographs allow the analyst to detect and demonstrate minute striations, indentations, or defects that are individual to the item of evidence. These photographs require a camera with high resolution and a stable shooting platform, like a copy stand. A good tripod can be used to support the camera in the field, but that tripod must have a center post that can be reversed so that the camera can be mounted in a manner to allow it to photograph between the legs of tripod, or one that has an extendable boom arm.

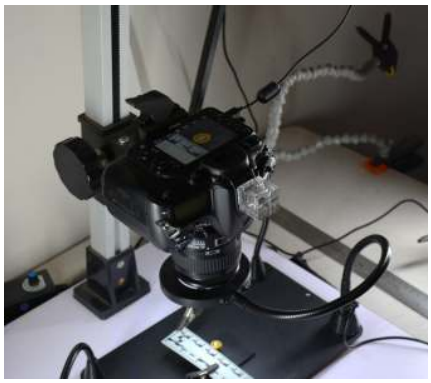


Figure **6.6.1**: Your author's macro-photography camera in his laboratory. Note the three-bubble level on the hot-shoe. - Author's collection

Distortions

Distortions occur in macro-photography when the resulting image has lines that appear curved or bulging, or one side of the image appears slightly larger than the other side of the image. Distortion are either caused by the lens of the camera or the camera being askew to the item being photographed. Either way, the resulting image will not be an accurate representation of the image and can cause errors in analysis. Therefore, it is important to use a good, dedicated macro-lens that minimizes **barrel distortion**, where the image bulges out in the center of the frame, and the camera is positioned parallel to the item. This can be accomplished using a **three-bubble level** that matches the camera's film or sensor plane with the item being photographed.

Same Plane Photography

As previously mentioned, it is imperative in macro-photography that the image must include a scale, and the scale must be on the **same plane** as the part of the object desired to be photographed. If the scale is slightly lower or higher than the object, the auto-focus feature of the camera may attempt to focus on both the object and the scale, resulting in both the scale and the object being slightly out of focus. If the photographer turns off the auto-focus feature and focuses the lens manually, either the scale or the object may be slightly out of focus. Carefully positioning the scale at the exact same height as the evidence item will correct this form of distortion. Furthermore, when photographing impressed footwear or tire tread, it is important to place the scale at the same level as the impression. Failing to do this will cause image distortion that will adversely affect comparison efforts.



Figure **6.6.2**: Same plane photograph with the scale even with the fired cartridge casing. Note the casing is curved and therefore the aperture was set at f22 for better depth of field. - Author's collection

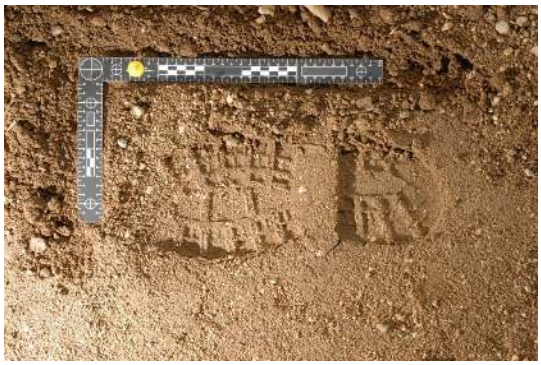


Figure 6.6.4: Footwear impression. Note the scale has been placed in a trench at the same level as the impression. Author's collection

Fill the Frame

The attention of the viewer should be on the subject of the photograph and not the background or unrelated objects in the frame. Even when photographing an object that requires a ruler or scale, it is best to take one photograph with enough of the scale for the analyst to know if the object was measured in inches or feet, or millimeters or centimeters. However, the next photograph should have the object in the center and filling the frame, and only the divisions of the scale are needed for scaling purposes.



Figure 6.6.5:

The object is centered and filling the frame, and only the divisions of the scale are in the frame. Author's collection

The Macro Lens

The **macro lens** allows the photographer to capture highly detailed and sharp images that appear much larger than the original object being photographed. These lenses have shorter minimum focus distances than normal lenses. “True” macro lenses offer magnification of 1:1 ratio. This means that the subject appears on the camera’s sensor the same size as in real life. Some macro lenses offer magnification ratios of 2:1, or even 5:1. The drawback of the macro lenses are that they are very expensive and have an application that is limited in forensic photography mostly to laboratory use where the stability of the camera, the adjustment of

light sources, and the necessary equipment and conditions exist to safely photograph the item with limited contamination or destruction to the item of evidence being photographed.

ISO Film Speed

The last topic to mention in close-up or macro photography is the **ISO film speed**. ISO film speed was originally the International Organization for Standardization rules representing the sensitivity of photographic film as designated by a numerical value. In the digital era, ISO represents the standards of the sensitivity to light of the camera's sensor. ISO settings on most digital cameras vary between ISO 25 to ISO 6,400, or even higher. A high ISO film speed setting allows images to be captured in darker lighting conditions. A lower ISO film speed setting allows images to be captured in conditions with more available lighting. The drawback is that higher ISO settings tend to be grainy, especially when the image is enlarged. Lower ISO settings capture images that are sharper. Comparison quality photographs must always be captured using an ISO setting of 100 or less. In comparison quality or macro photography, the camera should be set at ISO 100 (or less), with an aperture of F18 to F22, and a shutter speed of 1/60th of a second; therefore, there are few people who can hand-hold a camera steady at those settings, and that is the reason a copy stand or good camera tripod are required for this type of photography.

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6.7: Things to Remember

The following is a list of things to remember when performing forensic photography:

- Identify the crime scene and the items of evidence it contains
- Choose the appropriate camera
- Photograph from the outside of the scene inward to the individual items of evidence inside the scene using overview (scene establishing), medium view (evidence establishing), and close-up (evidentiary) photographs
- Photograph the compass points and points in between when outdoors
- Photograph the flats and corners when indoors
- Compose the frame, focus on the primary subject of the frame, and maximize the depth of field
- Photograph without scale first and again with markers and then with scales and markers
- Center the image within the frame and fill the frame with the image
- Maintain the victim's modesty when photographing injuries on sensitive parts of the body
- Be certain to capture clinical photographs as well as prejudicial photographs
- Photograph with natural perspective and the perspective of the participant(s)
- When photographing items of evidence for comparison purposes, be certain the camera is parallel and perpendicular to the item
- Photograph with the scale on the same plane as the item surface to be compared
- All photographs taken at the scene of a crime are subject to discovery
- There must be a chain of custody for the photographs to be admissible in court

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6.8: Final Thought

One final thought on the importance of the scale in comparison photographs. First, your author shakes his head every time a patrol officer presents him with a photograph of a footwear impression that lacks a scale, and the inevitable question is, “What size shoe is this?” The answer is always, “I have no idea.” Look at the following photograph and tell me what size shoe you think it is.



Figure **6.8.1**: A footwear impression that lacks a scale. Author's collection

Would it surprise you to know that it is a boy’s size 6 shoe that left this impression? Remember also that a developed fingerprint must have a scale representing the size of the fingerprint or it cannot be entered into the AFIS database.

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6.9: Test Questions

1. The term DSLR stands for:
    a. Digital Short or Long Range
    b. Digital Single Lens Reflex
    c. Digital Single Lens Reticle
    d. Digital Small Lens Reflexive
2. Which of the following is the benefit(s) of a DSLR.
    a. They look more professional
    b. They are the only cameras that have a built-in flash
    c. They have better depth of field and interchangeable lenses
    d. They fit in your pocket and 98% of Americans own one
3. This method of crime scene photography allows the scene to be established:
    a. Overview photography
    b. Medium-view photography
    c. Close-up photography
    d. Macro photography
4. This method of crime scene photography allows the relationship of items of evidence to be established:
    a. Overview photography
    b. Medium-view photography
    c. Close-up photography
    d. Macro photography
5. This method of crime scene photography provides an image of an item of evidence as it looked when it was discovered:
    a. Overview photography
    b. Medium-view photography
    c. Close-up photography
    d. Macro photography
6. This method of crime scene photography provides an image that is highly detailed and generally captured using a 1:1 ratio lens:
    a. Overview photography
    b. Medium-view photography
    c. Close-up photography
    d. Macro photography
7. This type of wound photography captures images that will not play on the emotions of the judge or jury and are therefore admissible in court proceedings:
    a. Prejudicial photographs
    b. Exemplar photographs
    c. Macro photographs
    d. Clinical photographs
8. When photographing a footwear impression, it is important to place the scale:
    a. On top of the soil
    b. In a trench at the same level as the impression
    c. In a trench just below the level of the impression
    d. A scale is not required when photographing a footwear impression
9. This is the purpose of ISO film speed:
    a. Nothing, it was only used for silver halide film
    b. It is a numerical scale representing the sensitivity to light of the camera’s sensor
    c. It is a numerical scale representing the speed of the shutter

d. It is numerical scale representing the aperture of the lens

10. These principles of photography are essential for forensic photography:
    a. Artistically composed, dark, and shadowy
    b. Without scales, underexposed, and grainy
    c. Overexposed, random, and without method
    d. Maximized depth of field, properly composed, and appropriately in focus

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6.10: Suggested Essay Topics

1. Write an essay on the means by which crime scenes were documented before and after the invention of photography.
2. Write an essay on the earliest applications of photography in crime scene investigations.
3. Write an essay about the complete methodology of crime scene photography.
4. Write an essay on the contributions of Alphonse Bertillon and Edmond Locard to crime scene photography.

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6.11: References

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CHAPTER OVERVIEW

7: Crime Scene Investigations

Learning Objectives

- To learn the scientific methodology of crime scene investigations
- To understand the roles of the crime scene technicians
- To understand the types processing of a crime scene
- To understand the importance of the proper documentation of a crime scene
- To learn the importance of diagramming a crime scene as an aid to testimony
- To learn the different methods of diagramming a crime scene

Every criminal investigation must have a foundation that is based upon facts that can later be proven in court. If the evidence is not legally obtained, documented, or properly preserved, the entire case will be in jeopardy and may be dismissed by the magistrate under Section 871 of the California Penal Codes. The foundation for crimes against persons and property is established by a process of diligently discovering, preserving, documenting, and collecting the evidence from the scene of a crime, as well as analyzing clues from the criminal event. This process involves employing scientific methodologies and forensic procedures to understand the event, and to provide a connection between the scene and the victim, the scene and the suspect, the scene with potential witnesses, and a link between the victim and the suspect. This process is called **crime scene investigations**.

7.1: The Discovery and Preservation Process
7.2: Admissibility of Evidence
7.3: Responsibilities of the crime scene technician
7.4: Make-up of a Crime Scene Team
7.5: Crime Scene Processing Methodology
7.6: Measuring, Sketching, and Diagramming
7.7: Test Questions
7.8: Suggested Essay Topics
7.9: References

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7.1: The Discovery and Preservation Process

Critical to the discovery of evidence, and the subsequent preservation of that evidence, is the ability to quickly stop all movement that could potentially damage or destroy the evidence in the scene of a crime. This responsibility falls on the first responding law enforcement personnel to arrive on the scene. The first responder has a very essential role in crime scene investigation and processing. Without proper preservation of the crime scene, there may be no crime scene to process. The responsibilities of the first responder includes: controlling the scene, affecting custody of the suspect if present, if not, to broadcast a description and direction of travel to other responding officer; locating victims; interviewing witnesses; and making the scene safe for fire, ambulance, and crime scene personnel, while evacuating the scene of unessential or unaffected people, thus preserving **perishable** and **transient** evidence. Perishable evidence is that which can be easily disturbed or destroyed, like impression evidence or bloodstains. Transient evidence is that which may move or dissipate, like a piece of paper bearing a threat or criminal intentions, which can be blown away by the wind or damaged by rain. The first officer on the scene must also determine the extent of the crime scene, with consideration to avenues of ingress and egress of the suspect, ensure that emergency medical services personnel do not destroy important aspects of the scene, stretch crime scene tape, and make the necessary notifications to request detectives and crime scene investigations personnel to respond to the scene. It is also up to the first officer on the scene to render aid to those requiring medical assistance while awaiting the arrival of the emergency medical services. Saving a human life or preventing additional injury is a primary responsibility of law enforcement, and it may be said that it is far better to save a life than an item of evidence. However, it is possible to maintain the integrity of scene, and the evidence it contains, as much as possible while rendering that aid. The officer must use discretion and first aid knowledge to balance the need for medical aid, but with the knowledge that the evidence must be preserved. Once all of this is done, the officer must start a **crime scene log**, which is a record of all personnel who were in the scene before and after the perimeter was established, and the purpose for their presence in the scene.

Guns and Other Weapons

The first responder should not examine or touch the contents of the crime scene unless the evidence is perishable or transient and will be lost if not immediately recovered. Weapons used in the commission of a crime should only be collected if the area cannot be contained and there is a possibility that the item may be used by the suspect or other actors against peace officers or other persons. In this event, the weapon must be retrieved paying particular attention not to disturb fingerprint, blood, or hair and fiber evidence and, if possible, to prevent contamination. The weapon must never be returned to the crime scene if it is removed by the first responder. Weapons used in the commission of the crime should remain in the crime scene, untouched, provided it is safe to do so. Never disturb a firearm or “render it safe” before the arrival of crime scene technicians. Post security by the weapon until such time as the crime scene technician can collect DNA specimen, and only then prepare the weapon for evidence packaging. On one occasion, your author arrived at the scene of a homicide where a gun had been found near the body of the decedent. Unfortunately, the gun was immediately collected by the first officer to arrive on the scene, and rendered “safe” with ungloved hands, and thrown on top of his duty jacket in the trunk of his patrol car. Your author asked the officer to explain his actions, to which the officer responded that he was worried the gun would be “picked up.” “By whom? The decedent?” was your author’s response. The gun was dropped by the suspect in his haste to escape the scene. The obvious court challenge was had the DNA that was recovered from the gun been deposited by the suspect or was it transferred from the contact with the jacket in the trunk? Every law enforcement officer should be trained to consider the potential for destroying or contaminating critical evidence before handling any weapon found at the scene of a crime.

Scene Contamination

Gone are the days when a detective or crime scene investigator enters a crime scene with a cigar in their mouth, wearing short sleeves, and beshoed with their favorite pair of tennis shoes. We must remember that a suspect may leave touch DNA in a crime scene, but the detective or crime scene technician too may inadvertently contribute our own DNA in the exact same place. It is suggested that humans shed upwards of 400,000 epithelial skin cells in a 24-hour period, which by your author’s maths is almost 278 cells every second that you are in the crime scene. The suspect who wore gloves, a hat, a mask, a long-sleeve shirt and spent three minutes in the crime scene, will invariably contribute far fewer cells than the detective or crime scene technician who is not wearing a mask, has no gloves, is not wearing head covering, is wearing a short-sleeved shirt, and spends an hour in the crime scene. Although there is no such thing as an uncontaminated crime scene (unless someone at the forensic lab murders their

supervisor in the sterile evidence examination room), it is important to make every effort to mitigate further contamination and to prevent cross-contamination of evidence. Protective clothing must always be worn (face mask, shoe coverings, latex gloves, etc.) and great effort should be made not to handle items of evidence before they have been documented and photographed, and only after changing gloves between each item of evidence handled. This is also very important for patrol officers to remember to don or change their gloves before handling evidence. If a suspect attempts to flee and should the officer pursue and apprehend the suspect, and during the overcoming of resistance a gun falls from the waist of the suspect, the officer must don or change gloves before retrieving the gun as evidence. If not, the defense can claim the DNA found on the gun was transferred to the gun by the officer after having physical contact with the suspect; and they would be correct. It is important to know that the majority of DNA that is deposited by law enforcement personnel in the crime scene comes from the mouth and nose. That is why it is essential to wear an N-95 mask when entering the crime scene or when inspecting or processing items of evidence.

Unintended destruction

Medical and fire department personnel responding to the scene of a crime can, unwittingly, cause tremendous destruction to the crime scene. Medical and fire personnel rate nothing more than the highest praise for their often-heroic efforts to save lives and to prevent further destruction of buildings and additional loss of life. Granted if your crime scene is on fire, it is most desirable to let the fire department do what they do best; also granted that it is far more important to save a life than it is to preserve evidence. However, most often these departments find themselves involved in incidents that do not involve fires or are bereft the imminent loss of life. It is during these occasions that the crime scene technician wishes most that these departments could balance their responsibilities with the urgent need to preserve the crime scene and the evidence it contains. Even simple contributions such as not discarding used latex gloves into the crime scene would go a long way to prevent crime scene contamination. Fire personnel, anxious to remove victim garments in order to affix AED pads, could well serve the crime scene technician by carefully preserving bloodstain evidence, gun powder burns, and bullet and edged weapon defects.

Not many years ago, your author responded to the hospital following a brutal assault with great bodily injury. The victim had been transported to a local hospital before officers arrived at the scene. The victim had been attacked by an unknown assailant from behind. One of the injuries sustained by the victim was a vicious bite to the back. The bite mark, which was not deep enough to draw blood, was a textbook impression and presented a large quantity of saliva. Unfortunately, in the three minutes that it took your author to report to the hospital, medical personnel had already sanitized the wound with rubbing alcohol and rubbed in an antiseptic ointment, thus destroying any DNA evidence that may have remained and making photography difficult owing to the glossiness of the ointment. The case was not prosecuted by the District Attorney's Office as the victim was unable to identify his attacker, as he was attacked from behind, and there were no other witnesses. The victim had sustained a life-changing injury during the assault, a wound to the side of the face that left a deep scar. The only evidence that would have led to the identity of the attacker would have been the DNA from the saliva surrounding the bite mark, which was lost. Had the nurse just applied a small amount of sterile water to a sterile gauze, both of which were readily available, gently rubbed the area of the bite mark, and placed the gauze back into its original packaging prior to applying the rubbing alcohol, the DNA would have been preserved.



Figure **7.1.1**: A bite wound that lost its vital evidence. Author's collection

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7.2: Admissibility of Evidence

As discussed in the previous chapter, in order for evidence to be admissible in court proceedings, the following standards must be met:

- The evidence must be legally obtained
- It must be properly collected
- It must be relevant to the criminal charge
- There must be a proper chain of custody
- It cannot be overpowering to play on the emotions of the judge or jury

Therefore, it is essential that all items of evidence in a crime scene are collected by well-trained, ideally certified, crime scene personnel.

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7.3: Responsibilities of the crime scene technician

The primary ambition of the crime scene technician should be: the proper documentation of the scene; the proficient and legal collection of all items of evidence within the scene; the maintenance of the chain of custody of the evidence; and the ability to articulate the steps taken, including scientific methodologies, evidence collected, photographs captured, measurements documented, diagrams made, and to paint a visual picture of the scene to the jury, judge and attorneys during courtroom proceedings.

When arriving at the crime scene, the crime scene technician, or analyst must first determine that the scene is safe to enter, for themselves and for their team members. The technician should then make a quick assessment of the scene for perishable or fleeting evidence and for any hazard that might alter or damage the scene before it can be processed. Once satisfied that the scene is safe and not in danger of losing valuable evidence, the technician must then determine the crime scene perimeter by speaking with the first responder on scene to determine what actions they saw, what evidence they noticed and where they discovered victims, suspects, and witnesses. The crime scene technician should then ensure that the crime scene perimeter has been properly established, and the perimeter is large enough to contain an outer and inner perimeter. This is generally accomplished with crime scene tape. It is always best to have a large outer perimeter that will keep the media and on-lookers far from the actual crime scene but will also maintain a containment of the areas of ingress and egress. Crime scenes can be made smaller, but they can ever be enlarged, and therefore the larger area would be contaminated prior to any items of evidence having been found. Once the outer crime scene perimeter has been established, the technician can designate a primary crime scene, which includes the actual crime scene itself, and a staging area for equipment that is just outside of the primary crime scene. It is important to maintain proper protocols for the mitigation of contamination for equipment remaining in the staging area and for equipment being utilized within the primary crime scene perimeter.

Scene security is important to the safety of the crime scene team and for the protection of the scene and the evidence it contains. Therefore, it is a good idea to arrange for the posting of armed officers outside of the outer crime scene perimeter to control the crowd, the curious, the media, or the return of the suspect(s), which has happened to more than a few technicians.

The crime scene technician should immediately determine if the suspect(s) is in custody or is at large, if the victim is deceased at the scene or if life-saving efforts are on-going, or if not to ascertain where the victim(s) has been taken. Should an eyewitness be available, the investigator should briefly interview them focusing on what they saw, smelled, and heard. It should be noted that a crime scene technician will ask different questions than a first responder. The first responder is intent upon locating the victim, additional victims, suspects, and other eyewitnesses, and perhaps a perfunctory overview of what happened. Amongst the information the crime scene technician is most concerned about is what happened and where, who was in the crime scene before, during and after the event, what weapons were used, what was touched by the suspect, what injuries were sustained by the victim, was the suspect bleeding, and in which direction did the participants arrive and depart. If possible, it is imperative that the technician also talks to any responding medical personnel who remain at the scene. If the suspect is in custody, the crime scene technician should make recommendations regarding the collection of the suspect's clothing, the bagging of hands to preserve transfer evidence, the collection of gunshot residue specimen, photographing injuries, or the swabbing of hands for DNA.

Once the initial information gathering interviews are finished, the technician should meet with the other members of the crime scene team outside of the secondary crime scene. The team should be given assignments such as scribe, photography, diagramming and measurements, evidence collection, and other duties. They can then don protective coverings and make their initial examination of the crime scene. At this time, the technician or analyst will determine the appropriate path through the scene that will prevent destruction of evidence and ensure that each member adheres to the selected route. It is essential that the crime scene and evidence are not disturbed and that nothing is touched or moved.

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7.4: Make-up of a Crime Scene Team

The ideal composition of the crime scene team is as follows:

- **Lead investigator** (Crime Scene Analyst or Senior Crime Scene Analyst – Overall responsibility for the processing of the scene)
- **Assistant to the Lead** (Crime Scene Analyst responsible for the well-being and needs of the team)
- **Scribe** (The Scribe documents everything in the scene from the location of the evidence, to team duties and actions, to all of the details of the scene)
- **Photographer** (Photographs the crime scene in a methodical manner, and all of the items of evidence in the scene)
- Evidence Collection Officer/Field Evidence Technician (Crime Scene Investigators responsible for preserving, identifying, collecting, and processing the evidence)
- **Diagram technician** (Takes measurements of the crime scene and creates 2-D or 3-D drawings of the scene)
- **Specialists**: Latent print, bloodstain pattern analyst, crime scene reconstructionist, forensic photographer, or any other specialist

Responsibilities of the Crime Scene Team

Although there are numerous responsibilities within the crime scene, it is not necessary to have a dozen technicians in the scene, unless it is an exceptionally large scene, which can be separated into grids or sections. Your author finds that the ideal number of technicians crime scene is that which can be efficiently managed, perhaps five or less. Any more than that and you risk contamination and destruction of evidence. Some scenes in the correctional setting, like a cell, are too small to permit more than one or two people to even enter the scene. There have been, of course, many occasions when your author has processed scenes without the assistance of a team. This is fine, but as they say two sets of eyes are far better than one. It is, however, necessary that all the duties of a crime scene team are met, regardless of the number of people employed in the task of processing the scene.

Lead Investigator or Crime Scene Analyst

It is the responsibility of the lead investigator or crime scene analyst to ascertain the known details of the crime from the primary responding units, medical and/or fire department personnel, and any witnesses who remain on the scene. It is also their responsibility to get a copy of the crime scene log; to ensure that the crime scene perimeter is properly established; that perishable evidence is documented and collected, and that the scene and team are safe. Furthermore, it is the responsibility of the lead investigator to determine the legal authority to be in the crime scene and to work with the incident detective and District Attorney's Office (prosecutor) personnel to obtain a search warrant, if necessary. The lead investigator will brief the crime scene investigation (CSI) team and assign tasks. Following this, the lead investigator will visually inspect the crime scene, preferably using a forensic or clean white light, looking up, down and all around, considering the crime scene as a whole; and by holding the light at an oblique angle to ground. The lead investigator will dictate the conditions of the scene and point out obvious items of evidence that need to be documented and collected. The lead investigator will coordinate with officers and investigators conducting witness canvasses or who had accompanied victims to the hospital. The lead investigator will send technicians to search areas outside of the perimeter for ingress and egress evidence. The lead investigator will coordinate with the photographer to identify items of evidence and to determine the placement of evidence markers and photographic scales and will make sure that proper evidence processing, and personal protection equipment is present and used. The lead investigator will also provide for the well-being of the team by making sure that they are hydrated and that they do not spend more than 90 minutes -45 minutes in warmer climates- in a Tyvek suit without resting, re-hydrating, and changing suits. They will also coordinate with analysts from other agencies who have specialized training, such as bloodstain pattern analysis or latent print development. Furthermore, one of the most important roles of the lead investigator or crime scene analyst is to provide continuous updates of the progress of the crime scene processing to the detectives, as well to the administrative assistant or public information officer who may need to make announcements to the media.

The Assistant to the Lead

The assistant to the lead investigator helps to identify evidence, places markers, and to develop a processing plan of action. The assistant's focus is the crime scene and keeping the lead investigator informed of developments when they are away from the scene. The assistant acts as a second set of eyes making sure that the team is using all equipment properly, that all efforts are made not to contaminate the scene and the evidence within the scene; and that the team is safe. It may also fall on the assistant to the lead to make arrangements for special equipment or for personnel who have specialized training, such as bloodstain pattern analysts, latent

print development technicians, and crime scene reconstruction experts. It is also the duty of the assistant to the lead investigator to ensure that agency policies and protocols associated with crime scene investigations are properly followed.

The Scribe

The scribe has one of the most important roles in the crime scene team and is often the individual with responsibilities that are ignored. It is the responsibility of the scribe to document EVERYTHING in the crime scene: from the conditions in which the crime scene was found, to maintaining a running time-log of events, and documenting the location, description, finder, and processor of every item of evidence discovered and collected. The scribe will also document what notifications were made, and to whom they were made, while in the crime scene. In the prison or jail setting, the scribe also has an important role not usually found outside of the jail or prison crime scene. Following a major incident in a housing unit, dining hall, exercise yard or program where numerous inmates are assembled, it is the responsibility of the scribe to document the presence and position of every inmate detained in the area. The scribe must positively identify each inmate using a photographic means of identification and must accurately record the exact position of each inmate. Failure to document the presence of a suspect detained during an incident might provide him with an alibi that he might later use in court.

The Photographer

The photographer is responsible for documenting the crime scene with images that capture the visual aspects of the crime, which are needed to convey the look of the scene to investigators, attorneys, judge, and jurors, who will not have the opportunity to view the scene firsthand in the manner in which it was viewed by the first responder and the crime scene investigator. The photographer must capture overview scene establishing, medium view evidence establishing, and close-up or evidentiary photographs of the scene and its evidence; as well as photographs that depict the relationship of items of evidence to other items of evidence and to the crime scene. It is essential that the photographer captures images of the scene before any alteration has occurred. That means that they must photograph the scene prior to the placement of markers and the movement or collection of evidence. Evidentiary photographs must be taken with the film plane parallel and perpendicular to the item of evidence, and with scales placed on the same plane as the item being photographed. The photographer must maximize depth of field; may need to control, add, or eliminate lighting in the scene; and must ensure that the image is sharp, centered, in focus and fills the frame. The photographer may be required to take photographs that are representative of the natural perspective of the crime scene, and of the line of vision of victims, witnesses and first responders. When photographing items of evidence depicted with scales or rulers, the photographer should always photograph the item with and without the measuring device first. The photographer must also maintain a log, file, or contact sheet containing a description of each frame or image captured, along with its metadata.

The Evidence Collector

In a major crime scene, it is best to assign one member of the team as the evidence collector. In this regard the chain of custody for the item of evidence can be restricted to the finder and the collector. Furthermore, in some jurisdictions the evidence collector can testify on behalf of the evidence finder during preliminary courtroom proceedings, thus eliminating the need for additional staff to be away from their duties. The evidence collection officer must follow all procedures for the collection of the items of evidence, avoid contamination, and document in their report the identification of the person who found the evidence, the description of the evidence and the location where it was found as well as its disposition.

The Diagram Technician

The diagram technician is the too often forgotten member of the crime scene team. It is the responsibility of the diagram technician to accurately record the dimensions and measurements of the crime scene, horizontally and, in some cases, vertically, as well as documenting the relative positions of items of evidence in the crime scene and the size, shape and dimensions of the items of evidence collected. The diagram technician may be called upon to “map” the scene for bloodstain evidence analysis and therefore must have training in this regard, although it is not necessary for the technician to be a bloodstain pattern analysis. There is more on bloodstain mapping later in this book. It is your author’s belief that diagram technicians should be taught the “old” ways of sketching and measuring a crime scene. Modern computer-assisted “mapping” systems are wonderful devices, but your author’s opinion of technology will always be that either it will take longer to use the device on small scenes or, as technology will often do, it will fail when you need it most. The diagram technician will need to have that old-fashioned back-up plan. The old-fashioned way is discussed in a later chapter.

Other Specialist

Other specialists, such as bloodstain pattern analysts, impression evidence comparison analysts, specialized latent print development technicians, forensic videographers, forensic pathologists, crime scene reconstructionist, or any other specialized forensic discipline practitioner may be requested when needed.

Remember, it may not be possible to have the number of people described above in the crime scene team, but all these functions must be accomplished regardless of whether it is just one person or six doing the job.

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7.5: Crime Scene Processing Methodology

The following crime scene processing methodology is based on your author's personal experience and on the methodologies that are presented by numerous forensic authors, such as Ross Gardner in his book Practical Crime Scene Processing and Investigation (CRC Press 2019, Chapter 2, pages 79-85), with some modifications.

Process #1: Initial notification and response

Document the time, date and method of the call to service. Gather as many details as possible that are available to determine if specialized equipment or chemicals will be needed for the scene. Select your response route, vehicle staging area, and assembly point for responding crime scene personnel. Upon your arrival at the scene, note the time, weather conditions, including winds, precipitation, temperature, and barometric pressure; odors that may be present; the available ambient lighting at the scene and the need for supplemental lighting. Pay attention to the crime scene perimeter as established by the first responders and make the necessary adjustments.

Process #2: Conduct initial observations and deploy additional resources

The crime scene technician should take immediate control of the crime scene and to clear the area of non-essential personnel. If life-saving efforts are on-going, it is recommended that photographs be taken to document the efforts of the medical responders. This documentation can be useful in fending off litigious actions alleging negligence. The photographs may also be useful to convey alterations to the scene during the medical response. If the victim has been removed from the scene, it is imperative to determine their location and to dispatch a photographer to capture images of the injuries before they are bandaged or wrapped, and to collect their clothing. The crime scene technician should make their initial observations, noting environmental conditions and visible items of evidence. It is important to detect and safeguard perishable or fleeting evidence. This evidence may need to be quickly documented and collected before it is lost or destroyed. If the first responding officer is on the scene, it is best to gather information about the scene as it was first discovered, the personnel who had entered the scene and the role they played within the scene, if any item of evidence had been moved or disturbed from its original position of discovery, and any life-saving efforts that occurred. If witnesses to the crime are present, it is advisable that the crime scene technician ask probative questions that might assist the team with determining the sequence of events or evidence that might have been overlooked. Remember that eye-witness testimony may be incorrect depending on their perspective of the scene. Always allow the scene to dictate the processing based on the training and experience of the technician, and not a pre-conceived theory of what occurred. The technician should look for impression evidence, transfer evidence, perishable evidence, trace evidence and scene conditions (odors, lights on or off, doors and windows open or closed/locked or unlocked, etc.) prior to stepping into the crime scene. This can be done conducting a "sweep" of the area using clean white light from a handheld flashlight at a low, oblique angle to the ground. This will allow small objects of evidence that would ordinarily remain unnoticed to cast a shadow. The shadow will direct the attention of the technician to the evidence. The crime scene technician will determine the scope of the scene, establish the crime scene perimeter(s) have been properly established, consider areas of ingress and egress and determine if additional scene security will be required. The technician will make a determination of the type of equipment that will be needed, and to select an area where your equipment can be staged that is outside of the primary crime scene. The technician will determine at this time if there are technicians or analysts with special abilities (i.e. bloodstain pattern analysis, latent print development, shooting reconstruction, etc.) needed and make the appropriate notifications. It is essential that the technician must don footwear covers, latex gloves, Tyvek suit if needed, and an N-95-type face mask before entering the crime scene. The initial inspection of the crime scene is done without touching or disturbing anything in the scene. The experienced crime scene technician will conduct this walkthrough with their hands behind their backs to make sure nothing is disturbed.

Process #3: The decedent

As the body of a person known to be dead falls under the jurisdiction of the County Coroner's Office or Medical Examiner's (ME) Office. The scene should be secured, with only rudimentary photographic documentation conducted prior to the arrival of a representative of the Coroner's or ME's Office. Efforts to identify the decedent will assist the Coroner or ME, provided these efforts are non-obtrusive in nature and do not involve rummaging through pockets. The decedent should not be fingerprinted at the scene. This should be accomplished following the autopsy in an effort to preserve what forensic evidence may be present on the

hands, fingers or under the fingernails of the decedent. In cases where physical contact appears to have been made between the decedent and the suspect, such as manual strangulation, it is advisable to collect sterile swabs of the neck and arms of the decedent for touch-DNA prior to the arrival of the coroner's detective, or immediately upon their arrival should their presence be required. Inspect the decedent along with the Coroner's or ME's representative once they are on scene. Pay attention to body position, clothing, obvious signs of injury, petechiae and anything unusual or out of the ordinary. Coordinate the removal of the body and establish a time for the autopsy. Whenever possible, the body should remain at the crime scene until it can be documented, and all items of evidence recovered. This, however, is at the discretion of the Coroner's or ME's Office representative. It must be remembered that in some states, such as California, it is a misdemeanor to move or disturb the body of a person known to be dead without permission of the Coroner, ME or their appointed representatives. Coordinate with the Coroner or Medical Examiner for the time and date of the autopsy, especially if a representative of the law enforcement agency is required to be in attendance.

Process #4: Photographing the crime scene

The crime scene technician should begin (or continue) photographic documentation of the scene. Following established protocols, the technician should capture overall images (scene establishing), medium view (evidence establishing or relational images, and close-up or evidentiary images. Micro-photography is best captured at the forensic laboratory. The technician should first photograph the entire crime scene without scales and markers prior to the addition of these items. When photographing the exterior of a building, the technician should photograph the exterior corners, sides, entry and exits with identifiers such as street signs, address numbers, building name, etc. When photographing the interior of a building, the technician should photograph rooms from the corners toward the center of the room and from the flat walls toward the opposite wall, taking care to overlap each frame by several feet. The technician should remember to record the floor and ceiling of the room. All items of evidence must be photo-documented prior to their removal or collection. Take care not to photograph items added to the crime scene by the crime scene investigation team (forensic lights, forensic equipment kits, etc.). It is best that these items remain outside of the crime scene until the photographic documentation is completed. If additional evidence is discovered following the use of these tools, the tools should be removed from the area before taking additional photographs. Avoid photographing crime scene personnel in the scene unless it is required to accurately depict the object being photographed or in demonstrating a forensic procedure. Evidentiary images should be taken with the goal to fill the frame with the object parallel and perpendicular to the lens. The use of scales in evidentiary photography should be on the same plane with the top of the object being photographed. Compose the photograph, fill the frame and be aware of the lighting and shadows and what is in the background.

Process #5: Documentation of the crime scene

The entire scene should be documented by the crime scene team in a narrative, sketched, and written form prior to the removal, disturbance or collection of any item. The scene should be described in detail beginning outside of the scene and moving inward towards the center of the scene. The narrative should include the building, room, furniture, fixtures, and all pertinent items of interest. The diagram technician should create a rough sketch of the scene including room dimensions, position and dimension of furniture and all items of evidence. The diagram technician should determine the compass direction of true or magnetic north and indicate on the map that the sketch is not to scale. Outdoor scenes may need to be laid out in a grid pattern or searched utilizing one of the approved methods (grid pattern, line, spiral, etc.) prior to sketching. All items of evidence should be measured in their fixed position prior to being collected. At times it is necessary to move items in order to measure or map a crime scene. For this reason, it is essential that the entirety of the crime scene be photographed, before and after the placement of evidence markers, prior to being measured and sketched.

Process #6: Bloodstain pattern mapping

Mapping, marking, measuring, documenting and presumptive testing of bloodstain patterns should be performed by the crime scene analyst or a technician trained and experienced in bloodstain pattern analysis. The documentation of bloodstain patterns should be conducted following the removal of the body. Bloodstain mapping is generally the last stage of the crime scene processing and should only be conducted by trained personnel using appropriate scales and markers.

Process #7: Conduct the first evaluation

Following the thorough visualization of the crime scene and all pertinent items of evidence contained therein, and following the identification, photographing, documentation and sketching of the crime scene, the crime scene team should gather and review

notes and observations before continuing with the crime scene processing.

Process #8: Collection of the evidence

Once all items of evidence have been documented, photographed and sketched, it is now appropriate to begin removing, identifying, inventorying and establishing a chain of custody for the items of evidence being collected. As each item is collected, it should be examined for additional physical evidence. Any additional items discovered when the item was moved should be documented, sketched and photographed. Each object should be handled in accordance with established protocols with consideration for subsequent forensic analysis and processing. Should your agency see fit, it is acceptable to appoint one crime scene member as the Evidence Collection Officer. This person can collect all items of evidence, noting the identity of the original person of discovery for the chain of custody, and process all items into evidence. In this regard, the chain of custody is limited to one or two individuals and only one person is required to testify in preliminary court hearings.

Process #9: Conduct the second evaluation

Following the collection of all known items of evidence, it is now a good time to inspect the crime scene using a forensic light source or ALS for overlooked or evidence such as body fluids, trace fibers, hairs, etc., not detected by white light. Following this, it is an appropriate time to process the crime scene for latent prints. With each new discovery, the technician must repeat the above steps in the processing methodology. The crime scene team (ideally lead by a crime scene analyst or above) should ensure that all areas have been searched and that no areas have been overlooked. Advanced forensic chemical examination techniques (Bluestar, luminol, Amido-black, Coomassie Blue, Hungarian Red, Aqueous Leuco Crystal Violet, etc.) or external ballistic examinations should be considered at this time.

Process #10: Scene periphery

The scene perimeter and outlying areas, which should have been checked during the initial observations, should be thoroughly checked again. Information developed during the processing of the crime scene may lead to additional discoveries peripheral to the crime scene. Additional photographs should be taken of these areas if applicable. If items of evidence are discovered outside of the crime scene perimeter, it may be necessary to establish a secondary crime scene and to process the scene as a separate crime scene but using the same case number.

Process #11: On-scene debriefing of the crime scene team

The on-scene debrief consists of accounting for all technicians, evidence items, and equipment. The team should briefly discuss equipment or procedural problems encountered during the processing of the crime scene, and the need for resupply or procurement. This is a good time to discuss any issues that might be challenged later in court.

Process #12: Securing or releasing the scene

A determination should be made by the appropriate investigative personnel, with consideration to the opinions of the crime scene team and analysts, to either release the crime scene to the responsible custodial authority or to secure it for follow-up examination In suspicious death or homicide scenes, it may be prudent to maintain control over the crime scene until the autopsy, as discoveries during the post mortem examination may require additional speculation of the crime scene. Remember, once the scene is released, it may take a court order to return to the scene.

Process #13: Processing the evidence and report writing

At this time, all items of evidence should be appropriately packaged for long-term storage and placed in approved evidence lockers. Determinations should be made as to the disposition of the items of evidence and whether additional forensic examination is warranted. Chain of custody should be maintained, along with an inventory of all items processed into evidence. Reports, finalized sketches, photographic logs, crime scene entry/exit logs, and crime scene notes should be prepared and collected for review and submission. Equipment should be sterilized and provisioned for the next crime scene call-out.

Process #14: Formal debriefing

A formal debriefing should be held within 48 hours of the processing of the crime scene with the crime scene team, analysts, and detectives to discuss the important aspects of the crime scene investigation. This is a good time also to review protocols and procedures, as well as any concerns regarding the functionality, supply or need of equipment to be used at future crime scenes.

Process #15 – Formal debriefing with the prosector

The one process that often gets overlooked until the case is ready to begin the trial process is the debrief of the forensic documentation, evidence collection, and subsequent analysis of the crime scene and the evidence from the scene with the entity that is prosecuting the case against the suspect. This is often left up to the detective who is assigned as the case agent; however, a full understanding of the crime scene and its evidence is not fully presented to the prosecutor. Your author believes that it is always best to have crime scene personnel, especially those who are trained as analysts, to meet with the prosecutors, and to provide them with the accurate details of the crime scene, its evidence, and documentation.

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7.6: Measuring, Sketching, and Diagramming

One essential process in any crime scene investigation is measuring, sketching, and diagramming the scene. This process is often ignored when trained crime scene technicians are not called out to the scene. Diagramming a crime scene is the process by which a two-dimensional or three-dimensional visual representations of the crime scene. These visual representations become an important part of preserving a record of the scene for detectives, bloodstain and shooting scene analysts, crime scene reconstruction analysts, and, perhaps most importantly, for the courtroom proceedings. These diagrams must be highly detailed and accurate measured or **mapped** in order to present a fair representation of the scene in a way that it can be understood by the defendant, witnesses, attorneys, judge, and jury. It can also be a visual representation of the scene that can be relied upon to verify eyewitness testimony in court; certainly, in a manner that surpasses that of a hastily drawn rough sketch.

The most common sketches and diagrams used in crime scene processing are: the ‘bird’s eye view’ where you are viewing the scene as if you were looking down from the ceiling; the ‘elevation view’ where you are looking at a side view such as a door or wall; the ‘exploded view’ where it looks like you opened a room as if you laid the walls flat on the ground; and the ‘plot plan’ or ‘aerial view’ where you must document a crime scene that encompassed several city blocks or even miles of roadways. Measurements should be recorded in feet and inches.

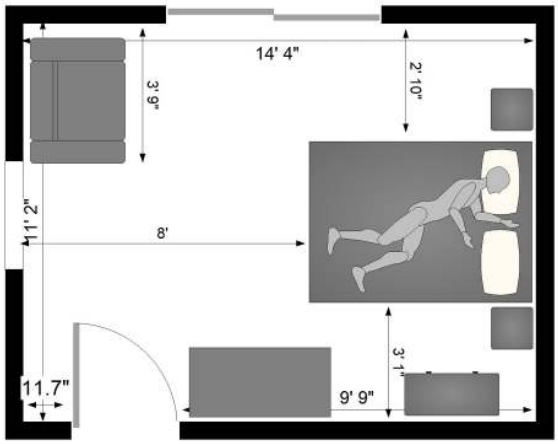


Figure **7.6.1**: Bird's eye view diagram. Created with ScenePD 6. Author's collection

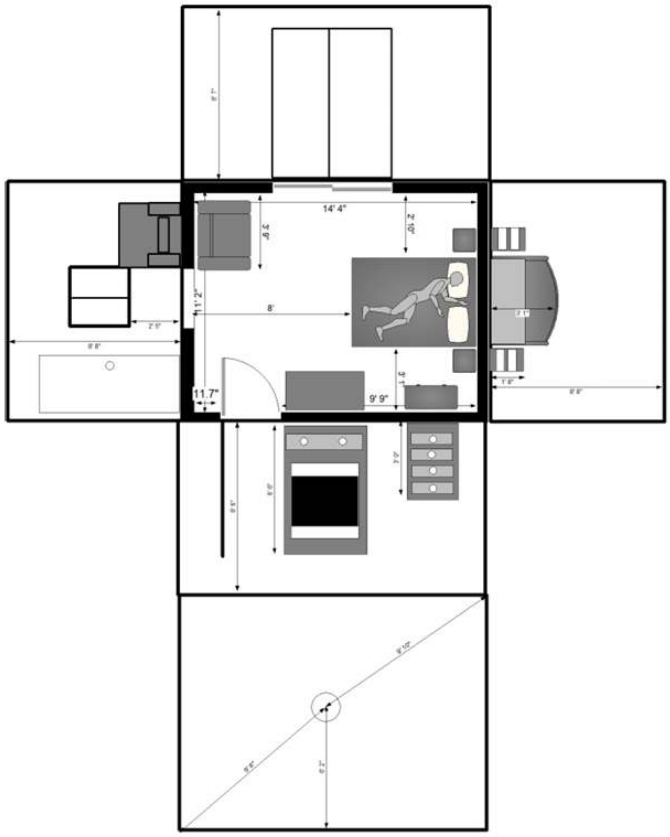


Figure **7.6.2**: Exploded View Diagram. Created with ScenePD 6. Author's collection

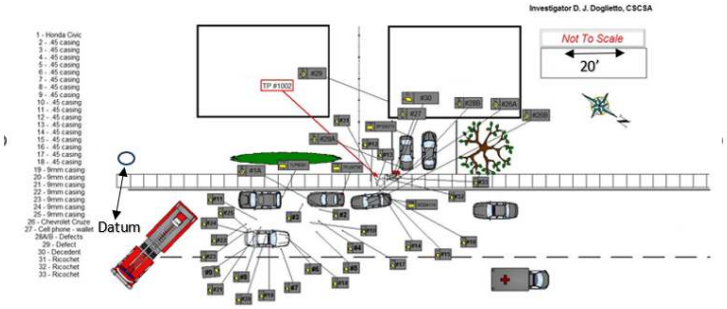


Figure **7.6.3**: Aerial view diagram with legend and compass rose. - Created with ScenePD 6. Author's collection

Orientation, Compass Rose, Legend, Title Block, and Datum Point

There is disagreement in the crime scene investigations community on how the diagram technician should orient their sketch and diagram; whether it should be as viewed by the technician or with north always being at the top of the page. Your author is of the opinion that in both indoor and outdoor scenes, the diagram should be oriented as viewed by the technician. The true compass direction should be represented by a **compass rose** on the diagram. Either method is acceptable provided the true compass direction is included on the diagram. The **legend** provides useful information to the viewer to identify items of evidence or important features within the scene. If dimension lines complicate the overall view of the diagram, the measurements can be included within the legend. If the dimension lines are removed from the diagram, it is important to include a scale for reference. The **title block** contains the information pertinent to the diagram including the location of the scene, the date and time of the incident, the case number, and the name of the diagram technician. Finally, the **datum point** allows a starting point from where the measurements were taken. This datum point should also be captured as an image to assist anyone who is tasked with reconstructing the scene.

Measuring Methods - Baseline, Rectangle and Triangulation Methods

The **baseline** method of collecting measurements is likely the most useful. In order to use this method, you must have at least one fixed point (datum) that will not change (fire hydrant, telephone pole, light pole, the corner of a building, etc.) and a compass heading. If you do not have a fixed reference point in a large field or wooded area, you can use a portable GPS unit and place a stake or marker at the GPS coordinates. Roll out a fiberglass measuring tape along this line and leave it in place. This line becomes your baseline or **'X' axis**. Facing away from your fixed point, you may have items of evidence laying either to the left or right of the line. Those items laying to the left can be measured back to the baseline on a **'-Y' axis** at a 90-degree angle, and those items lying to the left can be measured back to the baseline on a **'+Y' axis** at a 90-degree angle.

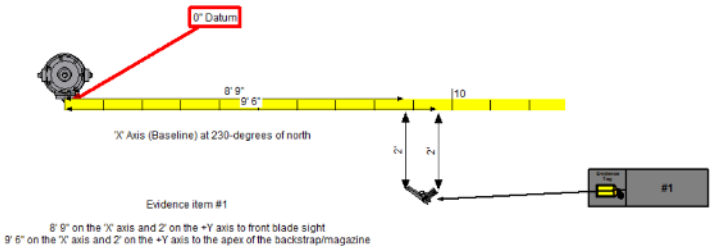


Figure **7.6.4**: Baseline measurement method diagram. Created with ScenePD 6. Author's collection

Remember, the purpose of measuring and sketching the crime scene is so that any person can go back to the scene and recreate it with accuracy. Therefore, it is critical to have a compass heading for the baseline.

The **rectangular** measurement method is best for items of evidence that are found in areas that have a defined shape and fixed points, such as a shed, room, prison cell, bathroom, yard, etc. Run two fiberglass or metal tape measures along two adjoining walls or fences so that they meet at the corner. The corner will be the '0' datum for both tape measures. Designate one tape measure as the 'X' axis and the other as the 'Y' axis. Then measure from various noted points on the object back to the axis' and record the measurements. Items that have a shape will need multiple measurements; whereas items with an irregular shape, or are too small to measure multiple points, such as a fired cartridge casing, are measured to center of the object.

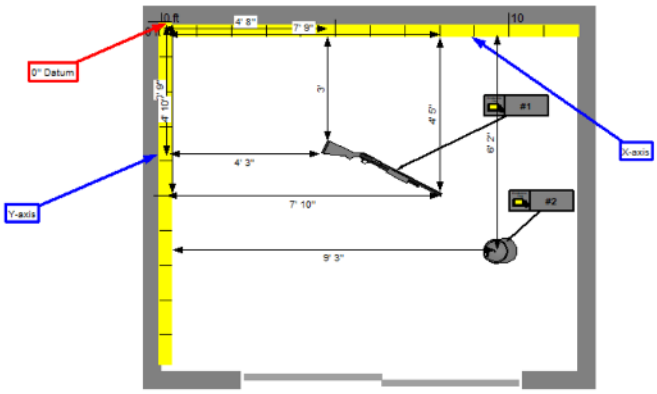


Figure **7.6.5**: Rectangular measurement method diagram. Created with ScenePD 6. Author's collection

The **triangulation** method can be used for items of evidence that have a distinctive shape and for items that do not have a distinctive shape but are found in an area that has a defined shape and fixed points. This is likely the most accurate measurement of the three methods listed provided a compass direction is given for each leg of measurement. Items with a distinctive shape will have at least two three-point (triangle) measurements, although three would be preferred. Items without a distinctive shape will have at least one (triangle) measurement to the center of the object. Just as with the rectangular method, you must first determine the fixed points and stretch your tape measures so that they meet in the corner with both, or all three, starting at the '0' datum, then take three-point measurements back to the object.

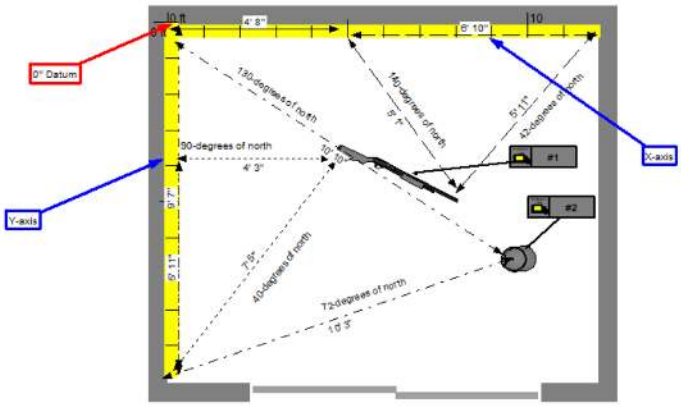


Figure **7.6.7**: Triangulation measurement method diagram. Created with ScenePD 6. Author's collection

There may be occasions where the fixed points for your crime scene are too far away to be useful for establishing a baseline or have a distinct boundary for either the rectangular or triangulation methods, you may have to combine the baseline and triangulation methods as illustrated below. You will need a very long tape measure and a compass. Sink metal stakes at the datum points should the fixed feature be removed. Establish GPS coordinates for each datum point as well for future reference.

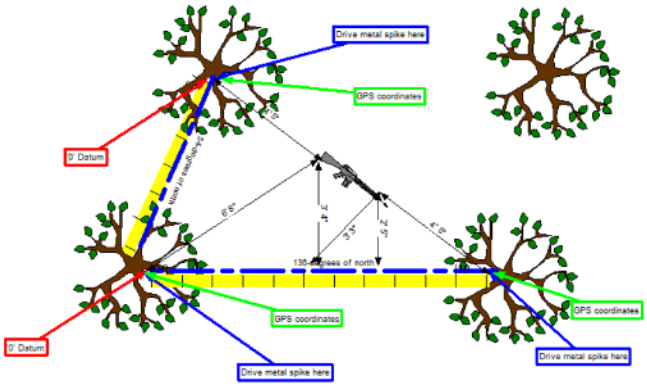


Figure **7.6.8**: Triangulation on a Baseline Diagram. Created with ScenePD 6. Author's collection

The Rough Sketch

Your author will be the first to admit that he is not an artist. He can manage something just marginally better than a stick figure. This fact does not excuse him from trying to create at least a rudimentary sketch of the scene. These rough sketches can be extremely useful when writing reports and for creating the final sketches that will be submitted for courtroom proceedings. They are especially helpful in shooting scenes where multiple fired cartridge casings remained in the scene. Often times it is difficult to appreciate the relationship of the shell casings to the other objects in the scene if you are reliant only on the photographs taken of the scene. Photographs are not good at depicting the distance between evidence items. A sketch, especially a bird's eye view sketch, with proper measurements is far more useful. It is, however, imperative that the diagram technician retains the rough sketch with their field notes as they are discoverable evidence. It is best to scan the field notes and rough sketches into PDF files and save them in electronic form.

Your author recommends the reader find a suitable place with fixed features or walls. Place a kitchen knife in the center of the area and practice measuring and diagramming the scene. Once you have recorded the measurements and photographed the position of the knife, pick up the knife, hand it to a fellow student or friend, along with your diagram, and challenge the friend to put the knife back in the scene exactly the way it was found. Use the baseline, rectangular, and triangular methods to see which method was the most successful.

The Future of Crime Scene Diagramming

Technology is the master of all things including crime scene diagramming. Engineers have long had the ability to conduct 3-dimensional Global Positioning System (GPS) scanning of the topography of land to assist them with the design and construction of roadways. It was therefore a foregone conclusion that some bright crime scene technician had the brilliant idea of “borrowing” the scanner used by their public works department and applied it to a large crime scene. Enter the Leica Scan and FARO 3-D software and hardware GPS scanning and diagramming systems. These systems capture data by emitting laser beams to selected datum points, which create an accurate **mapping** of the area by collecting millions of data points that produce a **point cloud** imaging of the scene. Proprietary software allows the technician to create a diagram of the scene using the point cloud imaging that provides a precise representation of the scene. The benefits of GPS scanning systems are that the scans are extremely accurate, and they produce very detailed diagrams of the scene when using the proprietary software that converts the point cloud data into a visible 3-D diagram. The drawbacks are that they are bulky devices that require large tripods for the laser-scanning units, and the technician must be trained to input the datum points, which can be time consuming. They may not be the best method for diagramming small scenes. The point cloud imagery is unrecognizable without the additional software needed to create the diagram. The devices can be cost prohibitive for small agencies, although leasing options and grant funding are available. Some environmental conditions like rain, standing water, or high winds can adversely affect the quality of the data being collected. Your author can see the benefits of these devices but recommend highly to every agency that employs them to be sure to train your technicians in the tried-and-true methods of diagramming, because there always needs to be a plan ‘B’ when technology fails.

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7.7: Test Questions

1. The person with the primary responsibility of preserving the scene of a crime is the:
    a. Fire chief
    b. Emergency medical responder
    c. First law enforcement officer on the scene
    d. Crime scene technician
2. Which of the following is evidence that may be lost if not immediately documented and collected?
    a. Transient evidence
    b. Perishable evidence
    c. Pliable evidence
    d. Impression evidence
3. Which of the following is evidence that may be disturbed or moved if not immediately documented and collected?
    a. Transient evidence
    b. Perishable evidence
    c. Pliable evidence
    d. Impression evidence
4. This member of the crime scene team is responsible for the documenting everything in the scene from the location of the evidence, to team duties and actions, to all of the details of the scene:
    a. Lead investigator or analyst
    b. Diagram technician
    c. Scribe
    d. Evidence collector
5. This method of crime scene diagramming is from the perspective of as if the viewer was looking down from the ceiling:
    a. Bird’s eye view
    b. Exploded view
    c. Aerial view
    d. Line of sight view
6. This method of crime scene diagramming is from the perspective that all walls and ceiling are laid out:
    a. Bird’s eye view
    b. Exploded view
    c. Aerial view
    d. Line of sight view
7. This type of crime scene measurement utilizes an ‘X’ axis measurement from which items of evidence are measured on the -/+Y axis at 90-degrees back to the ‘X’ axis:
    a. Rectangular measurement method
    b. Baseline measurement method
    c. Triangulation measurement method
    d. Grid pattern measurement method
8. This type of crime scene measurement utilizes the corner of a room with two measuring tapes beginning at the 0” datum and items of evidence are measured back at 90-degrees to tape measures:
    a. Rectangular measurement method
    b. Baseline measurement method
    c. Triangulation measurement method
    d. Grid pattern measurement method
9. This type of crime scene measurement uses fixed points and three points of measurement to document the position of items of evidence either with defined shape or irregular shape:

b. Baseline measurement method
c. Triangulation measurement method
d. Grid pattern measurement method

10. This basic diagram is drafted by the crime scene technician or diagramming technician as a perfunctory drawing of the scene:
    a. Stick figure sketch
    b. Line sketch
    c. Rough sketch
    d. 2-D or 3-D computer assisted drawing

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7.8: Suggested Essay Topics

1. Write an essay on the qualities you believe a person should have to be a good crime scene technician.
2. Draw a crime scene with several items of evidence and a scale. Write an essay outlining the how you would process the crime scene in detail.
3. Select a high-profile homicide investigation and write an essay about the efforts of the crime scene team to preserve, document, and collect the evidence from the scene of the crime.
4. Write an essay about the benefits and disadvantages of the triangulation method of diagramming compared to the baseline method.
5. Write an essay about the benefits and drawbacks of 3-D laser emitting GPS scanner systems, and what you think crime scene diagramming might be done in the next 25 years.

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7.9: References

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CHAPTER OVERVIEW

8: Evidence

> *"Wherever he steps, whatever he touches, serve as silent witness against him. The hair, the fibers from his clothing, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects, all of these and more bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence, physical evidence cannot be wrong; it cannot perjure itself; it cannot be wholly absent, only its interpretation can err. Only human failure to find it, study and understand it can diminish its value."*
>
> *Paul Kirk on Edmond Locard's Principle of Evidence Exchange*

Learning Objectives

- To understand the weight of various types of evidence court proceedings
- To learn about prejudicial evidence and how it can influence a judge or jury
- To learn about the different types of evidence in court proceedings
- To understand comparison evidence and the difference between class and individual characteristics
- To understand the role of physical evidence in criminal investigations and court proceedings
- To learn the difference between trace and transfer evidence
- To understand the role of digital evidence in criminal investigations and court proceedings

8.1: Introduction
8.2: Court Evidence
8.3: The Manifestations of Evidence
8.4: Test Questions
8.5: Suggested Essay Topics
8.6: References

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8.1: Introduction

Contrary to common belief, all evidence was not created equal. Evidence can have varying weight in courtroom proceedings. Some evidence, such as **circumstantial** or **testimonial** evidence, has less weight than others, like **video** or **physical** evidence, which has more. Evidence can prove or disprove a fact in question. Evidence can prove whether a crime was or was not committed. It can **inculpate** or **exculpate** a suspect. It can assist with the reconstruction of a crime in order to assist the lawyers, judges, and jurors to understand the incident and sequence of events that encompass the crime. Unfortunately, evidence can also prove to be prejudicial.



Figure 8.1.1: The Boston Massacre by Paul Revere. Public Domain

On March 5, 1770, a party of the British 29th (Worchestershire) Regiment stood in rank before a crowd of peaceful protestors, angry over the provisions of the Stamp Act, and without cause or merit was directed by a captain to open fire on the crowd, killing three and fatally wounding two others who were carried from the scene. A British “loyalist” also gave fire upon the crowd from a window of the Butcher’s Hall building. This unprovoked attack upon a peaceful crowd was the tinderbox that started the Revolutionary War of Independence. That is what you would think, and likely learned in school if you are of a certain age, if you were just to look at the famous engraving by Paul Revere entitled *The Boston Massacre* or *The Bloody Massacre*.

In truth, the events that led to the discharge of muskets on March 5, 1770, were a bit more disorganized. The crowd that had assembled were definitely not “peaceful” by any means. The trouble started earlier in the day when Private Hugh White, of the 29th Regiment, was on lone sentry duty in front of the Customs House. Edward Garrick, a young wig maker, had approached Private White and chastised him for not paying for a wig that he had ordered. An argument ensued and Private White struck Edward across the head with the butt of his musket. The injury was not great, but when word got out of the incident, a large crowd gathered, some armed with clubs, who began taunting the soldier. As the mob grew and joined by a number of sailors from the docks, Private White became concerned and called for a party of soldiers, six in number and one corporal, to respond as reinforcements, with Captain Thomas Preston in command of the small group. Captain Preston attempted to calm the crowd and promised to investigate the incident, but this did not satisfy the mob, which was now led by Crispus Attucks, a former slave of great size and strength. Captain Preston, who had previously ordered bayonets to be affixed to the muskets and the weapons loaded, assembled the soldiers in a skirmish line. According to H. Evergard in the history of the Worchestershire regiment, the following account transpired, with a statement by Captain Preston:

‘The mob pressed closely upon them, and advanced up to the points of the bayonets. The soldiers stirred not a step from where they were posted, and merely used their weapons to keep off the mob. Emboldened by their apparent fear, (Crispus) Attucks and the sailors, giving three loud cheers, pressed closer upon the troops, and with clubs beat their bayonets and muskets, crying out to the rest, Come on, don't be afraid of 'em; they dare not fire. Knock 'em over! Kill 'em!" Presently Attucks aimed a blow at Captain Preston, who was using every endeavour to appease the fury of the populace. The blow fell on the captain's arm, and knocked down the musket of one of the men, the bayonet of which was seized by the mulatto (Attucks). At this time there was a confused cry, proceeding from some persons behind Captain Preston, "Why don't you fire! Why don't you fire!" Montgomery, the private whose bayonet was seized by Attucks, and who in the struggle was thrown down, soon rose to his feet in possession of his gun, and immediately fired. Attucks fell dead. This was followed by straggling shots from five or six others. Three persons were killed, five dangerously wounded, and a few more slightly. The populace instantly retreated, leaving the killed on the ground, but soon returned to carry off the bodies.’

> *"On the people assembling again," said Captain Preston, in his written defense, "to take away the dead bodies, the soldiers, supposing them coming to attack them, were making*

> *ready to fire again, which I prevented by striking up their firelocks with my hand."*

If Captain Preston is to be believed in his testimony, the depiction of events as recorded by Paul Revere would suggest that the soldiers fired upon the crowd as they peacefully returned to carry off the dead and wounded, which did not happen.

In fact, at the time the Revere engraving was circulating around Boston, the trials of Captain Preston and the eight soldiers who fired on the crowd, causing the deaths of Crispus Attucks, Samuel Grey, James Caldwell, Samuel Maverick, and Patrick Carr, were about to begin. John Adams, one of the Founding Fathers of the country, represented the defendants in a bifurcated trial. The first trial was held on October 24, 1770, and lasted six days. The trial was based primarily on eyewitness testimony, which was often contradictory. Some prosecution witnesses could not even agree upon what Captain Preston was wearing; however, it came down to the testimony of a few witnesses who saw Captain Preston standing in front of the soldiers when they fired. In fact, Newton Prince, a freed slave, testified that he saw Captain Preston standing in front of the soldiers and, "Heard no orders given to fire." John Adams successfully argued that had Captain Preston given orders to fire, he certainly would not have been standing in front of the muskets. No one testified that a shot was fired from the Butcher's Hall building windows. The jury delivered a not-guilty verdict. Next came the trial of the eight soldiers, William Wemms, Hugh White, Hugh Montgomery, James Hartigan, William McCauley, Mathew Kilroy, William Warren, and John Carroll, on November 27, 1770. John Adams again represented the defendants. There was no argument that the eight soldiers on trial were present during the incident, and that some had discharged their muskets, which led to the deaths. This was a fact that made the job of the prosecution easy. The defense needed to argue that the soldiers fired in self-defense. Once again, the evidence was primarily that of eyewitness testimony. Important to the defense was the testimony of Surgeon John Jeffries, who tended to Patrick Carr as he was dying. Surgeon Jeffries testified that Patrick has made a deathbed statement saying that he did not blame the soldiers for firing to defend themselves. In Surgeon Jeffries own words as documented by Hiller Kobel in his 1996 book *The Boston Massacre*, "He told me that he was a native of Ireland, that he had frequently seen mobs, and soldiers called upon to quell them…he had seen soldiers often fire on the people in Ireland, but (he) had never seen them bear half so much before they fired in his life." In other words, one of the victims of the shooting, as he lay dying, confessed to his surgeon that the soldiers acted in self-defense. In closing arguments, the prosecution argued that the soldiers could have simply walked away from the fray as they possessed an avenue of escape. In his closing argument, John Adams provided the following:

> *'I will enlarge no more on the evidence, but submit it to you.—Facts are stubborn things; and whatever may be our wishes, our inclinations, or the dictates of our passions, they cannot alter the state of facts and evidence: nor is the law less stable than the fact; if an assault was made to endanger their lives, the law is clear, they had a right to kill in their own defence [sic]; if it was not so severe as to endanger their lives, yet if they were assaulted at all, struck and abused by blows of any sort, by snow-balls, oyster-shells, cinders, clubs, or sticks of any kind; this was a provocation, for which the law reduces the offence of killing, down to manslaughter, in consideration of those passions in our nature, which cannot be eradicated. To your candour [sic] and justice I submit the prisoners and their cause.'*

The trial lasted nine days. In the end, the jury deliberated for two hours before rendering a verdict: William Wemms, Hugh White (the soldier whose actions began the series of events), James Hartigan, William McCauley, William Warren, and John Carroll were acquitted of the charges outright. Hugh Montgomery, who had fired the first shot, and Mathew Kilroy were found guilty of the lesser charge of manslaughter. However, John Adams successfully argued for the application of an obscure English law called the *Benefit of Clergy*, which allowed for a reduced sentence for first-time offenders. Their punishment was to have their right thumbs branded; likely with an 'M' for murder.

Obviously, the Revere engraving would never have been allowed in courtroom proceedings as evidence; however, it was available to the jury before the trial began. In the end, it did not influence their decision. It did likely reflect upon, or influenced, eyewitness testimony of the event, which was contradictory at the trial. We must consider that the engraving was the photograph of the day. Engravings, like photographs, can provide an altered perception of the facts. Photographs can be altered using computer software or artificial intelligence. That is why it is essential that those experts who are providing testimony in court are of the highest moral

character and can testify without hesitation that the photographs are a true and accurate representation of the scene, event, or item of evidence, and that the images are free of manipulation. Also of importance is the role of the crime scene analyst or reconstructionist who can render an opinion as to the accuracy of the image when compared to the evidence collected from or the conditions of the scene.

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8.2: Court Evidence

The California Evidence Code, or **Evidence Code**, governs the admissibility of evidence in courtroom proceedings. It dictates what evidence can be presented in courtroom proceedings, how that evidence should be presented, and the weight that should be considered for each type of evidence presented. The evidence that is admissible in court is as follows:

- **Real evidence:** Real, tangible, or physical objects that are present in court to prove a fact (weapons, documents, developed latent prints, etc.) (see also physical evidence)
- **Demonstrative evidence:** Items that are used to demonstrate or illustrate something related to the case (photographs, diagrams, desktop or CAD models of the crime scene)
- **Documentary evidence:** Documents that may be presented to prove a fact (reports, contracts, emails, correspondence, checks, etc.)
- **Testimonial evidence:** Verbal evidence presented by a witness regarding what they experienced, heard, smelled, or saw
- **Direct evidence:** Evidence that can prove a fact (eyewitness account, video, etc.)
- **Circumstantial evidence:** Evidence that can propound a fact by inference or suggestion (an eyewitness seeing someone in the area of a crime or fleeing from the scene)
- **Hearsay evidence:** A statement that is made by a witness who cannot present the same statement in court. This type of evidence is generally inadmissible in courtroom proceedings, but there are 17 hearsay exemptions in the California Evidence Codes
- **Expert evidence:** Opinion testimony of an expert on a given subject that pertains to the case, as deemed appropriate by the judge
- **Digital evidence:** Evidence that is stored or captured in electronic form (cellular telephone data, emails, social media, GPS tracking, computer storage devices, etc.)
- **Physical evidence:** Any relevant object that may prove a fact (DNA, fingerprints, gunshot residue, transfer evidence, etc.)

Other forms of court evidence are **admissible evidence**, **inadmissible evidence**, **exculpatory evidence,** and **incriminating evidence.** Admissible evidence is that evidence which the judge has deemed appropriate to be presented in court. Inadmissible evidence is that evidence which the judge has deemed inappropriate to present in court. Exculpatory evidence is that evidence that would tend to prove that the defendant did not commit the act for which they are being charged. Incriminating evidence is that evidence used by the prosecution to prove that the defendant is guilty of the act for which they are being charged. Purposely ignoring exculpatory evidence during a criminal investigation, or withholding the information from the court, can result in serious consequences for the detective or investigator.

Comparison Evidence

Of great importance to the courts is **comparison evidence.** Comparison evidence is that evidence that can be compared by a skilled and qualified analyst to determine if it is of a common origin as another item that has been documented or recovered. There are many applications of comparison analysis including, but not limited to, fingerprint comparison, footwear and tire tread comparison, ballistic and firearm comparison, handwriting comparison, DNA typing, and hair and fiber comparison. The analysis of comparison evidence is essential in forensic science to for a link between the suspect to the crime scene, to confirm the source of materials, and to identify persons associated with the incident. In order to understand comparison evidence, you will first need to understand the difference between **class characteristics** and **individual characteristics**.

Class characteristics describe attributes that are common to a group of objects and therefore provide the ability to compare the objects to that group. Consider the tire that you purchase for your car or the work boot you purchased for your foot. As each of these products come down the assembly line, each product will look exactly like the one before and the one after, provided there is not a defect or wear in the manufacturing tooling that occurred between their production. Thus, as in the photograph below, the outsole of this work boot will look exactly like the others making their way merrily down the production line.



Figure **8.2.1**: The outsole of a new pair of Bates brand boots (left boot). - Author's collection

The impression left by this boot, if worn for the very first time, would look exactly like a person wearing a boot of the same size that was produced directly after. Although the comparison of this boot impression would be useful to say it is a Bates work boot, men's size 11, other than that there is nothing to say who wore the boot other than perhaps the size of their foot.

Individual characteristics, on the other hand, are characteristics that are unique to one specific item, resulting either from manufacturing defect, wear, damage, or natural variation, also known as **pattern evidence**. Although the analyst can no longer say that the item can be compared to the exclusion of all others, they can determine that the item can be consistent with having originated from a common source. Let us look at the outsole of the boot after your author has worn the boot for six months



Figure **8.2.2**: The Bates brand boot after six months of wear. - Author's collection

The analyst can see that although the wearer has good foot alignment, the wear is quite unique to the particulars of how the wearer walks, what he has stepped on, and where he has walked. The defects exhibited on the proximal heel and proximal toe were created by stepping on sharp objects. Those defects, as well as the wear pattern, would be transferred to an impression of the boot; thus, allowing that boot to be uniquely compared to the impression. A forensic podiatrist can also compare the wear patterns of the boot with the characteristics of the wearer's foot. Although the analyst cannot say that it is absolutely impossible for someone wearing a boot of the exact same brand and size to step on the exact same sharp object in the exact same manner that caused a defect in the exact same place, or stepped on the a pebble with the exact same shape that wedged in the exact same groove at the exact same angle, because somewhere in the world this coincidental occurrence may have transpired. However, the chance that these two people just happened to be in the same place at the same time is extremely remote. The same can be applied to pattern evidence suchStyle as fingerprint comparison.

Biological Evidence

Biological and physiological evidence are evidence that pertain to the human body. **Biological evidence** is any tissue, organ, fluid or secretion related to the body. This may include blood, semen, saliva, excrement, skin cells, sweat, vaginal secretions, or other fluids or organs associated with the suspect or victim. **Physiological evidence** is quantitative data related to the internal functions of the human body, which can be used to support or refute a fact in court. This evidence is associated with the functions of the brain, heart, hormonal levels, or any other bodily processes as related to different conditions or stimuli.

Chemical Evidence

Chemical evidence is any evidence that requires chemical analysis to determine identification, origination or composition to link the substance to a crime, crime scene, or event. This evidence includes presumptive and confirmatory testing of narcotics or

controlled substances, blood or bodily fluids, minerals, paper composition, tobacco, gases, solvents, explosives or gunpowder, fire debris, and alcohol.

Non-Specific or Miscellaneous Evidence

Non-Specific or miscellaneous evidence is evidence that does not fit into the other categories of evidence and may require the interpretation of an expert to understand. Voice-stress analysis, polygraph, photography, videography, fire origin and spread analysis, entomology, Global Positioning data, computer analysis, or anything else that does not necessarily belong in other categories.

Physical Evidence

As previously mentioned, physical evidence is tangible or physical objects that are used in courtroom proceedings to prove a fact. Consider a handgun found in a vehicle that was chased by the police following an armed robbery at a market. The video acquired from the market shows a person, likely a male, wearing a hooded sweatshirt, grey in color, gloves, and holding a black Glock-type handgun. The video outside of the market shows the robber entering a silver Honda Civic sedan without a front license plate. The sedan has a left front fender that has a dent near the headlight assembly. The video also shows that the suspect is the only occupant in the vehicle. A bulletin is released for the suspect vehicle and an alert highway patrol officer observes a vehicle matching the description enter the highway at a high rate of speed. The patrol officer attempts a traffic stop and the chase is on. After several miles at speed exceeding 100mph, the suspect vehicle runs out of gas and rolls to the shoulder of the highway. The male driver runs from the vehicle, but the officer is able to chase him down and to take him into custody. A second patrol officer arrives on scene to make certain the vehicle is secured, and to her surprise, she finds the vehicle occupied by a patient and cooperative male passenger, who is subsequently detained. The passenger is the same height and weight as the driver. The passenger is identified, and, following a records check that revealed an outstanding felony warrant, detained. The officer asked the passenger how he got into the vehicle, to which he stated that the driver picked him up just before getting onto the highway. On the backseat of the vehicle, the officer observes a grey hooded sweatshirt, a mask, a pair of gloves, and a black semi-automatic handgun that resembles a Glock model 19. During an in-field investigation, the passenger informs the officer that the driver was the person who robbed the market. When asked how he knew the driver had committed the robbery, the passenger stated, “He told me after I got in the car.” Is the case closed? Do you charge the driver for the robbery, write your reports, and process the recovered items and video as evidence? Do you use the statement of the passenger in furtherance as your probable cause to charge the driver for the crime? Or does the evidence, both testimonial and physical, represent merely that which is circumstantial to the driver? What about the addition of the second male in the vehicle? At what point did he enter the vehicle? Certainly, the patrol officer was correct to arrest the driver for recklessly operating a vehicle on a highway while in an attempt to evade and elude the lawful traffic stop, and yes, it would appear that there is sufficient probable cause to charge the driver with the robbery, but it would be prudent to allow the forensic scientist to extract additional information from the **physical evidence** to identify the real perpetrator of the crime. Video analysis identifies the hooded sweatshirt to be consistent with the item of evidence based on the position of the logo and a stain on the right sleeve. The mask and gloves have class characteristics that are consistent with those in the video. The handgun also has class characteristics that are consistent with those in the video. Fingerprint analysis of the handgun reveals a left thumbprint on the right side of the magazine. The thumbprint comparison reveals that it is consistent with having been contributed by the driver. DNA specimen collected from the interior of the sweatshirt reflects two male profiles consistent with the driver and the passenger as contributors. However, subsequent analysis for DNA specimen from the interior of the mask and gloves produced only one contributor, the passenger. Follow-up inquiry conducted by detectives discovered an additional eyewitness of a hotdog vendor who witnessed the Honda leave the parking lot of the market and stop at an intersection of the road where he observed a male exit the backseat of the vehicle, where he was crouched behind the seat, and exchange positions with the driver. The first driver was observed entering the vehicle by the right front passenger door. During an in-custody interview, the driver admitted that they had hoped the police would not be looking for a car with two occupants if the video indicated only one person committed the crime. The appropriate course of action would be to charge the driver with the forementioned traffic violations, conspiracy to commit robbery, and being an accomplice to the crime. An arrest warrant for the passenger for felony armed robbery should be petitioned from the court. It was the analysis of the physical evidence in the case that not only proved the facts of the crime, but identified the participants and their roles, and aided in a reconstruction of the crime. However, as can be seen in the previous scenario, physical evidence may, without further analysis or investigation, be circumstantial in nature. Take for instance a fingerprint developed on a demand note used in the robbery of a bank. Does the fingerprint, when identified, prove that the person who deposited the latent fingerprint on the note was

the person who committed the crime? No, the suspect of the crime might have found the paper, which was previously handled by the person who deposited the fingerprint. The suspect may also have asked the contributor of the fingerprint to hand him a piece of paper, and the contributor provided the paper without knowledge of its eventual use. However, if further investigation indicates the contributor was in fact the suspect, then that fingerprint becomes real evidence during the subsequent trial.

Physical evidence does not always fit strictly into one category but might be a combination of one or more. Thus, physical evidence is divided into three sub-group types:

- Trace or Transfer evidence
- Indented or impression evidence
- Striated evidence

Trace or Transfer Evidence

Transfer evidence is any evidence that is passed from one source to another through some form of contact. This evidence can be small, latent, or microscopic in nature, and can include fingerprints, epithelial cells, bodily fluids, hairs, fibers, glass fragments, paint chips, soil, ashes, and gunshot residue. **Trace evidence** is any transfer evidence that can be traced to a specific source, such as fingerprints, DNA, bodily fluids, chemicals, hairs, and fibers. Transfer and trace evidence can link a suspect to a victim, a victim to a suspect, or any person to a crime scene.

Impression or Indented Evidence

Impression evidence is physical evidence that is created by the contact of one object into a softer medium or the transfer of a substance from one surface onto another surface, thus leaving a two-dimensional or three-dimensional mirrored impression of the object. Examples of impression evidence are fingerprints, footwear and tire tread impressions, and bite marks. **Indented** evidence is faint impressions or indentations left from one object onto another by movement or friction. Examples of this would be the indentation of writing from one sheet of paper to a sheet of paper that was underneath. Firing pin marks, firearm extractor and ejector marks are also examples of indented evidence.

Striated Evidence

Striated evidence is scratches, striations, or drag marks, often microscopic, that are created when a hard object that is in motion contacts a softer surface. These markings can be specific to the hard object or tool that caused them and can therefore be linked to one consistent source. Striation evidence is often discovered by firearms examiners who analyze rifling on bullets, firing pin drag markings, or striations that are transferred to soft metal cartridge casings by the breech or chambers of a firearm.

Digital Evidence

In today's world, even your toaster knows what time you get out of bed, how dark you like your toaster strudel, and your plans for the day. Even in his advanced age, your author has an unhealthy fixation with his cellular telephone. Your vehicle likely knows where you have been during your driving excursions, and how fast you drove to get there. It may even have a video of you behind the wheel. Certainly, your social media activity can be very useful in criminal investigations; as are internet browser, email, and web search history. **Digital evidence** is data collected from electronic devices that is generally either stored or transmitted by binary code that can either be used to prove or disprove a fact in court. The importance of digital evidence in courtroom proceedings has magnified over the past decade and will likely rival other forms of evidence in the coming decades. It is the responsibility of the trained digital evidence expert to properly collect, preserve, and analyze the data, and to provide expert witness testimony during court proceedings. Digital evidence can be complex, encrypted, perishable, easily altered, and purposely or accidentally destroyed, and therefore it is essential that the evidence is authenticated and deemed reliable by the highest skill and ethical standards of the analyst.

Types of digital evidence are:

- **Electronic communications**: Social media posts, emails, text messages, etc.
- **Website activity**: Browsing history, webpage visits, cookies, etc.
- **Transaction and Financial Data**: On-line purchases, money transfers, banking transactions, etc.
- **Metadata**: Generally hidden file information that includes creation dates, authors, device information, etc.
- **Cloud Storage Data**: Files that are stored on internet-based third-party servers

- **Internet of Things (IoT) Data**: Data from smart phones, wearable technology, home appliances, etc.

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8.3: The Manifestations of Evidence

It is important not only to understand the various types of evidence, but also to be able to recognize and identify the manifestations of evidence as noted in the following effects and details:

- Predictable effects
- Unpredictable effects
- Transitory effects
- Relational detail
- Functional detail

Predictable Effects

Predictable effects of evidence are those changes to the crime scene or the evidence within the scene that occur with regularity or that will provide the investigator with a factual reference or inference as to the time the event may have occurred. An example of predictable effects would be the analysis of insect activity at the scene of a homicide scene wherein a forensic entomologist can establish a period of death based on the stage of insect development.

Unpredictable Effects

Unpredictable effects of evidence are those changes in the crime scene or the evidence within the scene that occur in an unexpected or random fashion, thus altering the original scene. Examples of this would be officers and emergency services personnel who are the first to arrive on the scene moving the body of a decedent, turning on lights in the house, opening windows, moving items of evidence, or “making safe” a firearm found at the scene. These changes can have serious deliberate consequences for the overall investigation. The crime scene investigators follow a meticulous scientific methodology to prevent creating, or including, unpredictable effects in the crime scene documentation or subsequent analysis.

Transitory Effects

Transitory effects are those temporary conditions of a crime scene that might be overlooked if not noticed by a trained and experienced technician. Examples of transitory effects include un-melted ice in a drinking glass, a still smoldering cigarette, or the smell of cologne or burnt gunpowder. If this evidence is overlooked during the initial inspection of the scene, it will likely result in the loss of significant evidence, especially for the establishment of a timeline of events.

Relational Details

Relational details of the scene are provided through the investigator’s ability to physically recognize the relationship between items of evidence in the scene. Examples of this can be found in bloodstain pattern analysis and the ability to associate the bloodstains in the scene with the actions that created the stains, the sequence of the deposition of the bloodstains, and position of the participants of the blood-letting event. The relationship between bullet defects and fired cartridge casings in the scene is also an example of the relational details of the scene.

Functional Details

Functional details of the scene present themselves in the operational condition of the evidence found in the scene. These details are determined by the investigator to determine if a handgun found in the scene was capable of being loaded and fired, if a door was capable of being locked, or if a mechanical defect in an automobile caused an accident. Functional details are useful in supporting or disproving specific allegations, to support or refute witness statements, or it can help define a timeline of events.

Understanding the relevance and importance of the various types of evidence discovered during the investigation of a crime is decisive to the criminal court proceedings because it has the most direct effect on the decision-making by the judge or jury when determining the guilt or innocence of the defendant who is being charged with the crime.

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8.4: Test Questions

1. This type of evidence can play on the emotions of the judge or jury:
    a. Physical evidence
    b. Testimonial evidence
    c. Prejudicial evidence
    d. Direct evidence
2. This “Founding Father” served as the attorney for the defense of the soldiers who fired on the crowd at the Boston Massacre:
    a. George Washington
    b. Benjamin Franklin
    c. Thomas Jefferson
    d. John Adams
3. This evidence includes the sub-categories of class characteristics and individual characteristics:
    a. Physical evidence
    b. Comparison evidence
    c. Digital evidence
    d. Impression evidence
4. This evidence includes verbal evidence presented by a witness regarding what they experienced, heard, smelled, or saw:
    a. Physical evidence
    b. Testimonial evidence
    c. Prejudicial evidence
    d. Direct evidence
5. This evidence can prove a fact in question:
    a. Physical evidence
    b. Testimonial evidence
    c. Prejudicial evidence
    d. Direct evidence
6. This evidence is passed from one source to another through some form of contact. This evidence can be small, latent, or microscopic in nature, and can include fingerprints, epithelial cells, bodily fluids, hairs, fibers, glass fragments, paint chips, soil, ashes, and gunshot residue
    a. Comparison evidence
    b. Transfer evidence
    c. Impression evidence
    d. Digital evidence
7. This evidence is any transfer evidence that can be traced to a specific source, such as fingerprints, DNA, bodily fluids, chemicals, hairs, and fibers:
    a. Comparison evidence
    b. Trace evidence
    c. Impression evidence
    d. Digital evidence
8. The rifling on a bullet is an example of which type of evidence?
    a. Impression evidence
    b. Trace evidence
    c. Transfer evidence
    d. Striated evidence
9. This type of evidence does not fit into the other categories of evidence and may require the interpretation of an expert to understand:

b. Digital evidence
c. Testimonial evidence
d. Unusual evidence

10. This evidence is data obtained from smart phones, wearable technology, and home appliances:
    a. Electronic communication evidence
    b. Metadata evidence
    c. Internet of Things Data evidence
    d. Website evidence

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8.5: Suggested Essay Topics

1. Write an essay regarding historical court proceedings that might have been improperly influenced by prejudicial evidence.
2. Write an essay from the point of view of the jury in the Boston Massacre criminal court proceedings.
3. Selecta high-profile homicide investigation, like the O. J. Simpson trial, and write an essay about the presentation of the evidence to the jury and their understanding of that evidence as it related to the verdict.
4. Write an essay about the analytical process of conducting a forensic examination of a hair or a fiber found on the victim of violent crime.
5. Write an essay about the various types of digital evidence available to an investigator during a homicide investigation,

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CHAPTER OVERVIEW

9: Forensic Entomology

Learning Objectives

- To understand the role of forensic entomology in courtroom proceedings
- To understand the postmortem intervals of death
- To learn about the different types of postmortem conditions and processes
- To understand the role of insects such as flies and beetles in determining an estimation of time of death
- To understand the role of insects such as flies and beetles in determining possible ingestion of toxins and drugs by the victim before death, and how they can help identify the victim
- To learn the proper techniques for the collection and preservation of insects
- To understand the role of forensic taphonomy and anthropology in buried body and surface skeleton investigations

9.1: Introduction
9.2: Post-Mortem Changes in Body Condition
9.3: Sample Collection and Scene Processing
9.4: Forensic Taphonomy and Clandestine Grave Detection
9.5: Conclusion
9.6: Test Questions
9.7: Suggested Essay Topics
9.8: References

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9.1: Introduction

In death investigations, especially those of a suspicious nature, it is critical to accurately determine the time of death for the decedent. This information can establish the timeline of events leading to the death, prove or disprove a suspect alibi or witness statement, and assist the investigator in identifying potential suspects by providing a period of time that will allow the investigator to focus their canvass for eyewitnesses, video surveillance, and digital evidence searches. Historically, it has been very difficult to establish death, let alone the time of the death. Prior to the 1819 invention of the stethoscope by Rene Theophile Hyacinthe Laennec in France, methods of determining death could have been compared with the same techniques to garner a confession under torture, such as placing a candle flame under a finger or burning the nose of the patient. Even if death can be easily determined, figuring out the actual time of death may not be so easy since most deaths, especially suspicious deaths, occur while unattended and without witnesses. According to Darren Drake in his 2020 article, *A Time Recorded in History*, 'It used to be that a time of death was simply a time the coroner pronounced, arrived on the scene, or used witness statements to determine when a person passed. Many of those same techniques are used today, but with far greater consequences, if not accurate.' Most estimations of the time of death are rendered when life-saving measures have ended, whether if the patient was ever responsive to the efforts of the fire or medical personnel or not, or if an officer arrived on scene and determined that death was obvious, rather because of decomposition or an unserviceable physiological derangement. The apparent problem with this estimation of the time of death is that it does not accurately reflect the exact moment of death. Of course, the only accurate determination of the time of death can only be made when the death is witnessed and a person with the authority is present to pronounce death. All other determinations of death are estimations. Where estimations become most problematic is when a body is discovered days, months, or years following the event that resulted in the termination of life. It is in this regard where the study of insects and their arthropod relatives can assist the detectives, medical examiners, and the legal system with determining a window of the death event by establishing: the time interval between the death event and the discovery of the body (also known as the **postmortem index** or PMI); the post-mortem interval of decomposition; the cause and manner of death; the determination of the death location or the placement of the body after death; and the association of suspects at the crime scene. The science that embodies this study is **forensic entomology**. Forensic entomologists provide this information by an analysis of insect and larvae morphology, development history, species distribution, and toxicity.

First Use of Forensic Entomology in Court

Aside from the story of Song Chi in Chapter 1, the first documented use of forensic entomology occurred in 1855, when a young couple who were remodeling their small Parisian apartment found the mummified body of a small child hidden in a wall behind the mantelpiece. Even though the couple had only recently moved into the apartment, the police believed they were guilty of the murder of the child. Doctor Louis Bergeret d'Arbois, a physician, conducted an autopsy of the decedent and noticed evidence of insect populations present in the body. By conducting an analysis of the life cycles of the various types of insects, he calculated that the body of the child had been placed behind the mantelpiece in 1848. The Paris police were able to identify the tenants of the apartment in 1848 and arrest them for the murder. They were subsequently convicted following a trial whereby the testimony of Dr. Bergeret was critical to the prosecution.

Forensic Botany

A forensic science that often works in tandem with forensic entomology is **forensic botany**, which is the study of plants and plant materials. A forensic botanist's understanding of the growing cycles of plants, as well as the native species of the area, can help to identify the time and place of death. Therefore, it is essential that the crime scene investigator who is tasked with processing the scene of a body found outdoors, or where a body has been buried following a criminal act, must preserve, document, and collect all vegetation surrounding the body, as well as either on the surface or at depths within the grave. Purge fluids from the decomposition process of a human body can destroy all vegetation within 20' of the body. Therefore, an analysis of that "dying-off" and regrowth cycle can assist with the estimation of the time of death or deposit of the body.

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9.2: Post-Mortem Changes in Body Condition

No discussion of forensic entomology would be complete without first discussing the postmortem (after death) changes that occur to the condition of a body following death. Death, decomposition, and insect activity are entwined in a complete cycle of life and death. The forensic science student often finds this topic the most difficult with which to cope. It is best to think of the body of one who is no longer living as an empty shell or an item of evidence. There are three processes in the human condition: **maturation, declination, and decomposition**. Maturation is the process of human growth from infancy to adulthood. This involves physical, mental, and hormonal changes that begin at birth and progress through puberty and end in mature adulthood. Sadly, there is a period of declination when cognitive and physical abilities begin to be impaired or lost. The end result, however, is decomposition. Decomposition is the breaking down of the body owing to the degeneration of the cells and organs after death and the growth of bacteria. Although the rate of decomposition may vary owing to such variables as environmental conditions, obesity or emaciation, light or heavy clothing, or the surface upon which the body lay, the means of decomposition remains the same and involves two processes: **autolysis** and **putrefaction**. Shortly after death, the cells in the body begin to breakdown because of the absence of oxygen and the end of blood circulation. During this stage of decomposition, enzymes within the cells are released. These enzymes begin what can only be described as digestion. This process is called autolysis. As the cells and organs break down, the beneficial bacteria that is already present in the body and have been starved of the nutrients upon which they have become accustomed to but were deprived following the death of the host, become overwhelmed with a new source of food: the body. As the bacteria feast on the available food source, especially in the digestive system (bacterial flora), they release gas biproducts that infiltrate into the body tissues and organs. This begins the putrefaction process. The gases produce **bloating** of the skin; hydrogen sulfide invades the blood vessels making the veins and arteries making them appear darker and more pronounced called **marbling;** and the skin blisters and peels as **skin slippage**. Once this occurs, the gases are released from the body, in particular the foul-smelling diamines **cadaverine** and **putrescine,** into the atmosphere. It is the release of the sulfur-based and ammonium-laced chemicals associated with decomposition that attract the attention of insects and beetles. Among these insects and beetles are those that are only interested in feeding on the body; those that are feeding on the body and other insects and beetles; and spiders, isopods, and hexapods who use the body for shelter and an expansion of their environment. The species that are most important to forensic entomology are those that feed on the body and those that feed on the body and other insects and beetles. These are the flies (**Diptera**) and beetles (**Coleoptera**).

Diptera

The most common species of Diptera are the blow flies (Calliphoridae), common house flies (Muscidae), and flesh flies (Sacrophagidae). These flies may be the first to arrive on the scene following a death; especially if it associated with a blood-letting event. It is estimated that the common house fly can smell blood at a distance of up to four miles. Although the blow flies and flesh flies waste little time in joining the feast, house flies tend to wait for the bloating stage of decomposition to begin their egg-laying. That egg-laying is the beginning of the colonization period of the fly. The colonization will be an aggregation of eggs laid in one area of the body. Areas of trauma, natural openings of the body, hair, or folds of skin are prime locations for egg-laying. It is important to know the eggs will be deposited near the sight of trauma, but not within the wound itself as the eggs need to breathe. The preferred areas of egg-laying on the body that are the first to be colonized are the nose, eyes, ears, and mouth. After mating, the female fly will lay batches between 75 and 150 eggs. This egg-laying process is known as **oviposition**. Each egg measures approximately 1/16th of an inch (1.2mm) and is yellowish white in color. Depending on temperature and humidity, it takes an average of 12 to 20 hours for the egg to hatch into a **larvae** (maggots). The larval stage of development consists of a period of eating and growing that can take several weeks to a month. Maggots are small, legless and worm-like, will measure between 1/3rd and 1/10th of an inch (3mm to 12mm), and are brownish white in color. During this period, the maggots will shed their skin (**molt**) several times. Colonization during this period will always be from the head of the decomposing body downward, or from the area of trauma downward. Clothing does not interfere with or alter this distribution. Maggots cannot penetrate skin, so there must be an opening in the skin or an area of trauma. It is possible to extract human DNA from maggots during the larval stage, which is very important to forensic scientists. Maggots can also be a good source to determine if the victim had drugs or toxins in their system; however, insect toxicology cannot determine if the victim had over-dosed. This examination is referred to as **entomotoxicology**. Once the maggot has fully developed, it will move to a drier part of the decomposed body and will **pupate.** As the maggot pulls itself out of its current shell into a **pupa**, it will purge liquids that will stain the body and destroy nearby plants. This stage of

development is often called the “wandering stage” (also migratory or post-feeding) as just before they pupate, the maggots will move towards light, whereas in the larval stage, the maggot is repulsed by light. This wandering allows the maggot to find an area that is away from predators and close to soil where they can instantly burrow to facilitate the transformation into pupal form. The pupal stage of development is the transformational period for the maggot to develop into an adult fly. This period lasts between a few days and a week depending on the temperature and environment. The transformed adult fly will exit the pupal shell, which will remain in the environment and will look like a small greyish brown to brown ribbed capsule. This entire cycle takes between seven to ten days depending on the environment and climate. If sufficient food source from the decaying body remains, the cycle will be repeated. It is therefore necessary to collect a large enough sample of the oviposition detritus. This will be discussed later in this chapter.

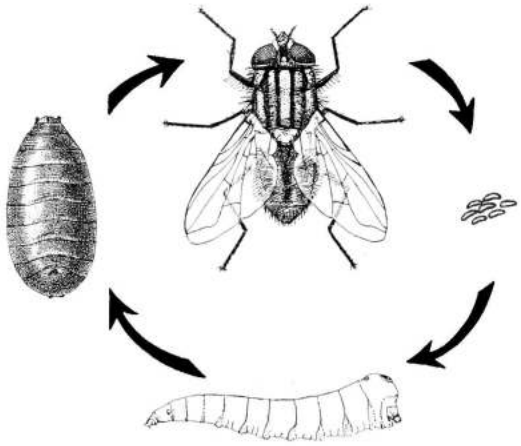


Figure **9.2.1**: Life cycle of the common house fly. – Wikimedia

Coleoptera

Although ants would appear to be the most prolific insect in the world, the beetles are definitely on their heels. It is estimated that there are between 400,000 and 600,000 species of beetles on the planet, perhaps even more that are yet to be identified. The main varieties of beetles are the rove beetles (Staphylinidae), scarab (Scarabaeidae), clown beetles (Histeridae), carrion beetles (Silphidae), ground beetles (Carabidae), checkered or bone beetles (Cleridae), and skin beetles (Dermestidae). For the purpose of this chapter, we will discuss only skin beetles and bone beetles. Skin beetles are small, oval shaped beetles measuring less than ½” (12mm). In fact, the larvae of skin beetles can be longer than the actual beetle itself at 15mm. They are generally grey or greyish brown in color and may be covered in hairs or scales. They voraciously consume decaying flesh and can clean the skin of a decomposing human body within a week or less depending on the size of the colony and the environment, leaving only skeletal remains. The female skin beetle can lay up to 150 eggs at one time. The eggs are tiny (.02” or .5mm), white or cream in color, and are characteristic by small spine-like projections and ridge-like lines that resemble a skeletal back bone. The eggs usually take one or two weeks to hatch into the larvae. The larvae are elongated and taper to one end, rust or dark brown in color, and are hairy. There are three instar phases of larval development, each characterized by a growth in size. The larval stage of development lasts between five and six weeks. The pupa is slightly smaller than the larvae, is white to light brown in color in the early stages and will appear darker once the encapsulated beetle begins to take adult form. Depending on the species of skin beetle, the pupa will take approximately one week to develop into an adult beetle and shed its capsule. The chewing pattern of the skin beetle is very unique with the edges of the holes that are created having jagged or uneven edges. Bone beetles are attracted to the latter-stage of the decomposing body when fly larvae provide a good food source, as well as the dry remains of the body such as hair and skin. Bone beetles are active in cold weather when fly activity is diminished. Bone beetles can feed on the dry remains of the body long after other insects have departed. Therefore, they are useful to forensic entomologists in cases involving mummified bodies and skeletal remains.

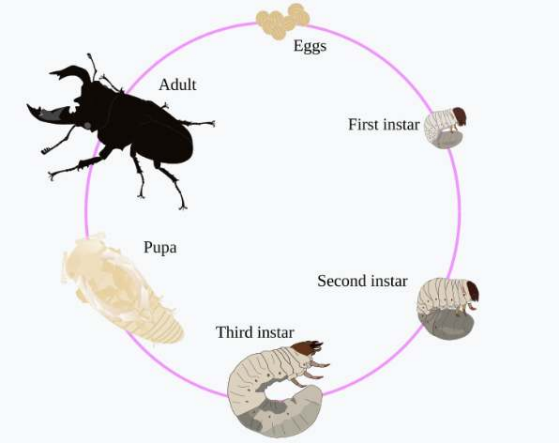


Figure **9.2.2**: The life cycle of a beetle. Courtesy Bugboy52.40 Wikimedia

Frass is the term used for the fecal matter of beetles and other insects. It resembles sawdust, but can be white, off-white, or brown in color. Frass is a good source of victim DNA if collected and analyzed within two weeks following death.



Figure **9.2.3**: Beetle Frass - Courtesy Jim Tassano, Foothill Sierra Pest Control

Other Considerations

Plastic sheeting covering the body will produce a barrier against flying insects; however, once the plastic begins to deteriorate the flying insects will enter through the gaps. As previously mentioned, cold weather will slow fly colonization but not stop it. In snowy conditions, flies may still lay eggs, but the eggs will likely overwinter until the weather gets warmer. Alternatively, temperatures in excess of 110-degrees Fahrenheit are lethal to flies. Therefore, in the event of a burned body, the flies will not colonize the body until temperatures have dropped below that which is lethal. Ants will inhibit fly activity as they like to feed on fly eggs and maggots. Ants will also feed on the skin of the decedent, producing small, cluster patterned holes. Scavenging by ants may also resemble cigarette or acid burn marks. Ants deposit formic acid as they chew; although this will not cause a reaction on the swelling or reddening reaction common to ant bites on persons who are still living. Ants typically do not eat hair because they cannot digest the shaft. They also tend to feed on the boney prominences of the body. Roaches will do the same thing except they do eat hair, eyebrows, eyelashes, and hairs in the pubic region. In fact, a forensic entomologist can tell the species of roach by examining the cut in the shaft of the hair. Silverfish (Lepisma saccharina) are common to North America, Europe, China, and even the Hawaiian Islands. They tend to lay their eggs in dark areas like the folds of skin on a decomposing body. The food source for the silverfish will include the clothing of the victim as well as the skin and the bodies of dead insects. Therefore, the presence of silverfish on and near the body should be documented.

Insect colonization may occur in the anal or genital areas of victims of sexual trauma or assault. Therefore, an inspection of these areas should be made regardless of the assault or trauma being obvious or apparent.

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9.3: Sample Collection and Scene Processing

When a clandestine grave, surface skeleton, or decomposed body has been discovered, the first step is to preserve the area, to limit access to the area, and to conduct a full scene identification and documentation process. Some helpful information regarding clandestine grave and surface skeleton investigations will be provided at the end of this chapter.

Scene Documentation

Outdoor

The scene must first be documented in its entirety by digital photography and sketches following documentation procedures described in Chapter 7, making note of the weather conditions, temperature, barometric pressure, and ambient lighting. Consider using a bucket-lift, drone, or other means for aerial photographs. Make notes regarding the vegetation, both living, dead, or in stages of decay. Note the variety, height, maturity, and health of each plant. Note the topography of the scene, including the slope and exposure, as well as the percentage of sun, shade, or partial shade. Note if the body is located on dry or moist ground, exposed, or partially exposed, or if it fully or partially submerged in water. If submerged in water, note if **saponification** has occurred. Saponification is the process where body fat is converted into a waxy, oleaginous or soap-like quality called **adipocere**. If the body is in direct sunlight in an arid environment, the body may exhibit signs of mummification. If present, the degree of mummification should be noted.

Prior to collecting environmental and body temperature using a thermocouple thermometer, a sample of adult flying insects should be collected. This can be accomplished using a student insect net and the “catch and grab” method. The student insect net has a net diameter of 15” to 18” with a 24” to 36” handle. The method of using this net is to sweep the air about five feet above the body in a lazy-eight pattern, grabbing the net at about one-third of the length from the handle, and emptying the net into a suitable container using a funnel. This sweep should be repeated three or four times until a sufficient sample of adult insects are captured. Once this is completed, make a similar sweep in a circle approximately five feet around the surface area of the body. Empty the net into a separate container. Each container must have a label that is written using a pencil placed within the container, and a second label bearing the same information on the outside of the container. Inks tend to fade or may be subject to being destroyed with the application of preservative chemicals. Pencil graphite is more stable, resilient, and better suited for long-term storage.

As mentioned, environmental temperature readings can now be made using a thermocouple digital thermometer as follows:

- Ambient air temperature – operator’s chest height, sun and shade
- Micro-climate air temperature - operator's knee height
- Surface temperature – decedent’s upper body
- Ground temperature – the area between the body of the decedent and the ground
- Soil surface temperature – a measurement below 1” of the soil surface (excluding areas saturated with decomposition fluids)
- Humidity reading – if possible, record the humidity level of the ai

Indoor

Documenting the indoor scene of the discovery of body decomposition, skeletonization, or mummification is done much in the same manner as the outdoor scene, with a few changes. In addition to the standard documentation of the scene, the technician should also note the following if the doors or windows of the house or building were opened or closed, if lights were on or off, and if the house was heated or cooled by artificial means (was the A/C or heater on or off). The technician should also note if there was anything that would have contributed to insect activity such as rotting food or produce, garbage, or animal feces. Obvious entry means like broken windows, missing doorknobs, air conditioning window vents, gaps in exterior doors or mail slots, should be documented and checked for evidence of insect activity. Door, window, and wall construction material should be documented, as well as the position of the body relative to doors and windows. Adult flying insect specimen collection should be performed as it would be in the outdoor setting. Environmental temperature readings should be recorded as follows:

- Ambient air temperature – operator’s chest height, sun and shade
- Micro-climate air temperature – 12” above the floor
- Ground temperature – at the surface of the floor away from areas with purge fluids
- Humidity reading – If possible, record the humidity level of the air

Specimen Collection

Specimen collection of insects for forensic entomology purposes involves the active techniques of physical interaction of catching the insect as opposed to passive techniques that involve traps or other capture devices. As previously mentioned, aerial nets are the best method of collecting adult flying insects; whereas sweep nets are good for catching insects that are inhabiting the blades of grass or on the leaves of shrubs. Tweezers are good for collecting crawling insects as well as the carcasses of dead insects or the detritus of the oviposition and maturation processes. Pipettes or aspirators can be used to collect small or delicate samples using suction, thus less likely to cause damage. Plastic spoons are preferred for collecting colony samples. Soil sifters are useful for collecting insects or insect pupae that have burrowed into the ground. It is best to collect samples of dirt from the elevated areas first and work downhill moving from east to west. Fly larvae appear off-white in color when first laid but will turn orange to reddish-brown to black once hatched. It is important to document where each specimen was collected. Insects collected from clothing should be kept separate from insects collected from the body or the environment. Each specimen sample should be individually labelled. If insects are collected from the nostrils, the insects from the left nostril should be collected separately from those found in the right nostril and labelled as such. The same applies to the ears and eyes of the body. When collecting fly larvae (maggots), it is best to place them into vials individually, labelling them with area found and the sex of the larva. It is easy to sex a maggot. The female maggot will have a gap between the eyes; whereas the male maggot will either have no gap between the eyes or will have a very narrow gap.

Preserving Specimen as Evidence

In order for the forensic entomologist to have a precise understanding of the life-stages of the insects collected from the crime scene, it may be necessary to stop the growing process. This is done using different methods of killing and preserving the insects; although some insect development should be captured and collected in a living state. Adult flying insects caught in nets can be pushed from the net through a funnel into a glass jar containing a cotton ball soaked in acetate (fingernail polish). This will affect death, and the cotton ball will be removed and the jar filled with isopropyl alcohol (not stronger than 80%). The jar must be labelled as previously described and included on the label should be listed the manner of killing and the preservative medium. Beetles are robust and can be killed and preserved in the same manner. Larvae and pupae should be placed in water exceeding 110-degrees Fahrenheit, but not boiling, for one to five minutes, and then placed in a jar or vial containing < 80% isopropyl alcohol. Adult flies and beetles and larvae can be placed individually into a small, capped vial and placed into a freezer and frozen. This is sufficient to preserve the insect for DNA extraction, but it is essential that the specimen must be delivered to the forensic laboratory before they have thawed, and long-term storage is not advised. Living habitats can also be used for larvae, pupae, and crawling insects intended for DNA extraction. These habitats can be constructed of a plastic container with a tight lid. **Vermiculite** provides a good soil substitute for insects to thrive. Small holes punched into the lid provide an oxygen source as well. A small piece of aluminum foil should be placed into the container with a small amount of wet cat food (beef or chicken) as a food source for the insects. Again, the container should be delivered immediately to a forensic laboratory or entomologist and must not be place in long-term evidence storage.



Figure 9.3.1: Your author's "bug box" forensic entomology collection kit. Author's collection



Figure **9.3.1**: Inside of the bug box showing the kit

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9.4: Forensic Taphonomy and Clandestine Grave Detection

Forensic taphonomy is the study of what changes occur to a body between the time of death and the moment of discovery, also known as the postmortem process, in order to draw conclusions for courtroom purposes. Although closely related to **forensic anthropology**, forensic taphonomy is more focused on the decomposition process whereas forensic anthropology is specifically interested in the skeletal remains of the body. What both sciences have in common is the analysis of trauma and the systematic approach to a reconstruction of the death event, which includes preservation of the remains, observation of the remains within the environment, and the recovery of the remains. Both sciences would earn an entire chapter themselves; however, for the purpose of forensic entomology, we must explore what both sciences do exceptionally well: finding decomposed bodies, surface skeletons, and clandestine graves. We have discussed at length in this chapter the discovery and processing of scenes containing bodies in various stages of decomposition. Let us turn our attention to surface skeletons. Skeletal remains discovered on the surface will either be intact or scattered. It is not uncommon to find a skeletal skull many yards from the rest of the body as once detached from the neck, they tend to roll when in a downhill orientation, or with the run-off from rainfall, or the activity of animals. Animals alone are capable of scattering bones up to 100 yards from the scene. Bones that have been subjected to the environment for lengthy periods of time may take on the appearance of natural material like sticks, rocks, or other stone features. Furthermore, if recognized as bone, a determination must be made if the bones are of a human or an animal, which may require the analysis of an anthropologist. Once the bones are confirmed as human, a systematic search for the entire skeleton should be conducted using the grid-pattern search method. Documentation of the scattered bones should also be completed with the bones *in situ* within each grid. The bones can then be collected and reassembled following proper crime scene processing procedures, paying careful attention to the detritus of insect and arthropod activity. Clandestine graves are those that are not officially recorded and are generally used to dispose of a body following a criminal act. These graves are most often located in remote outdoor wooded or desert areas or in the basements or gardens of occupied or unoccupied houses or buildings. These graves are generally hand-dug, shallow, and of an irregular shape. Clandestine graves in building basements can be very difficult to find; especially if a layer of stone or concrete has laid or poured on top of the grave. **Ground Penetrating Radar** (GPR), which use radar pulses directed downward into the ground, have some success as a non-obtrusive means of body detection, as well as the use of cadaver canines. It is important to know that most commercial GPR systems are not calibrated to detect gravesites, and therefore some software adjustments are required. Cadaver canines are also useful in outdoor grave detection, but equally useful is the trained eye of a taphonomist or anthropologist. The common Hollywood belief is that all clandestine graves will have irregularly shaped depressions that can be detected by the average novice. Although some depression may occur as a result of body decomposition, the rate of depression will be slow and often indistinguishable. In wooded or grassy areas, the vegetation on top of the grave may be more vigorous because the soil has been loosened and aeriated during the digging process. Paw marks from wild animals might be detectable, as well as rodent burrows. Once discovered, the gravesite must be meticulously documented and processed layer by layer until the body is fully uncovered. Once uncovered, the body is examined, documented, and recovered following proper crime scene processing procedures, paying particular attention to entomological evidence of insect activity. Once the body is removed from the grave, the soil beneath the body must also be examined and processed, as well as any dirt below the body until the hard pan level has been reached.

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9.5: Conclusion

Forensic entomology is a crucial part of homicide investigations involving dumped or buried bodies; especially for establishing the interval of death. The colonization of flies, beetles, and other insects and arthropods, and their life cycles, provide useful information to the forensic entomologists in determining; the estimation of the time of death; if the body was moved after death; if the victim ingested any toxins or drugs; and may help to establish the identity of the victim. Crime scenes involving bodies in states of decomposition, mummification, or skeletonization require technicians who are specially trained, meticulous in their documentation, and who will process the scene with considerations towards forensic entomology, taphonomy, and anthropology.

Your author recommends the reader conduct an internet search for the Organization of Scientific Areas Committee for Forensic Science, Standard for the Collection and Preservation of Entomological Evidence from a Terrestrial Environment draft report (OSAC 2022-N-0039) for more information regarding the collection and preservation of entomological evidence.

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9.6: Test Questions

1. The first recorded use of forensic entomology in courtroom proceedings was in which European country:
    a. Jianyang, China
    b. Lyon, France
    c. Paris, France
    d. Edinburgh, Scotland
2. This doctor determined the body of a child found behind the mantle of a French apartment belonged to a previous tenant and not the tenant who found the remains:
    a. Song Chi
    b. Edmond Locard
    c. Louis Bergeret d'Arbois
    d. Alphonse Bertillon
3. This insect will be the first to arrive at a blood-letting event crime scene:
    a. Flies
    b. Beetles
    c. Spiders
    d. Silverfish
4. This change occurs in a body that has been immersed in water or otherwise deprived of oxygen:
    a. Mummification
    b. Decomposition
    c. Saponification
    d. Bloating
5. The waxy, soap-like appearance of a body that has been immersed in water or otherwise deprived of oxygen is called:
    a. Adipocere
    b. Marbling
    c. Bloating
    d. Keratosis
6. Before recording temperature readings, the technician should do this first:
    a. Collect observable insects from the clothing of the victim
    b. Look for pupae that have burrowed into the ground
    c. Collect adult flying insects using an aerial net
    d. Identify the various species of frass in and around the victim
7. Which of the following is a good source of victim DNA:
    a. Adult flies
    b. Adult beetles
    c. Frass
    d. Silverfish eggs
8. The analysis of fly and beetle larvae for toxins or drugs is called:
    a. Forensic anthropology
    b. Forensic taphonomy
    c. Forensic keratotomy
    d. Forensic entomotoxicology
9. This is a suitable substitute for dirt in living habitat collection:
    a. Vermiculite
    b. Vermicelli
    c. Vellum

d. Volcanic ash

10. This science is focused on the changes in the body which occur during the time period between the time of death and the discovery of the body:
    a. Forensic pathology
    b. Forensic anthropology
    c. Forensic taphonomy
    d. Forensic entomology

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9.7: Suggested Essay Topics

1. Write an essay regarding a case study involving forensic entomotoxicology.
2. Write an essay explaining how you would process a crime scene involving a body that has been dumped in a wooded area.
3. Write an essay explaining how you would process a crime scene involving a buried body in the basement of a house.
4. Write an essay explaining how you would process a crime scene involving a surface skeleton with bone scattering.
5. Research a high-profile homicide investigation wherein forensic entomology was crucial to the investigation and write an essay explaining the investigation and the subsequent courtroom testimony.

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9.8: References

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Kulshresth. Pankaj a a, a, b, AbstractBeetles (Coleoptera) have been recognized as providing significant entomological evidence in the medico-legal field,

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CHAPTER OVERVIEW

10: Bloodstain Pattern Analysis

Learning Objectives

- To understand the role of bloodstain pattern analysis in criminal investigations
- To understand the dynamic characteristics of blood in flight
- To learn about the different types of bloodstain patterns
- To understand the role of the crime scene technician to document the blood-letting event
- To understand the role of the crime scene technician to collect bloodstain specimens
- To understand the various types of presumptive testing for bloodstain evidence
- To learn the proper terminology for bloodstain pattern analysis

10.1: Introduction
10.2: Bloodstain patterns
10.3: Collecting specimen
10.4: Bloodstain Scenario
10.5: Bloodstain Pattern Analysis Terminology
10.6: Test Questions
10.7: Suggested Essay Topics
10.8: References

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10.1: Introduction

The topic of bloodstain pattern analysis is best left to the many competent training programs available on the forensic training market, and to textbooks dedicated to bloodstain pattern analysis such as Tom Bevel and Ross Gardner's Bloodstain Pattern Analysis, 3rd edition, CRC Press or Toby Wolson's Handbook or Bloodstain Pattern Analysis, 1st edition, CRC Press. However, your author does believe the reader should have the ability to recognize bloodstain patterns within a crime scene, and to understand the potential significance of bloodstain patterns to the successful investigation of a violent blood-letting event or crime. Therefore, the purpose of this chapter is to familiarize the reader with an understanding of the proper discovery, recognition, preservation, documentation, and collection of specimens, the result of a blood-letting event, but not necessarily the ability to perform bloodstain pattern interpretation or analysis. For contemporary bloodstain pattern terminology, please refer to the American Academy of Forensic Science (AAFS) AAFS Standards Board (ABS) Technical Report 033, June 2017 (www.aafs.org/sites/default/files/media/documents/033_TR_e1_2017.pdf). The full list of terminology will be found at the end of this chapter.

It is essential that major blood-letting events must be properly mapped, diagrammed, and photographed. Contrary to the beliefs of some defense attorneys, a bloodstain pattern analyst can effectively analyze a blood-letting event using photographs taken at the scene; provided the photographs include overall measurements, the predominant stains are represented with a scale, and that the means to determine that the camera was perpendicular and parallel to the target is present. Documenting the crime scene for bloodstains is time consuming and requires the technician to develop a "mapping" plan, and to be meticulous about documenting and measuring the stains. Thus, the technician will need to have at least the rudimentary understanding of the characteristics of blood in flight. For that, it is important for the technician to understand that blood is a non-Newtonian viscoelastic fluid. Unlike water, which is held together by surface tension, blood is cohesive and is therefore held together by viscosity and internal cohesion. Therefore, blood is harder to break apart when energy is applied. Because of this, blood maintains a spherical shape in flight. It is because of this round shape that we can make an analytical examination of the resultant stains once the blood has impacted a surface. We can apply the laws of physics and mathematics to the observable characteristics of these patterns to determine the nature of the force that produced the patterns, the number of blows struck, the type of force applied, the sequence of events, the angle of impact and origin of the blood-letting source, and the position of the participants. The technician must also understand that a distribution of bloodstains on a target is called spatter patterns. This is of emphatic insistence with bloodstain pattern analysts and is beyond debate. The word "splatter" is a portmanteau word (a word created by blending the sounds of two words that have a similar meaning) created by combining the words "splash" and "spatter." Although our terminology includes a splash bloodstain pattern, which is produced when a large volume of blood spills onto a surface, the majority of bloodstain patterns are not the result of a splash. Therefore, it would be incorrect to generalize all bloodstain patterns with a word that includes "splash."

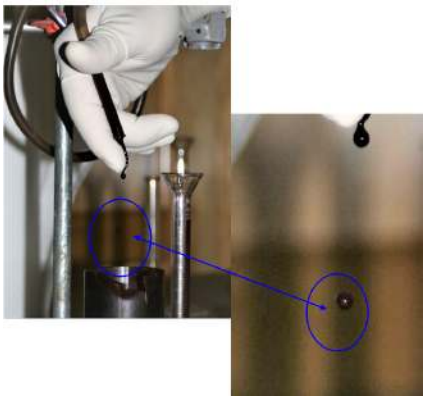


Figure **10.1.1**: A falling drop of blood and the same drop enlarged. Note the spherical shape. It is because of this shape that bloodstain pattern analysis is possible. – Author's collection

The technician will need a camera mounted on a tripod and must be cognizant of the need to augment or control lighting. The photographs need to be sharp and in focus. It is also essential that the analyst know that the stains being photographed are indeed bloodstains. Therefore, the technician must conduct presumptive testing of the predominant stains using a product like phenolphthalein or leucomalachite green, and ideally the Bluestar OBTI Immunochromatographic Rapid Test™ to determine

species, and, following documentation, to collect specimen and control swabs for DNA analysis. The surface upon which the blood has landed is referred to as the target.

The technician should assess the crime scene and assign each target, the area where the blood impacted, with an individual alphabetical or numeric designation. Each pattern within the designated target will then be given a sub-designation. Therefore, if the technician assigns one target area, such as the north wall in a cell, with the capital letter 'A' then the patterns within that area will have a numeric sub-designation, such as pattern 1, and a predominant stain can be selected from this pattern and documented. If the technician decides to document more than one stain in the pattern, each of the individual stains is then represented by a small letter. Therefore, a cast-off impression on the north wall will be designated as target 'A,' pattern 1 and stain 'a' (A1a), 'b' (A1b) and so forth.

It is necessary to include full-length measuring tapes vertically and horizontally in the mapping photographs. Although your author does have a few 48" yellow construction bubble sticks that work great in the crime scene, there is nothing that beats Evident Crime Scene Products' 48" SuperSticks™ for bloodstain mapping and Sirchie's SEARCH™ or Pocket Rod ™ tape measure used with the metal base that allows the tape to stand by itself. Both products are reasonably priced and an essential tool in the crime scene kit. Larger areas may require the use of fiberglass tape measures for horizontal measurements. Your author keeps a drawer full of disposable soft sewing tape measures. They are reasonably inexpensive and can be discarded after use to prevent contamination. Be certain to have strong adhesive tape on hand to keep the tape measures on the wall for the photographs.

The technician will also need alphabetical and numerical adhesive-backed stickers, adhesive-backed scales, and adhesive-backed circles. Although many of these products are available at all the forensic supply retailers, as well as craft and hardware stores.



Figure **10.1.2**: Impact pattern bloodstains on the exterior of a vehicle. Note the use of the orange dot underneath the capital letter to indicate the plane of the camera. – Author's collection



Figure **10.1.3**: Copy and Paste Caption here. (Copyright; author via source)Figs. 10.2A/B – Impact pattern bloodstains on the exterior of a vehicle. Note the use of the orange dot underneath the capital letter to indicate the plane of the camera. – Author's collection



Figure **10.1.4**: A large area with multiple blood-letting events recorded. Note the discarded latex gloves carelessly contributed to the crime scene by responding medical personnel. – Author's collection



Figure **10.1.5**: "Mapped" bloodstain patterns on a cell door. It is always a good idea to put something behind the door so that it does not open as you are taking the photograph. – Author's collection

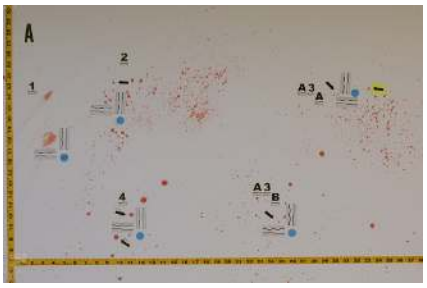


Figure **10.1.6**: Examples of different mapping techniques. – Author's collection

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10.2: Bloodstain patterns

Some important bloodstain patterns to document are impact spatter, cast-off and cessation cast-off, transfer and transfer impressions, voids, drip-trails, flow, pooled, and projected blood. Of course, these are only a few of the bloodstain patterns the technician will need to understand.

Impact spatter

When force is applied to a blood-letting source, blood will take flight primarily out and away from the source causing impact spatter. The faster (higher) the force (energy) applied, the smaller the blood droplets. When a high-velocity force such as a gunshot is applied, the resulting impact spatter will be mist-like, whereas a blunt or sharp force blow may produce impact spatter that is much larger. Remember, in order for a mist-like pattern to be associated with impact spatter resulting from a gunshot wound, there must be an exit wound and a corresponding bullet defect on the target. Direction of the force can be determined by the angle the blood impacts the surface. Forward spatter is blood that takes flight in the direction of the force of energy. Back spatter is blood that takes flight back towards the force of energy. Round stains indicate the blood impacted the surface at or near 90-degrees. Elliptical stains indicate an impact of less than 90-degrees. The more elliptical the stain, the lower the angle of impact. The direction of the stain can be determined by noting the "tail" of the stain known as the wave cast-off. The impact angle is determined using the same mathematical principles used to measure bullet defects. It is essential the bloodstains must have a scale, preferably in metric, to facilitate the calculations.

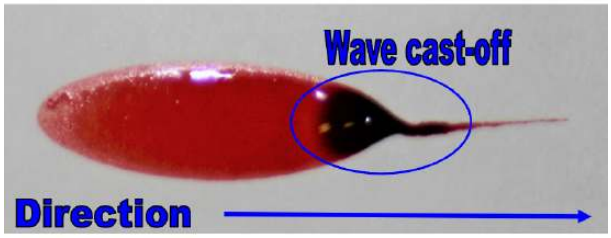


Figure **10.2.1**: The above stain impacted the surface at 40 degrees. The direction of the energy was from right to left. – Author's collection

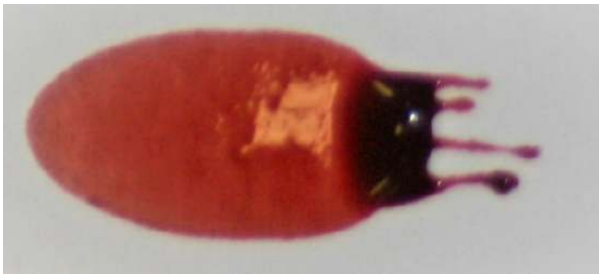


Figure **10.2.2**: The above stain impacted the surface at 60 degrees. Author's collection



Figure **10.2.3**: Impact spatter caused by a bat striking a blood source. Note the force of energy was from left to right. - Author's collection



Figure **10.2.4**: Forward mist-like impact spatter created by the perforation of a high-velocity bullet. Note the bullet defect in the center of the pattern. – Author's collection

Another misting pattern, called an expectoration pattern, is the by-product of blood being expelled from the nose, mouth, or a wound and caused by the blood being mixed with the flow of air. If you look carefully, you will see air bubbles, called bubble rings, in the resulting stain.



Figure 10.2.5: Expectoration pattern. - Author's collection

Determining Area of Convergence and Point of Origin

By analyzing the directionality of stains associated with impact spatter, it is possible to determine the two-dimensional source of the blood-letting event by calculating the area of convergence of the pattern. The area of convergence is the area containing the intersections generated by lines drawn through the long axis of individual stains.

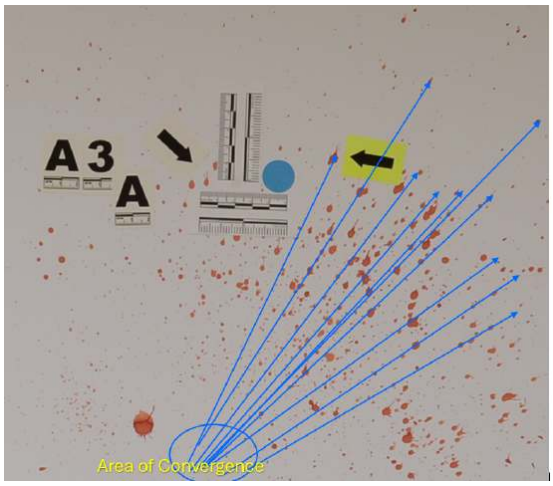


Figure 10.2.6: Determining the Area of Convergence. - Author's collection

Once we have determined the common convergence point several spatters may have made, we can then determine the point of origin of the stain by measuring the furthest stain in the common stains within each line back to the area of convergence and applying the average of the mathematical equation Tan1 of the width/length x the distance from the stain to the area of convergence. In the above example, the point of origin of the blood-letting source is approximately three inches.

Void patterns

A void pattern will result when an object intervenes with the distribution of blood. The resulting pattern is the absence of blood from an otherwise continuous stain. These voids can provide valuable information to the crime scene analyst and criminal investigator regarding weapons that might have been removed from the scene or the positions of victims, witnesses, or suspects.

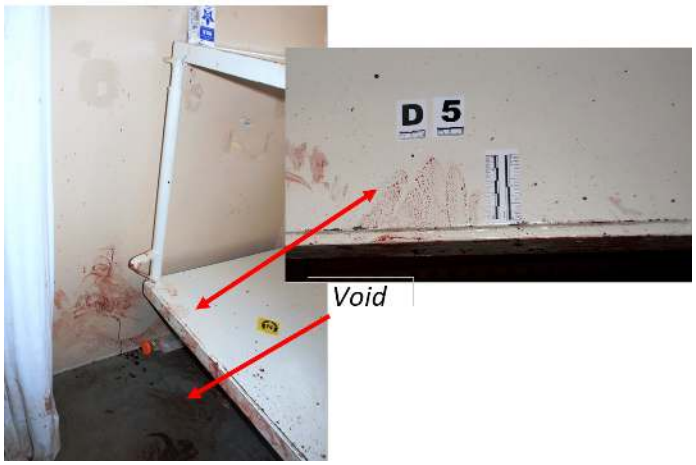


Figure **10.2.7**:Void area with corresponding finger impressions and transfers on the lower bunk and wall suggest the victim was kneeling in this position during the assault. – Author's collection



Figure **10.2.8**: The void pattern suggests the cardboard was at one time pressed against the wall during the blood-letting event. – Author's collection

Cast-off and Cessation Cast-off

Spatter resulting from blood being flung or "**cast-off**" from an object can also providevaluable information to the investigation. Case in point, the sweatpants of a suspect accused of a homicide involving the use of a club are collected and analyzed by a forensic technician trained in bloodstain pattern analysis. The inspection of the clothing in the laboratory revealed small spatters on the front and rear left leg. White reinforcement tabs were placed over the spatter to improve visualization. Spatter was noted on the front and back left legs indicating the suspect used his right hand to deliver the fatal blows. In the downward swing, blood cast-off of the club landing on the front left leg. As the club was brought back for another strike, the cessation of inertia caused the blood to cast-off onto the back of the left leg. This pattern is called **cessation cast-off**. Although the actual details of this case have been modified for this chapter, the gist of the investigation remains the same.



Figure 10.2.9a/b: The suspect's gray sweatpants with cast-off patterns on the front and cessation cast-off on the rear left leg. – Author's collection

As mentioned before, when looking for cast-off spatter, the investigator should inspect the ceiling and walls of the crime scene. Cessation cast-off is likely to be found low on walls and on the floor.



Figure **10.2.10**: Cast-off spatter being flung from a broken mop handle during an assault. – Author's collection

Transfer and Transfer Impressions

A transfer occurs when a bloodstained object presses against another surface thus transferring the blood from one surface to another. A bloodstain transfer impression occurs when a bloodstained object presses against another surface, leaving behind an image of the bloodstained object.



Figure **10.2.11**: There is no doubt what created this transfer impression. – Author's collection

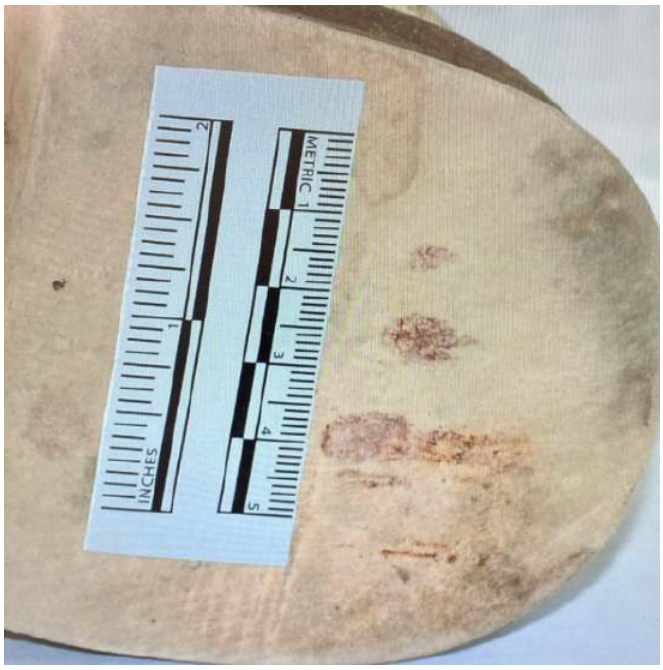


Figure 10.2.12: Blood drops transferred to the bottom of a shoe heel.- Author's collection

Drip Trail

Drip trails occur as the result of the movement of a blood source between two points. This can be passive blood-letting falling from a victim who is ambulatory, being carried or removed from the scene on a gurney, or blood falling from an object like a knife or blood-soaked garment. This is often the first clue to determining direction of travel. Dripped bloodstains that are close together can represent a blood source that is slowly moving through the crime scene. Dripped bloodstains that are further apart may indicate the blood source was moving quickly through the scene.



Figure 10.2.13: The blood drip-trail of a stabbing victim. – Author's collection

Flow

Blood flow occurs as the result of the movement of a volume of blood on a surface due to the pull of gravity, or the movement of surface upon which it was deposited, and before the blood had dried. Flow patterns can be an indicator that a victim has been moved after death.



Figure **10.2.14**: The inmate in this photograph was discovered in the supine position, but the flow patterns on the left side of his head indicated he was in the prone position during the blood-letting event.- Author's collection

Pooled Blood

Pooled blood occurs when a blood-letting source remains stationary in one area for a period time sufficient to result in the passive accumulation of blood. Pooled blood is often found in the final resting area of a victim of a blood-letting event.



Figure **10.2.15**: Pooled blood from the final position of a gunshot victim. Note the emergency medical services left something behind. – Author's collection

Projected Bloodstains

Projected blood stains occur when blood is forced out of an opening under pressure by the breech of an artery or large vein. Because this pattern is produced by the pumping action of the heart, the technician can deduce the victim was alive at the time of the blood-letting event.



Figure **10.2.16**: Blood projected through an open wound by a breech in a tributary vein of the jugular.



Figure **10.2.17**: Blood projected from the nose following a bullet wound to the head.

Wipes and Swipes

Two passive bloodstain patterns often found in crime scenes are wipes and swipes. Wipes occur when an object moves through a preexisting wet blood source, such as the arm of the victim moving through pooled or dropped blood.



Figure **10.2.18**: A wiped pattern caused by an object moving through dropped bloodstains. - Author's collection

Swipes occur when a bloodstained object moves across a clean surface thus transferring the blood onto the clean surface with the characteristics of relative motion between the two surfaces.



Figure 10.2.19: A swipe pattern created by blood-soaked hair being dragged across a clean surface. - Author's collection

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10.3: Collecting specimen

The one thing that is often neglected while processing the blood-letting event crime scene is the proper collection of specimen swabs for presumptive testing and laboratory analysis. Obviously, there will come a time either during analysis or when testifying in court that the question of who bled where will need to be resolved. Because of this, it is imperative that bloodstains must be swabbed and sampled. This is actually a very easy process, but it must be done properly. Step one is to don PPE's including an N-95 mask and gloves. Your author uses sterile 100% cotton-tipped wood applicator swabs that are in sterile packaging, like those found in a medical office. Prior to opening the swab envelope, your author uses a soft-tipped pen to write the important case information on the exterior of the envelope. Your author then carefully opens the envelope at the stick end (not the cotton end). Your author carefully pushes both applicators out of the envelope just far enough to slide an applicator collar on the end of each applicator. He then pushes the collars up to the middle of the envelope and then draws both applicators out of the envelope together, being very careful not to touch anything as he removes them from the envelope. Retain the envelope because you are going to use it again. If the blood being collected is dry, you will need to apply sterile water to the applicator tip. Be sure to use a sterile water ampoule and never touch the tip of the cotton swab with the tip of the ampoule. Instead, drop the water from a height of about one inch. If the blood is wet, you may disregard the need for sterile water. Dab the applicator tip into the blood, being sure not to collect from the periphery of the stain, or from the clotted center. Slide the collar up over the cotton tip, break off about 1/3rd of the remaining stick from the bottom, and carefully place the swabs back into the sterile envelope with the collar and cotton tip near the opening (stick end first). Be sure to air-dry the swabs before sealing the envelope with evidence tape. It is very important for the swabs to be dry before sealing the envelope for long-term evidence storage. If the blood specimen has dried to the point of flaking, you can use the above wet method or scrape the flaked blood into a coin envelope. Be sure to wear safety goggles whenever handling flaked blood as blood-borne pathogens may become airborne.

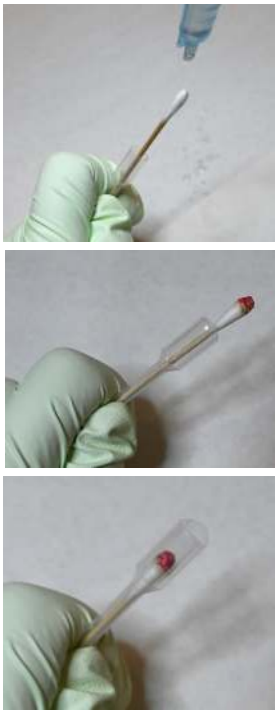


Figure 10.3.1: Be careful not to touch the tip of the vial to the swab. Author's collection

Note that it is not necessary to use the plastic collars when collecting blood swabs for presumptive testing, as you will likely sacrifice the swab during the testing process. Your author uses swab collars that are open on both ends (one small opening and one large opening). The open-ended collar allows for faster drying. Furthermore, it is imperative that you swab one stain at a time. This will prevent placing the wrong swab in the wrong envelope.

Finally, it is important to examine the suspect, and suspect clothing, of a blood-letting crime for signs of blood spatter. Document the discovery with photography and swab the stains in the manner explained above.



Figure 10.3.2: Spatter on the chest of the suspect of a brutal stabbing incident. Fortunately, the eagle-eyed investigators noticed it when the suspect had not. Author's collection

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10.4: Bloodstain Scenario

Your author was asked to conduct a bloodstain pattern analysis report for a homicide scene where a person was stabbed 116 times. The suspect had been taken into custody, but there were no witnesses to the crime. During an interview, the suspect stated that he was “attacked” by the victim, resulting in a prolonged fist fight. The suspect stated that the victim was much healthier than him and he feared he was going to lose the fight. He therefore picked up items of convenience that he could use as stabbing weapons in order to “defend” himself. These items were an ink pen and the prongs of an electrical plug. The suspect stated that during the scuffle, he stabbed the victim 116 times, inflicting only minor injuries, at which point the victim told him he did not want to fight any more and he laid down to rest. The suspect stated that when he awoke in the morning, he noticed that the victim must have died during the night. Although the medical examiner determined that the blade length of the weapon that was used far exceeded that of an ink pen or electrical prong, the prosecutor believed that the statement of self-defense would be credible. It took only one photograph, taken by an alert investigator, for your author to determine the statement by the suspect was contrived.



Figure **10.4.1**: The decedent with flow patterns. Author's collection

The flow pattern of the blood would suggest that the victim was on his back when the wounds were inflicted. At no point was he standing while being stabbed. If he had been standing, the blood flow would first be vertical and then horizontal after he laid down. A review of the autopsy report also indicated that the left orbital bone of the victim was fractured and there were no defensive injuries. Therefore, the victim was likely incapacitated by a punch prior to the stabbing event. Based on a complete bloodstain pattern analysis report by your author, the suspect accepted a plea agreement for a lengthy prison sentence.

For an inexpensive and excellent visual guide to bloodstain patterns, your author recommends Jeffrey Gentry’s A Visual Guide to Bloodstain Analysis, available, as they say, where books are sold, or by contacting him at JeffreyGentry.BPA@gmail.com. Jeff also provides free videos on bloodstain pattern analysis on YouTube at /Jeffrey Gentry BPA Bloodstain Pattern Analyst.

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10.5: Bloodstain Pattern Analysis Terminology

The terminology listed is from the American Academy of Forensic Sciences Standards Board (ASB) 2017 publication “Terms and Definitions in Bloodstain Pattern Analysis.” These terms and their definitions are given below.

Accompanying Drop - A small blood drop produced as a by-product of drop formation.

Altered Stain - A bloodstain with characteristics that indicate a physical change has occurred.

Angle of Impact - The acute angle (alpha), relative to the plane of a target, at which a blood drop strikes the target.

Area of Convergence - The area containing the intersections generated by lines drawn through the long axes of individual stains that indicates in two dimensions the location of the blood source.

Area of Origin - The three-dimensional location from which spatter originated.

Backsplatter Pattern - A bloodstain pattern resulting from blood drops that traveled in the opposite direction of the external force applied; associated with an entrance wound created by a projectile.

Blood Clot - A gelatinous mass formed by a complex mechanism involving red blood cells, fibrinogen,

platelets, and other clotting factors.

Bloodstain - A deposit of blood on a surface.

Bloodstain Pattern - A grouping or distribution of bloodstains that indicates through regular or repetitive form, order, or arrangement the manner in which the pattern was deposited.

Bubble Ring - An outline within a bloodstain resulting from air in the blood.

Cast-Off Pattern - A bloodstain pattern resulting from blood drops released from an object due to its motion.

Cessation Cast-off Pattern - A bloodstain pattern resulting from blood drops released from an object due to its rapid deceleration.

Directionality - The characteristic of a bloodstain that indicates the direction blood was moving at the time of deposition.

Directional Angle - The angle (gamma) between the long axis of a spatter stain and a defined reference line on the target.

Drip Pattern - A bloodstain pattern resulting from a liquid that dripped into another liquid, at least one of which was blood.

Drip Stain - A bloodstain resulting from a falling drop that formed due to gravity.

Drip Trail - A bloodstain pattern resulting from the movement of a source of drip stains between two points.

Edge Characteristic - A physical feature of the periphery of a bloodstain.

Expiration Pattern - A bloodstain pattern resulting from blood forced by airflow out of the nose, mouth, or a wound.

Flow Pattern - A bloodstain pattern resulting from the movement of a volume of blood on a surface due to gravity or movement of the target.

Forward Spatter Pattern - A bloodstain pattern resulting from blood drops that traveled in the same direction as the impact force.

Impact Pattern - A bloodstain pattern resulting from an object striking liquid blood.

Insect Stain - A bloodstain resulting from insect activity.

Mist Pattern - A bloodstain pattern resulting from blood reduced to a spray of micro-drops as a result of the force applied.

Parent Stain - A bloodstain from which a satellite stain originated.

Perimeter Stain - An altered stain that consists of the peripheral characteristics of the original stain.

Pool - A bloodstain resulting from an accumulation of liquid blood on a surface.

Projected Pattern - A bloodstain pattern resulting from the ejection of a volume of blood under pressure.

Satellite Stain - A smaller bloodstain that originated during the formation of the parent stain as a result of blood impacting a surface.

Saturation Stain - A bloodstain resulting from the accumulation of liquid blood in an absorbent material.

Serum Stain - The stain resulting from the liquid portion of blood (serum) that separates during coagulation.

Spatter Stain - A bloodstain resulting from a blood drop dispersed through the air due to an external force applied to a source of liquid blood.

Splash Pattern - A bloodstain pattern resulting from a volume of liquid blood that falls or spills onto a surface.

Swipe Pattern - A bloodstain pattern resulting from the transfer of blood from a blood-bearing surface onto another surface, with characteristics that indicate relative motion between the two surfaces.

Target - A surface onto which blood has been deposited.

Transfer Stain - A bloodstain resulting from contact between a blood-bearing surface and another surface.

Void - An absence of blood in an otherwise continuous bloodstain or bloodstain pattern.

Wipe Pattern - An altered bloodstain pattern resulting from an object moving through a preexisting wet stain.

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10.6: Test Questions

1. A bloodstain pattern analyst can effectively analyze a blood-letting event using photographs taken at the scene; provided the photographs include overall measurements, the predominant stains are represented with a scale, and _____.
    a. the camera is on a tripod
    b. the means to determine that the camera was perpendicular and parallel to the target is present
    c. the photographer uses a wide-angle lens equivalent to 28mm
    d. a lead-card is provided in the frame
2. The distribution of bloodstains on a target is called:
    a. Splatter
    b. Splash
    c. Spatter
    d. Spurts
3. This bloodstain pattern is characteristic of blunt-force trauma-type injuries:
    a. Impact spatter
    b. Flow
    c. Pooled blood
    d. Voids
4. This occurs when a blood-letting source remains stationary in one area for a period of time sufficient to result in the passive accumulation of blood:
    1. Impact spatter
    2. Flow
    3. Pooled blood
    4. Voids
5. This is the absence of blood from an otherwise continuous stain:
    a. Impact spatter
    b. Flow
    c. Pooled blood
    d. Voids
6. This pattern occurs as the result of the movement of a volume of blood on a surface due to the pull of gravity, or the movement of surface upon which it was deposited, and before the blood had dried:
    a. Impact spatter
    b. Flow
    c. Pooled blood
    d. Voids
7. This pattern occurs when blood is forced out of an opening under pressure by the breech of an artery or large vein:
    a. Drip trail
    b. Projected blood
    c. Misting pattern
    d. Transfer pattern
8. This is a bloodstain pattern resulting from blood reduced to a spray of micro-drops as a result of the force applied:
    a. Drip trail
    b. Projected blood
    c. Misting pattern
    d. Transfer pattern
9. This bloodstain pattern occurs as the result of the movement of a blood source between two points:

b. Projected blood
c. Misting pattern
d. Transfer pattern

10. This bloodstain pattern is the result of blood being expelled from the nose, mouth, or a wound and caused by the blood having been mixed with the flow of air:
    a. Projected blood
    b. Expectoration
    c. Impact spatter
    d. Cast-off

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10.7: Suggested Essay Topics

1. Research the history of bloodstain pattern analysis including the work of Dr. Eduard Piotrowski, Paul Kirk, and Professor Herbert MacDonell, and write an essay about their contributions to the science.
2. Write an essay justifying bloodstain pattern analysis as a scientific methodology.
3. Research a high-profile homicide investigation involving bloodstain pattern analysis and write an essay about the conclusion of the analyst.
4. Write an essay about how bloodstain pattern analysis can support or refute the statement of a suspect or witness.
5. Write an essay regarding the use of bloodstain pattern analysis in support of other forensic disciplines for a component of crime scene reconstruction

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10.8: References

American Academy of Forensic Science . (n.d.-a). ASB Technical Report 033, first edition 2017 terms and ... https://www.aafs.org/sites/default/f...TR_e1_2017.pdf

Doglietto, D. (2025). Crime Scene Processing in Correctional Facilities and Prisons. CRC Press, Taylor & Francis Group.

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CHAPTER OVERVIEW

11: Alternate Light Source

Learning Objectives

- To understand the role of the forensic technician to visualize trace and transfer evidence
- To understand the electromagnetic spectrum and light frequency
- To learn about the different wavelengths of light and how they can be applied to forensics
- To understand the properties of light including reflection, absorption, and contrast
- To understand the roles of the ALS and forensic light source in evidence discovery
- To understand the use of colored filters to subtract like colors for photographic documentation
- To learn about the appearances of bodily fluids under ALS
- To learn about the use of ultra-violet and infra-red spectrums

11.1: Introduction
11.2: Properties of Light
11.3: Alternate Light Source or Forensic Light Source
11.4: Visualization
11.5: True Ultra-Violet
11.6: Scales and rulers
11.7: Infra-Red
11.8: Summary
11.9: Test Questions
11.10: Suggested Essay Topics
11.11: References

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11.1: Introduction

The **Alternate Light Source,** or **Forensic Light Source,** is one of the most important tools in the forensic setting tool chest for the discovery of evidence that cannot be seen by the human eye; however, it is also, unfortunately, a tool that most law enforcement agencies do not seem to think they need. To understand the difference between the two light systems, you must first understand the concept of changing white light into specific bandwidths of light to better visualize latent evidence like bodily fluids, fabrics, or hair.

Visible light is a form of energy that is also known as electromagnetic radiation, the oscillation of electric and magnetic field waves, which is within the portion of the electromagnetic spectrum that can be perceived by the human eye. Light is measured in frequency or wavelengths, as measured in **nanometers**, and can either be visible as white light or invisible, within the infra-red and ultra-violet range.

All light waves have both a wavelength, the distance between the crests of the waves, and a frequency, the number of cycles per second of each wave. The **electromagnetic spectrum** encompasses the entire range of wavelengths and frequencies.

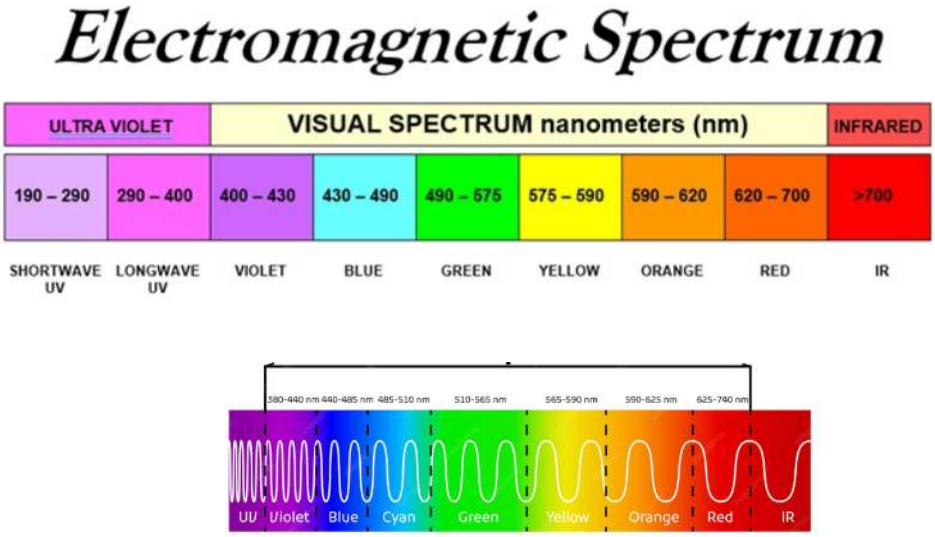


Figure **11.1.1**: Wavelengths of light - Courtesy of Designer Things

Visible or white light, the spectrum of light that we can see, is therefore that spectrum range between **400nm to 700nm**. This light can be either from a **natural source**, such as the sun or the moon, or fire, or an **artificial source**, such as electricity, candles, oil lamps, or the light from your cellular telephone. A rainbow is the perfect example of the wavelengths of light that the human eye can see.

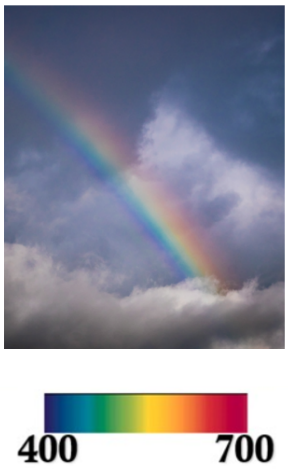


Figure **11.1.2**: Visible white light spectrum as a scale and also as seen in a rainbow - Courtesy of Yulia Gadalina

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11.2: Properties of Light

Light has many important properties including rectilinear propagation, the ability to travel in a straight line; refraction, the ability to bend when passing through glass or water; and most important for our purposes, reflection, when light bounces off a surface; absorption, when light is absorbed by a surface; and conversion, when light fluoresces. Reflected light defines the color of the surface of an object. Remember that light is necessary for photographic documentation. Reflection and absorption combined become an essential aspect of observing and photographing forensic evidence. Combined, they comprise the properties of contrast. Contrast is the visual ratio of light and dark areas of the object being visualized or photographed.

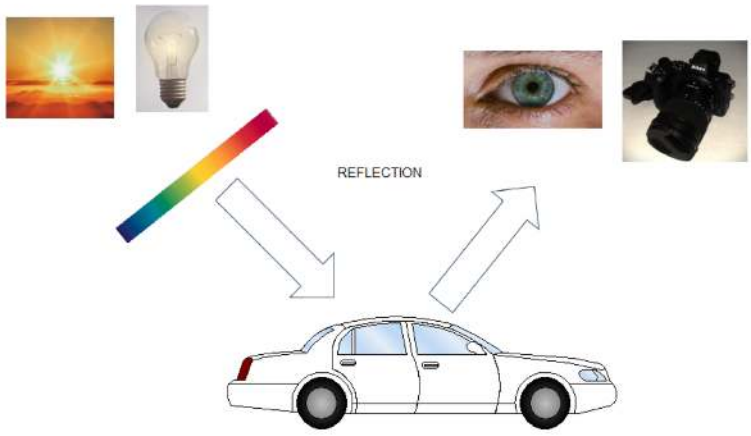


Figure **11.2.1**: Reflection off a white surface . Author's collection

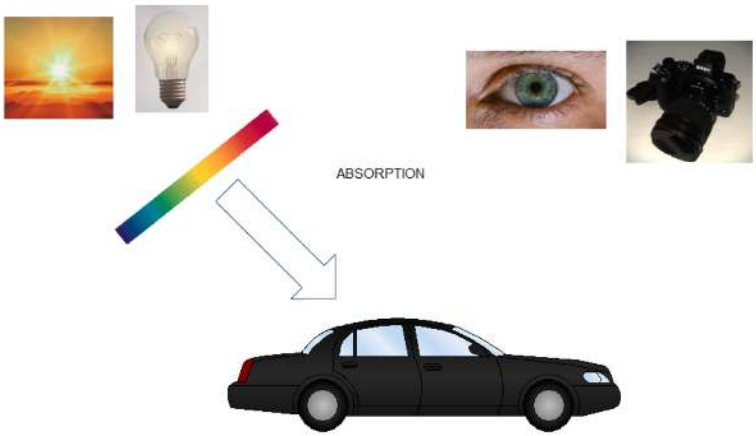


Figure **11.2.2**: A black surface does not reflect light - Author's collection

Contrast can be used in creative photography to enhance the photograph so that it is more appealing to the viewer. High contrast can create a dramatic visual effect by emphasizing the difference between light areas and dark areas. Low contrast can soften the image providing a moody atmosphere for the viewer. Color contrast can be vibrant and alluring to the viewer by using contrasting colors. Contrast in forensic photography is used solely to sharpen the entire image and to ensure the entirety of the image can be viewed apart from its background or surroundings. This is accomplished by correcting, removing, or enhancing lighting or color.



Figure **11.2.3**: Contrast on a developed thumbprint. Author's collection

Adding additional lighting can compensate for the absorption aspect, but this might provide too much light in areas that are reflective. Therefore, it might be necessary to add or subtract light on the same object being photographed, which takes a keen eye, skill, and paying a great deal of attention to detail. As every forensic technician will know, there will be those occasions when the object that you want to clearly visualize or photograph is on a multicolored surface or is being overwhelmed by the color of its background. The answer to this problem is color definition through reflection or subtraction, and monochrome photography.

Your author was tasked by the county prosecutor's office to review forensic evidence from a cold-case homicide that occurred in 2001. Unfortunately, most of the evidence collected from the scene had been damaged or otherwise contaminated and therefore was no longer available for analysis. Fortunately, the crime scene technician had taken care to document everything using 35mm emulsion film. While examining the photographs, your author came across a bloodstained footwear impression that had been deposited on a blanket that had been used to cover the decedent. The blanket had a checkered pattern that was of large dark blue and yellow checks. The problem was that the shoeprint straddled the blue and yellow checks but was mostly in the blue field. The blanket was also likely the source of the contamination that destroyed much of the stored evidence and therefore had been the first thing to be discarded. The technician had taken over 60 photographs of the shoeprint, but none of them were of examination quality because of the overwhelming saturation of the blue background. Your author's immediate thought was, had the technician only placed a blue filter on the lens of the camera and then photographed it with monochrome (black and white) film, the result would have been a proper examination quality image of the impression. The blue filter would eliminate the yellow background and since the impression itself was red, the impression would have had more contrast than the blue background. The contrast would be further enhanced by monochrome photography as it would turn the blue background grey while the bloodstain would remain dark. This can also be done using a forensic light or ALS.

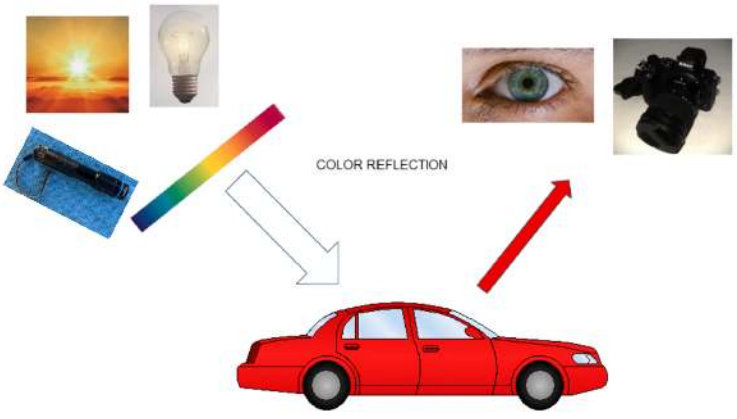


Figure **11.2.4**: Light reflecting from a red object. Author's collection

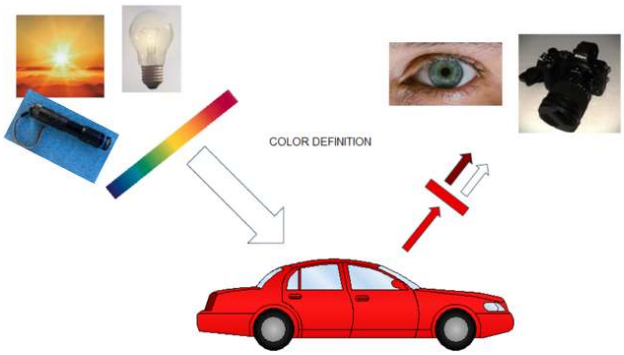


Figure 11.2.5: Color separation using like-colored filters. Author's collection

Take for example the thumbprint on the following photographs developed using black magnetic powders on a red surface. As you can see, the red background overwhelms the developed print. The application of a red filter on the camera lens eliminates the white of the scale and enhances the dark print.



Figure 11.2.6: Thumbprint developed with black powder on a red surface. Author's collection

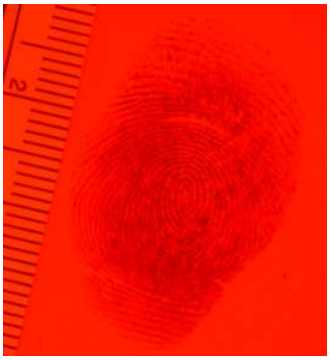


Figure 11.2.7: Developed thumbprint on a red background with a red filter. Author's collection

Photographing the developed thumbprint in monochrome turns the red background grey, which further enhances the dark print.

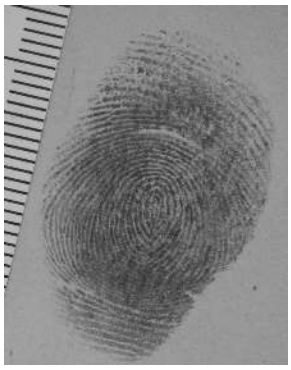


Figure **11.2.8**: The same thumbprint photographed in monochrome.

Using the color filter also allows the technician to ensure the object of the photograph is sharp and in focus instead of relying on the scale for focus.

This technique can also be used on multicolored surfaces. In the photographs below, you will notice that the thumbprint, also developed with black powder, is on a background with green, red, and white. In this case, the majority of the print is on a red background. Therefore, by using a red filter we can eliminate the white and green background and enhance the black print. Photographing the print in monochrome highlights only the print. Notice that the green filter did not enhance the print quite as well as the red filter did.

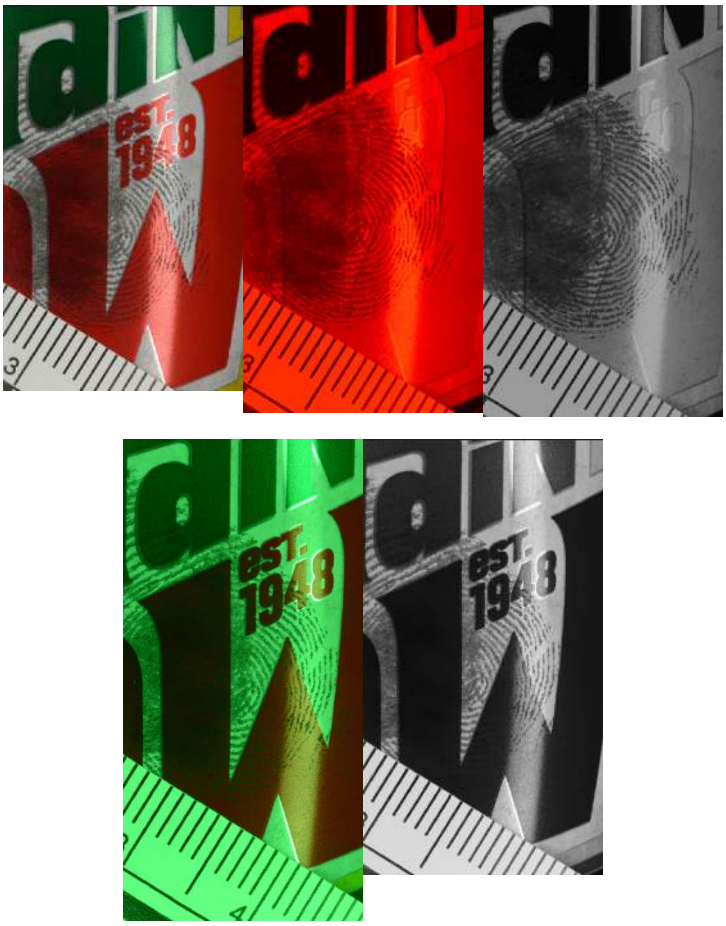


Figure **11.2.9**: A series of photographs demonstrating using red or green filters to remove background colors on the substrate and monochrome photography. Author's collection

It is important for the forensic technician to have color filters for their cameras that cover the visual light spectrum, not only for color subtraction, but to block the excitation light produced by the alternate light spectrum by using the opposite color of the light wavelength being used.



Figure **11.2.10**: Colored lens filters. Author's collection

Your author remembers the color wheel by common associations of color. Traffic light colors are red and green, which happen to be opposing each other not only for the flow of traffic, but also on the color wheel; Madri Gras colors are yellow and purple; and the Denver Broncos wear orange and blue as their team colors. Therefore, if you are using a wavelength in the blue spectrum, you would use an orange filter. If you are using a wavelength in the green spectrum, you would use a red filter. If you are using a wavelength in the violet spectrum, you would use a yellow filter.



Figure **11.2.11**: Opposing colors. Author's collection

Barrier filters for ALS and forensic lights come in the form of colored goggles or plates for the operator, but remember if you are photographing the visualized object, you must have the same color barrier filter on your camera lens as well. It is also important to understand that the Alternate Light Source or forensic light is best used in the dark, and therefore it is important to control the aperture and shutter speed of the camera. You will need a tripod or copy stand for your camera and an off-camera shutter release mechanism. You will need to set your camera to the manual mode on “bulb” setting. This will allow the camera to open the shutter until you decide you have captured enough light to preserve the image. Your aperture should be between f11 and f14, and your ISO should be set no higher than 400.

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11.3: Alternate Light Source or Forensic Light Source

An Alternate Light Source (ALS) narrows the bandwidth of light to a very specific spectrum wavelength. True ALS units tend to be very large, expensive, and are used primarily in the laboratory but are capable of being tuned to a wide range of bandwidths. A forensic light source achieves these results through the use of colored filters or colored LED lights. They do not have the range of bandwidths of the ALS, but they are smaller, less expensive, and can be easily brought into the crime scene. Both forms of light sources will be referenced in this chapter as ALS, although it is important to understand the difference between the two.



Figure 11.3.1: FoxFury brand forensic light. Author's collection

Certain items react better to different light wavelengths. Blood is best visible under 415nm light. Body fluids like sweat, saliva, and semen are best visualized under 455nm to 470nm. Hairs and fibers may be best visualized between 455nm and 485nm. It is important to have a wide range of forensic lights available either in the laboratory or in the crime scene. It is also important that forensic technicians use at least two different types of ALS when examining evidence, as sometimes one light source may be tuned slightly closer to the desired wavelength of light and therefore will detect what the other may not.

The ALS is an unobtrusive method of locating, visualizing, and documenting evidence that might otherwise be overlooked. They are easy to use and convenient to bring into the crime scene. They also will not alter or destroy DNA, with one exception that will be detailed later in this chapter.

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11.4: Visualization

Many stains and chemicals will “fluoresce” using the ALS or forensic light source. So, just because the stain or chemical is emitting light does not necessarily mean you are looking at a biological fluid. With experience, you will recognize what you are looking at. For example, sweat looks like a foamy wave receding from a beach. Saliva looks like sweat only round or oval. Urine is a solid stain (and best visualized with true UV light). Semen looks like a fried egg and will have a distinctive pattern. Phosphates glow brightly, as does bleach.

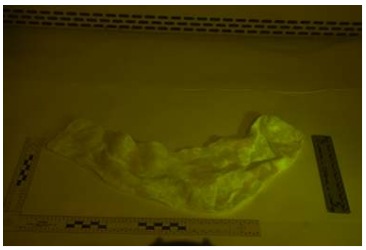


Figure **11.4.1**: Semen on a sock visualized with a forensic light. Author's collection



Figure **11.4.2**: The above sock photographed in monochrome. Author's collection





Figure **11.4.3*a*/*b***: Saliva on a white T-shirt. Author's collection

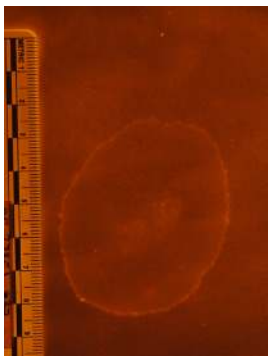


Figure **11.4.4**: Saliva visualized using a forensic light. Author's collection

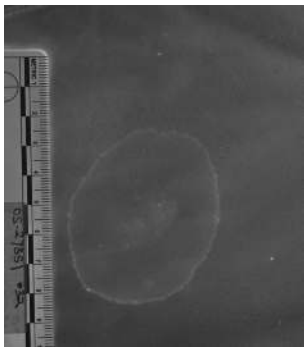


Figure **11.4.5**: The above stain photographed in monochrome. Author's collection

Again, it is important to have knowledge of the appearance of bodily fluids being visualized under ALS. As mentioned, bleach and phosphates will fluoresce under ALS. Therefore, just because you are visualizing a result using ALS, what you might be visualizing is a product used for cleaning.

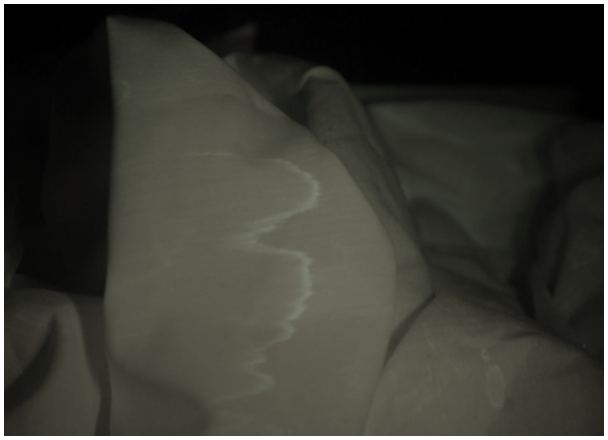


Figure **11.4.6**: Sweat visualized with 425nm ALS with a yellow filter and photographed in monochrome. Note the saliva to the right of the sweat stain. Author's collection

ALS is perfectly matched with fluorescent fingerprint powders, which can be used for other applications besides the development of latent fingerprints. In the following photographs, you will observe a footwear impression deposited on a wood floor. The impression was enhanced using fluorescent orange magnetic powder and observed under 495nm forensic light using an orange barrier filter, followed by monochrome photography.



Figure **11.4.7*a/b/c***: A developed footwear impression on a floor visualized visualized under 495nm and photographed in monochrome. Author's collection

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11.5: True Ultra-Violet

Your author has referenced “true ultra-violet” as opposed to just ultra-violet. True ultra-violet (UV) light is in the color spectrum 10nm to 399nm. Most “UV” lights on the market are in the 400nm to 430nm range, which is technically a violet color spectrum. Also, it is important to note true UV light appear in two wavelengths: short-wave and long-wave. Short-wave UV light is in the 10nm to 290nm range. Short-wave UV light is used in forensics primarily as a means to sterilize equipment and cabinets since this range of UV will destroy DNA after three minutes of exposure (not something you want to do during evidence examination). UV has the benefit that you will not need a barrier filter to visualize or photograph evidence visualized under UV light. Biological fluids will naturally fluoresce; however, most fabrics are treated with UV-blocking agents to keep them from fading in the sun. In this instance, it is best to switch to a visible light spectrum with an appropriate barrier.

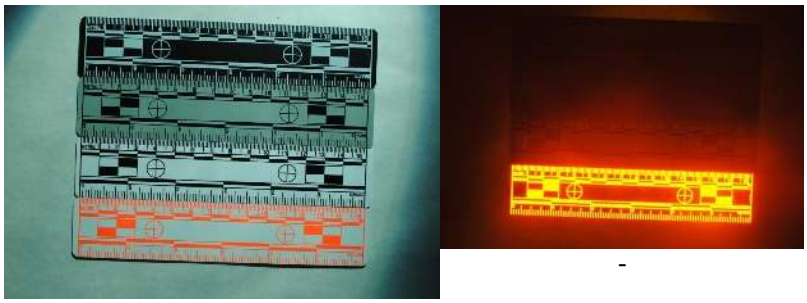


Figure **11.5.1*a/b***: Fibers visualized with pure UV. Fortunately these fibers were not treated with a UV blocking chemical. Author's collection

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11.6: Scales and rulers

It is important to select a scale or ruler that will be visible under the particular wavelength you are using but should not fluoresce over the image you are photographing. It may be necessary to use a very low-powered white light (45 lumens) to “paint” the scale momentarily while the shutter is open. Be careful not to introduce the white light onto the item of evidence.



-

Figure **11.6.1*a*/*b***: Various scales including a fluorescent scale that "bleeds" over the image. Author's collection

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11.7: Infra-Red

Infra-Red

The infra-red (IR) spectrum is very useful to the forensic technician when examining dark colored clothing and fabrics. Infra-red imaging occurs between 700nm and above. You will, however, need a DSLR camera that has been altered to photograph only in the infra-red spectrum (this is done by removing the IR blocker from the camera's sensor). Outdoor imaging and image captures are not a problem as the sun provides plenty of IR light for the camera's sensors. Indoors, however, the technician will need to bring an IR light source as LED, fluorescent, and tungsten lighting do not emit IR.



Figure **11.7.2*a/b/c***: A uniform shirt as visualized by the naked eye and by IR ima

A uniform shirt as visualized by the naked eye and by IR imaging. Author's collectionging. Author's collection

In the above photographs, not only are you better able to visualize the stab defects on the shirt, but your author was also able visualize the saliva of the suspect on the shoulder patch. It should also be noted that by preserving the shirt in waxed butcher paper, your author was also able to recover several hairs that provided a DNA match to the suspect. It is essential to take a context photograph in visible light of the item you are photographing before taking the IR photograph as you will need to explain to the jury the difference between the two images.

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11.8: Summary

In summary, Edmond Locard and Paul Kirk both opined that one of the most critical roles of the forensic technician is the task of locating trace and transfer evidence; some of which is latent to the human eye. Therefore, it is essential for the forensic technician to utilize all the tools that are available to them in their forensic toolbox. Amongst these tools are the magnifying glass, an Alternate Light Source or forensic light source, enhancement chemicals, knowledge of the appearance and identification of the developed or enhanced evidence, and the ability to document the evidence in a manner suitable for the presentation of that visualized evidence in courtroom proceedings. One benefit of the ALS is that it can, when following agency protocols, be used without concern for interference with subsequent DNA typing, providing you are careful when using short-wave ultra-violet light. Therefore, it is advisable that the ALS is used for the visualization of garments or footwear for bloodstain evidence, especially using the 415nm wavelength, before the application of chemiluminescent products.

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11.9: Test Questions

1. Light is measured in frequency or wavelengths, as measured in:

a. micrometers

b. nanometers

c. gigameters

d. millimeters

2. The ability of light to bend when passing through glass or water is called:

a. reflection

b. absorption

c. refraction

d. contrast

3. Light bounced off a surface is called:

a. reflection

b. absorption

c. refraction

d. contrast

4. In forensic photography, this is used solely to sharpen the entire image and to ensure the entirety of the image can be viewed apart from its background or surroundings:

a. reflection

b. absorption

c. refraction

d. contrast

5. This photographic technique allows the forensic technician to remove overwhelming color backgrounds in order to better visualize developed or enhanced evidence:

a. color separation

b. color enhancement

c. color subtraction

d. color elimination

6. Bloodstains are best visualized under this wavelength:

a. 395nm

b. 450nm

c. 500nm

d. 415nm

7. Fluorescent scales are not recommended in photography using ALS because:

a. The scale may “bleed” over onto the item of evidence being photographed

b. The color contrast of the scale may overwhelm the item of evidence being photographed

c. Fluorescent scales cannot be properly photographed using painting with light

d. The camera cannot properly color-balance the scale and the item of evidence

8. This spectrum of light is best used to visualize gunshot residue and bloodstains on dark clothing:
    1. Short-wave ultra-violet
    2. Long-wave ultra-violet
    3. White light
    4. Infra-red
9. This range of the electromagnetic spectrum is considered visible light to the human eye:
    1. 190nm-430nm
    2. 290nm-590nm
    3. 400nm-700nm
    4. 10nm-230nm
10. When using ALS in the 430nm-490nm range, what color barrier filter should be used?
    1. Red
    2. Green
    3. Yellow
    4. Orange

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11.10: Suggested Essay Topics

1. Research the history of the development of Alternate Light Source and its earliest applications to the discovery of trace and transfer evidence.
2. Write an essay explaining the benefits and drawbacks of using short-wave ultra-violet light with long-wave ultra-violet light with notable examples.
3. Research a high-profile homicide investigation wherein the application of ALS or forensic light source was crucial to the detection of trace and transfer evidence.
4. Write an essay regarding Locard's Principle of Evidence Exchange and how the application of ALS or forensic light source as it pertains to this principle.
5. Write an essay regarding the use of ALS in sexual assault investigations. Include in the essay the various wavelen

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11.11: References

Doglietto, D. (2025). *Crime Scene Processing in Correctional Facilities and Prisons*. CRC Press, Taylor & Francis Group.

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CHAPTER OVERVIEW

12: Impression Evidence



Figure 12: Archival photograph of an impression evidence technician. Courtesy of the Federal Bureau of Identification

Learning Objectives

- To understand the difference between class and individual characteristics
- To understand the importance of preserving footwear impressions in the crime scene
- To understand the documentation of footwear impression evidence in the crime scene
- To learn about the construction and terminology of footwear
- To understand the importance of tire tread impressions in the crime scene
- To learn how to do serial number restoration
- To learn about fracture matching as a means of individualization
- To learn about the role of the forensic firearm examiner
- To understand ballistics as a form of impression evidence comparison

12.1: Introduction
12.2: Footprints
12.3: Footwear impressions
12.4: Documenting and preserving footwear impressions
12.5: Tire tread impressions
12.6: Serial number restoration
12.7: Striated evidence
12.8: Ballistics
12.9: Test Questions
12.10: Suggested Essay Topics
12.11: References

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12.1: Introduction

Your author likes to refer to impression evidence as evidence that is the most ignored or overlooked evidence in the crime scene for the simple fact that it takes a trained eye to observe, and preserve, impression evidence before it is destroyed. Regrettably, the average patrol officer, firefighter, or emergency medical technician either lacks sufficient training, or has other priorities, to appreciate the importance of impression evidence to solving the crime. Impression evidence is the evidence in the scene that can link a suspect, or the tool the suspect used, with the crime scene. Impression evidence can be found in the form of footwear impressions, tire tread impressions, tool marks, ballistics, bite marks, as well as foot, hand, and fingerprint impressions.

As mentioned in previous chapters, impression evidence is designated either as having class characteristics or individual characteristics. Class characteristics are common to anything that is manufactured using mass-production. One pair of tennis shoes made by the same manufacturer using molds and production techniques that produce identical tennis shoes with the same material, patterns, size, and shape, will have characteristics that are common with the next pair of tennis shoes that come off the assembly line. Once the tennis shoes are purchased and worn, irregular imperfections resulting from wear, use or misuse, and damage will provide characteristics that are unique or individual to that pair of shoes. When a hard object is impressed or forced into a softer surface, the resulting impression may demonstrate the class and individual characteristics of the hard object. Shoes and vehicle tire tread impressions will provide size and pattern information as a class characteristic, as well as the wear, damage, or imperfections and defects caused by normal or unusual usage. Molded or plastic fingerprint impressions left in a soft material such as a candle, mud, or other soft medium like clay, will provide a mirrored image of the ridges, furrows, and minutiae that is unique to the individual who deposited them. Tools such as chisels, screwdrivers, saw blades, bolt cutters, knife blades, and hammers will leave the same class and individual characteristics when forced against softer materials in the form of compressed, scraped, or striated evidence. These marks can be matched to the tool which made them. Although the DNA collected from a bite mark may be of more use to identifying the individual who did the biting, some bitemarks left on skin or food items can be matched to available dental records by a skilled forensic odontologist. Most modern firearms are manufactured using steel alloys for those portions of the weapon that are designed to withstand the extreme pressures resulting from the discharge of a cased cartridge using modern propellants. Brass and aluminum cartridge casings are softer than the metal breech, breech face, or cylinder of the firearm. When discharged, the casing expands within the breech, inner cylinder wall, and against the breech face. Small imperfections in the metal surfaces of these pressure chambers will be imprinted into the sides and back (headstamp) of the casing. As the casing is extracted from the breech or cylinder, the same imperfections will drag or scratch across the casings. The firing pin is also much harder than the soft primer cap on centerfire cartridges or along the edge of rimfire cartridges, thus leaving a distinct impression of the firing pin as well as the mark of the side of the firing pin as it is retracting into its housing. This impressed or striated information that has been transferred to the shell casing can be compared to casings fired from a firearm to determine if there is a common link. Bullets fired through rifled barrels will similarly have individual characteristics that can be matched to one firearm.

Now that we have established a basic understanding of impression evidence, let us take a deeper look at each discipline excluding, of course, skin-print impressions that have already been addressed in previous chapters.

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12.2: Footprints

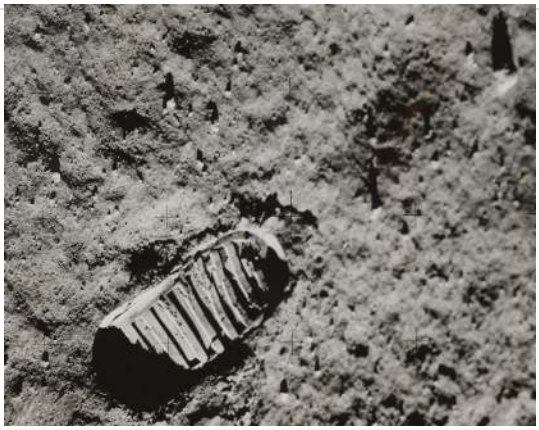


Figure **12.2.1**: Buzz Aldrin's footwear impression on the moon is very likely still there!

Footwear analysis is an interesting discipline of the forensic sciences. Valuable information is often obtainable from the analysis of footwear impressions left in a crime scene. Footwear impressions can provide class characteristics (brand, outsole pattern, and size) as well as individual characteristics if the impression contains good detail and clarity. Unfortunately, footwear impressions are generally the first item of evidence destroyed by responding officers and emergency medical personnel. That is why it is essential for the forensic technician to get to the scene as quickly as possible.

We can separate footwear analysis into three groups:

- Gait analysis
- Footwear impressions analysis
- Analysis of footwear



Figure **12.2.2**: The stride is the linear distance from the heel-strike of the same foot.

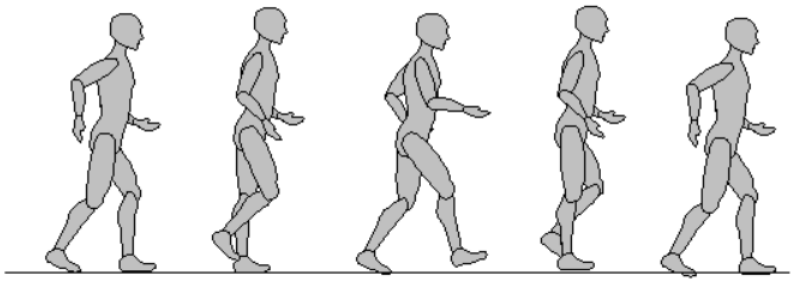


Figure **12.2.3**: The stride

When measuring the gait of an individual the stride is the linear distance from the heel-strike of the same foot. The step is the distance between successive points of foot-to-foot contact of alternate feet. In normal walking, the distance between heel strikes of

each opposing foot is a step and that of the same foot, a stride. The angle formed between each foot and the line of progression is the angle of gait. This type of information can be useful at the crime scene to assist in proving direction and participation of an individual, and may, with the appropriate analysis, provide information independently establishing the identity of the suspect.

> *'Where pathological changes occur in the foot and lower limb, obvious changes in step, stride, angle of gait can occur. Forensic podiatrists can interpret such changes, which can have value in the forensic interpretation of sequences of footprints and in observing any deliberate attempts to alter gait during the collection of suspect footprints.' (Wesley Vernon, 1998)*

Podiatry is a clinical profession with a focus on the foot and its disorders. Forensic Podiatry is the development and application of sound podiatric knowledge in a forensic context.

The potential areas of use include:

- Identification from podiatry records
- Biomechanical assessment of gait
- Barefoot pattern interpretation and analysis
- Footwear interpretation and analysis

Furthermore, footwear impressions can assist the analyst in determining the participation of suspects, witnesses, and victims; including the direction of travel and the speed (walking or running) they entered or exited. In our walking process, the deepest impressions will usually be at the toe and heel ends, with a slight elevation near the arch of the foot. In the running process, the action is usually in the toe area, with the toes digging in, followed by a backward kick; the heel is not usually as pronounced as the toes. A person walking in a backwards motion will have their strides shorter than in normal walking. Toes dig in as in running, but heel points will be more distinct than those found in running. The short steps occur from the structure of the leg muscles and an uncertainty as to just where the foot is being placed. An individual's gait pattern is relative to that person's physical qualities.

Your author investigated a crime scene that was in a dirt area between a building and railroad tracks. The deceased victim remained in the crime scene with a gunshot wound to the chest and another to the head. Your author detected two sets of footwear impressions that indicated two persons entered the dirt area walking side-by-side at first, followed by two sets of footwear impressions reflecting one person was being chased by the other. Finally, both footwear impressions doubled back to the area where the decedent lie that indicated a short scuffle ensued before the victim was shot in the chest. He was shot in the head after he fell to the ground. One set of footwear impressions indicated the direction of egress by the suspect. Since the victim was still wearing his shoes, it was easy to determine who was being chased by whom.

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12.3: Footwear impressions

As previously mentioned, a footwear impression is very useful to any criminal investigation. To understand footwear impressions, it is first necessary to understand how shoes are made and the nomenclature that is given to the manufacturing of shoes.

Modern athletic shoes are divided into three basic components:

- The upper
- The mid-sole
- The outsole



Figure 12.3.1: Tennis shoes. Courtesy of PN

The Upper

The upper may be constructed from leather, synthetic leather, suede, mesh, polyester, nylon, or a lightweight high-performance textile called Flyknit. The upper holds the foot securely over the midsole platform while providing flexibility and support.

The Midsole

The midsole platform gives the foot a stable cushion. The midsole can be made with lightweight foam called ethylene-vinyl acetate foam (EVA), pylon, or polyurethane.

The Outsole

The outsole is the bottom of the shoe. It provides durability and traction on a surface. The outsole can be made with a solid durable rubber compound, a carbon rubber compound, a blown rubber compound, a durable rubber material that contains 10% recycled rubber, or ethylene-vinyl acetate foam.

Outsole manufacturing processes

- Die cutting process
- Outsole cutting process
- Injection mold process
- Open pour mold process
- Ethel vinyl acetate

The modern outsole manufacturing processes the forensic technician will most likely encounter are the die cutting, open pour mold, and ethel vinyl acetate processes.

The die cutting process has been around since the 1940's and remains popular in Nike Cortez™ tennis shoes. Like a cookie cutter, the die is pressed onto a sheet of pre-formed rubber, and a design is "cut" for the outsole. Where this process is unique is in the way

the cutter hits the sheet of rubber in a different a location each time; therefore, the “chevrons” of the pattern are never the same length.



Figure **12.3.2**: Nike Cortez™ outsole - Courtesy of Sole Retriever

The open mold process is used by companies like Vibram™ (Quabaug) to produce outsoles for work and hiking boots. The outsole is poured, hardened, and then glued or nailed to the mid-sole.



Figure **12.3.3**: Vibram outsole - Courtesy Samuel Hubbard



Figure **12.3.4**: EVA lumps to be pressed into sandals. Courtesy of @ffactsyoudonotknow

Although EVA is the most common method of outsole manufacturing, the calendar press mold process can still be found in some countries and in boutique or handcrafted footwear manufacturers. The calendar press mold process involved rolling sheets of warm

rubber is fed through a series of heated rollers that press the rubber into a thin, uniform, and durable sheet of rubber from which the patterned outsoles are cut. The outsoles are then glued onto the midsoles of the shoe.

Other Shoe Terminology

Below is a pictorial list of other useful shoe terminologies:



Figure **12.3.5**: The upper. Author's collection



Figure **12.3.6**: The midsole. Author's collection

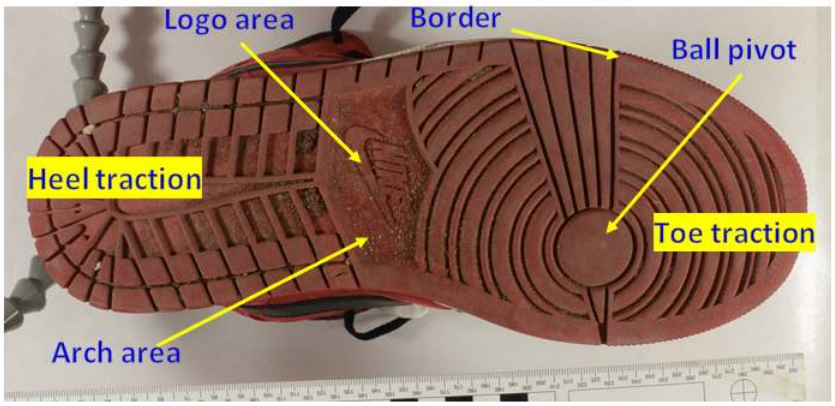


Figure **12.3.7**: Shoe terminology. Author's collection

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12.4: Documenting and preserving footwear impressions

The impression should be documented in two ways: photography and casting. Footwear impressions are not difficult to document and collect, providing you follow a systematic method. The equipment that you will need to document the impression will include: a camera; a flash that can be operated off the camera (either wireless or slaved); a shutter release cable; a tripod that will allow the camera to be suspended upside-down; a level and an L-scale. Your author uses the standard vinyl reversible macro-photography L-scale (300mm x 150mm), but he also glues a golf-ball marker to the face of the scale to assist the analyst in determining the direction of artificial and natural light. Using the flash to add light between near-oblique and 45 degrees can add contrast and depth to the furrows left by footwear that are molded (such as those left in mud, sand or soft dirt); thereby providing an image that has more definition and detail. However, the analyst may need to know if the detail is an individual characteristic made by the shoe or a shadow caused by the addition of the electronic flash. The shadow cast by the golf ball marker allows the analyst to make this determination.



Figure **12.4.1**: The L-scale ruler

Note in figure **12.4.1** that the scale has a small circle embossed on its face. This circle is useful to the analyst in determining if the photograph was taken with the film plane parallel and perpendicular to the object. Any deviation would result in an oblong image. That is also why it is important to use a level to make the final adjustments to your camera prior to taking the photographs.



Figure **12.4.2**: DSLR camera supported underneath the tripod

The first step is to set your camera on the tripod with the center column inverted. Many agencies utilize tripods with extended booms or multi-position center columns that project over the image being photographed. These tripods are terrific and extremely useful in the crime scene but beware of balance issues; a slight bump of the tripod might send your camera head-first into your evidence. Note that your author does not put the flash on the camera until it has been properly focused and leveled. Your author uses the flash on an off-camera cord as there is nothing worse than having it fall into the impression while making adjustments to the camera or tripod. Your author also attaches the off-camera shutter release wire before he puts the camera on the tripod; and he generally uses a clamp to hold that device from falling into the impression as well.



Figure **12.4.3**: Checking the level

Your author also checks the level of the camera twice: once before he focuses the camera and again following the focusing of the camera and the addition of the flash. Also, make sure the camera is on the same plane as the bottom of the impression.

The step that is often forgotten when teaching this technique is to furrow a trench in an L-shape far enough away from the impression as not to damage it or any physical evidence that might be present, yet close enough that the scale will be captured in the frame.



Figure **12.4.4**: Do not forget the trough for the scale.



Figure **12.4.5**: The scale

The reason for this trough is to allow the scale to be photographed at the same plane as the impression. This accomplishes two purposes: it ensures that the scale and the impression will both be in focus and it corrects distortions caused by the scale not being on the same plane as the object (parallax error).



Figure 12.4.6a/b: Oblique lighting with the flash

While holding the flash at between oblique and 45-degree angles, take the photographs of the impression, firing the flash between the openings of the legs on each side of the tripod. The flash should be held between 3' and 5' from the impression. Once you have accomplished this, take a photograph without the flash, if ambient lighting permits (or if you can make manual adjustments to the camera such as bracketing, adjusting the f-stop, or increasing the film speed).



Figure 12.4.7a/b: One for good measure without the flash.

Once the photographs have been taken, a casting of the impression can made using one of the casting materials commonly available from the forensic supply companies (such as Sirchie's Shake-N-Cast™, Lynn Peavey's Copy Cast™, or Arrowhead Forensics' Arrowstone™, amongst others). The process of casting the impression is simple; just follow the instructions provided with the casting medium, mix the compound to the consistency of pancake batter, gently pour it into the impression and allow it to dry. You may also use an alternate method whereby you pour water into the impression and then sift in the casting compound until it thickens if there are concerns that pouring in the mixture will alter the impression. You may have to use or construct a frame that will hold the compound until it dries. Your author will take subsequent evidentiary photographs of the casting in the laboratory once it is dry enough to package as evidence. The best method of packaging the casting into evidence that your author has found is to place the casting on a piece of cardboard that will fit the dimensions of a box the size of a shoe box. He then uses electrician's plastic wire ties to firmly affix the casting to the cardboard and then gently lowers it into the box.



Figure **12.4.8**: 1930's detectives only had plaster of Paris available to them, which is not used today owing to the short shelf-life of the plaster (it turns to dust after a few decades). Today we use dental stone as a permanent method of casting. – Courtesy of the Federal Bureau of Investigations Archives

Molded impressions, or those that are 3-dimensional, are most common to outdoor crime scenes, as are 2-dimensional bloodstained or dust impressions left on concrete; however, bloodstained footwear or impressions that are the product of a suspect stepping in a liquid or powder and transferring it onto the floor can be found in indoor crime scenes. Bloodstained impressions are documented using the same equipment as the molded impressions, only without using the flash to introduce oblique lighting as the flash may cause a 'hot spot' or 'burned' area that might obscure the details. Dust impressions may require the application of a forensic white light at an oblique angle to aid in visualization. This application is best done with a forensic light as opposed to a flash. The technique for capturing the image of a dust impression still requires the use of a tripod.

Dark prints left in dust or dried bloodstained footwear impressions can be lifted using casting material. It is important to make a frame around the impression using duct tape and then pour the casting material directly over the impression, making sure that the casting material is of the consistency of pancake batter. Allow the casting to dry thoroughly and use a putty knife to gently pry the duct tape away from surface, lifting the entire casting like a hinge. Remember that the recovered impression will be a mirrored image of the original. Also keep in mind that these castings are extremely thin and fragile. It is best to photograph them as quickly as possible and to firmly mount them in a covered box. The investigator should also consider using blood reagents, such as Coomasie Blue, Amido Black or Leuco-crystal Violet (LCV), to enhance bloodstained foot or footwear impressions prior to the application of the above listed documentation and lifting techniques.



Figure **12.4.9*a/b/c***: Thin casting a dust print

Footwear impressions deposited on carpeting may also be challenging to the investigator to document and collect and may take some creative solutions through trial and error.



Figure **12.4.10**: This impression was deposited on a dark gray carpet in a classroom. The medium appeared to be chalk dust. Using a tripod, your author set the camera at f/13, while bouncing the flash off of a nearby white wall. This provided the best image. Lifting this impression proved equally difficult, with the best result coming from the PathFinder™ electrostatic dust lifter.

This impression was deposited on a dark gray carpet in a classroom. The medium appeared to be chalk dust. Using a tripod, your author set the camera at f/13, while bouncing the flash off of a nearby white wall. This provided the best image. Lifting this impression proved equally difficult, with the best result coming from the PathFinder™ electrostatic dust lifter.

Exemplar footwear impressions should be collected from first responders, medical and fire personnel and the investigative staff on scene. Fortunately, there is no need to collect the shoes or even photograph them as there are several inkless shoe print documentation kits available on the market, such as Lynn Peavey's Inkless Shoe Print™ kit, which produce quality impressions that can be stored for extended periods of time. It is an easy process that requires the wearer to simply step upon the invisible inking pad and then place their foot on the special paper for the impressions. BioFoam is another great product for collecting exemplar impressions.

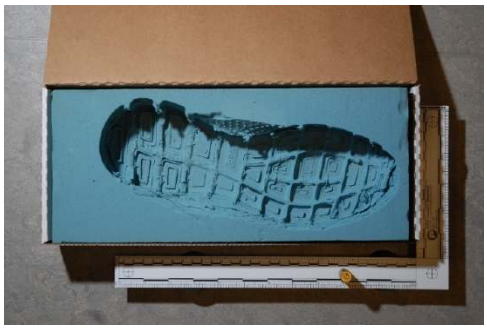


Figure **12.4.11**: BioFoam

Footwear that is collected at the crime scene should be stored as evidence in a box of a size consistent with the original shoe box in which they were purchased. Never place shoes in an evidence box with the soles facing or touching each other. Your author generally wraps evidence shoes loosely in butcher paper and place them individually into boxes, preferring not to store shoes in paper bags. Socks may be stored in paper bags but be certain to record the foot from which the sock was removed. Your author has seen more than one officer wish they had done just that when being questioned on the stand. Agency protocols should prohibit an officer or crime scene technician from writing anything on the sock, especially if the sock is to be submitted for DNA analysis. If it is necessary to mark the sock for identification in court, your author recommends that the officer complete an evidence tag and then use a piece of clean string to tie the tag to the sock, then fold the sock into butcher paper and place the tag on the outside of the butcher paper wrapper. Then place the butcher-paper wrapped sock into an evidence bag.

Shoe analysis

When a shoe suspected of being worn by the suspect of a crime is processed into evidence for forensic analysis, there are certain steps that must be followed in order to properly preserve the evidence. Your author always analyzes each shoe separately. He photographs the shoe upper and midsole and collects DNA-typing swabs from the interior and inner-sole (this is done in the likely hood the suspect will say someone else was wearing their shoes). He then removes the inner sole and examines it using alternate light source and infra-red to determine if one or more wear (foot) impressions are present. If necessary, your author will conduct several experiments for the presence of blood or gunshot residue on the upper, mid-sole, and outsole. If sufficient dirt is built up on the outsole, your author will carefully collect as much as possible for soil comparison with soil found in the crime scene. Following

this, the outsole pattern is carefully documented by photography with a scale for comparative purposes. The shoe is returned to evidence, and the work area is cleaned and sterilized prior to processing the mate to the previously processed shoe.

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12.5: Tire tread impressions

Tire tread impression analysis is conducted much in the same manner of footwear impression analysis and with footwear impression evidence, it too can be destroyed by the careless arrival of the first officers, fire or medical personnel on the scene.

Tread design, noise treatment, and tread-wear bars are all manufactured class characteristics that can identify the type, brand, and even model of tire leaving the impression. However, once the tire is sold, the individual history of the tire becomes unique and therefore offers the examiner individual characteristics. Every rock, metal object, or other debris driven over will leave a unique and distinct gouge or defect in the tire; as too alignment, heavy braking, and other driving habits will affect the wear of the tire. Furthermore, over inflation or under inflation of the tire can leave a distinctive tread impression behind. If a forensic technician is capable of noting the under or over inflation of one tire of four impressions, think how effective that is when the vehicle is found, and the very tire predicted by the technician to be improperly inflated is discovered.

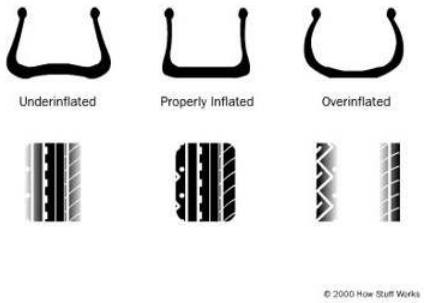


Figure **12.5.1**: Tire inflation and resulting impressions. Courtesy How Stuff Works

Documenting the tire tread impression is done in the same manner as footwear impressions; however, owing to the length of the tread impressions, it is important to overlap the photographs by about 1'. Collecting tire tread impressions is done with the same casting material used for footwear impression recovery. Collecting the exemplar sample of the tire tread can be done using ink transfer products available from forensic supply companies or using a lubricant spray like WD-40, which loosens road grime from the tread, and rolling the tires on clean white butcher’s paper. It is sometimes necessary to document tire tread impressions on skin. This is best done using photography (do not forget to include the scale).



Figure **12.5.2**: TreadPrint™ ink transfer product



Figure **12.5.3**:Tire tread and boot heel impression at a homicide scene. - Courtesy of the author

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12.6: Serial number restoration

Serial number restoration is, aside from being a fun thing to do, a form of impression evidence recovery. When a number is stamped into plastics or metals, the molecules are compressed at a different rate than the surrounding area. Therefore, when the number is obliterated, it is possible to recover the number by using acids that slowly dissolve the uncompressed molecules surrounding the compressed molecules and thus revealing the number. The trick is to be very careful how you file smooth the obliterated area. This must be done by hand using an Emory board and extra-fine sandpaper. Do not use a drill-mounted wire brush or Dremel tool as this will excite the molecules in the compressed area and the process will not work. Once the compressed area is glass-like smooth, build a dam using molding putty around the compressed area and apply the acid that is specific to plastics, aluminum, steel, or copper. Patiently allow the acid to reveal the number (it may take several applications) and then neutralize the area using a pH neutralizing agent like baking soda. Photograph the resulting recovery quickly as the acids may continue their work regardless of the neutralizing agent.



Figure **12.6.1*a/b***: Recovered serial number on the number plate of a Glock pistol – Author's collection

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12.7: Striated evidence

Striated evidence occurs when a hard object comes in contact with a softer material. This is most commonly found in residential, agricultural, and commercial burglaries, but can also be found at homicide or sexual assault scenes where the suspect gained entry to an area by forcibly breeching a door or window. Although ballistic evidence is, in fact, striated evidence, for the moment we will primarily focus on tool mark evidence. A tool mark is any impression, cut, gouge or abrasion left on an object that is softer than the object, tool that caused the marks.

Tool marks impressions are divided into three categories:

- Compression tool marks
- Cutting tool marks
- Sliding tool marks
- Saw and drill marks

Just as in footwear and tire tread impression evidence, all tools are manufactured through a variety of means, all of which create class characteristics. Once the tools are employed, however, their individual history results in unique individualistic characteristics through accidental variations on the edges and surfaces of the tool from use.

Compression tool marks

Compression tool marks are the most common marks encountered in the crime scene and are typically the type of evidence that will be found at a burglary scene. When a tool is pressed into a softer material, it will leave an impression that usually contains a clearly identifiable outline of the tool, such as a screwdriver, pry-bar, hammer, etc.

Cutting tool marks

Cutting tool marks are usually found on chains, hasps, locks, or chain link fences and are created by tools such as a pair of bolt cutters, hacksaws, etc.



Figure 12.7.1: A cut padlock

As the tool cuts the softer metal, it transfers marks and striations from the harder cutting surface to the softer surface of the item being cut. Those marks and striations can be macroscopically examined and documented, which can then be compared to the tool when recovered.

Sliding tool marks

Sliding tool marks are created when the surface of a tool slides along the surface of a softer material leaving patterns of parallel striations.



Figure 12.7.2a/b: Casting the tool to be compared with the casting from the impression.

Photograph the impression, cast it, and if possible, collect the item. Trace evidence may be located on the tool, if it can be found, and may provide a link to the impression area (i.e. paint chips, metal fragments, etc.). Never fit the tool back into the found tool marks! After the suspect tool has been checked for trace evidence, the tool mark examiner will make several comparison impressions that will be microscopically compared with the tool and the impression evidence submitted from the crime scene.

Drill and Saw Marks

When a drill or saw are used to bore or cut through a softer material, the resulting marks can identify the tool that was used by the distinctive impression that is left behind. Saw marks can reveal the pattern or number of teeth per unit length of the blade and may also provide identifying features of worn or missing teeth on the blade. The drill can provide information regarding the spiral "rifling" within the bore of the hole and may also exhibit the characteristics of the tip of the drill bit. Metal shavings from the saw or drill can also provide information as to their metallic construction, which can be matched to the blade or bit that created the cut or hole.

Fracture matching

Fracture matching or mechanical fit is a unique form of evidence. It is also a method of individualization. An item can be associated with a specific source based on the unique way the pieces fit together. The match of unique damage of an object makes it identifiable to the exclusion of all others.

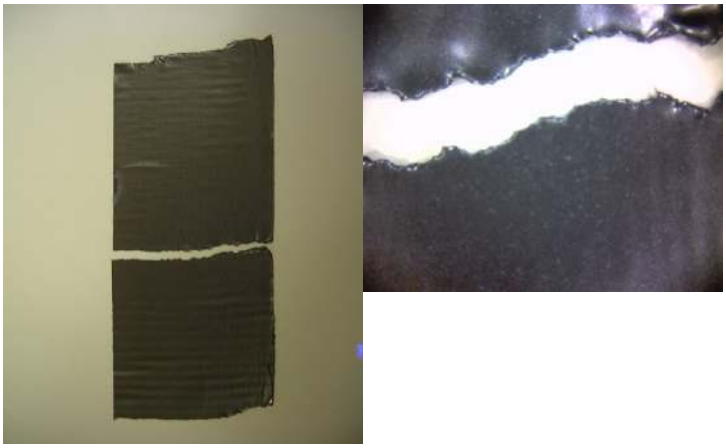


Figure 12.7.3a/b: By example, a roll of duct tape found in the trunk of the suspect's car may be fracture matched to the end of a piece of duct tape removed from the victim of a homicide.

Fracture matching, or mechanical fit, is also a useful tool for the forensic technician in cases of automotive accidents where the vehicle has left the scene. A close examination of the accident scene will generally result in the discovery of an ejected piece of the vehicle. That piece can later be fracture matched to its original source.



Figure **12.7.4*a***: A piece of automotive grill left at a hit and run scene.



Figure **12.7.4*b***: A perfect fit! Mechanical fit of item left in the scene.

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12.8: Ballistics

Obviously, the study of ballistics can encompass not only its own chapter, but also its own book. The forensic science of ballistics is broken down into three fields of study: external ballistics, internal ballistics, and terminal ballistics. External ballistics is the playground of the crime scene analyst who will consider the flight path of the bullet once it has left the firearm by examining the defects created by the bullets as they encounter an object or the ground. Although some forensic experts prefer to place fired cartridge casing cluster patterns within the realm of the internal ballistics' expert, your author disagrees and will leave them in the safe hands of the crime scene experts. Internal ballistics is the main focus of the forensic firearms examiner, whose main concern is the study of the firearm itself, which also includes its functioning, chambering, extraction and ejection of fired cartridge casings, gunshot residue deposition, and other related aspects to the mechanical operation of a firearm. Terminal ballistics is best left to the medical examiner or forensic pathologist, as it is the study of the effect of the bullet after it has struck a human target, including the path of the bullet through the body and the impact of the bullet on organs and tissue as it travelled through the body.

For the sake of brevity, we will examine some of the aspects of internal ballistics. The forensic examiner will receive the firearm as an item of evidence. Their goal will be to first check the condition of the weapon to see if it was capable of discharging a cartridge, as well as its ability to return the weapon to battery for subsequent firing. Following this, they will examine the weapon for a variety of class and individual characteristics that will facilitate interrelation and identification of bullets and casings recovered from the crime scene, or to exclude them from consideration. Sometimes this is relatively easy to do. By example, if the recovered firearm is chambered in 9mm Luger (9mm x19mm) and the fired cartridge casings and bullets recovered from the crime scene are consistent with a .45 caliber firearm, then the exclusion is obvious. However, if the casings and bullets are in agreement with the caliber of the weapon, the examiner must now consider the similarities in the information impressed upon these softer materials by the hardened surfaces of the weapon. In order to do this, the examiner must consider the following individual characteristics created by barrel rifling and striated action marks, which include chamber marks, firing pin impact and drag marks, extractor marks, and ejection marks.

First, for the very basics. When a cartridge, a brass or aluminum casing containing an explosive propellant, primer, and seated with a bullet, is discharged, the casing expands within the chamber and is pushed against the hard surface of the breech face. This occurs in revolvers, auto-loaders, derringers, or any other weapon that would accommodate a center or rim fired cartridge. Defects from wear or manufacturing imperfections found within the breech, chamber, or on the breech face, will be transferred onto the softer metal of the cartridge casing. In auto-loading weapons, the fired cartridge casing is pulled from the breech by an extractor arm during the action of the sliding mechanism and cleared from the receiver in order to facilitate the loading of a subsequent cartridge. Rifling lands and grooves within the barrel of the weapon (excluding smooth-bore weapons) will transfer to the softer metal of the bullet as it is propelled down the barrel. We will start with the bullet.

Barrel rifling

Excluding shotguns and muskets, modern firearms have grooves cut into the interior of the barrel to assist the projectile to maintain a straight path once it exits the barrel by adding spin that creates stabilization of the bullet. These grooves are called rifling and appear as raised ridges called 'lands' and furrows called 'grooves'. The direction of the lands and grooves are referred to as the barrel's 'twist', whether clockwise or counterclockwise. As mentioned, wear, scratches from repeated cleaning using wire brushes, or manufacturing imperfections will be impressed upon the bullet as it travels the length of the barrel. An exemplar bullet fired by the examiner from the weapon can then be matched to a bullet recovered from the scene or body using a comparison microscope or by using 3-D imaging software instrument.

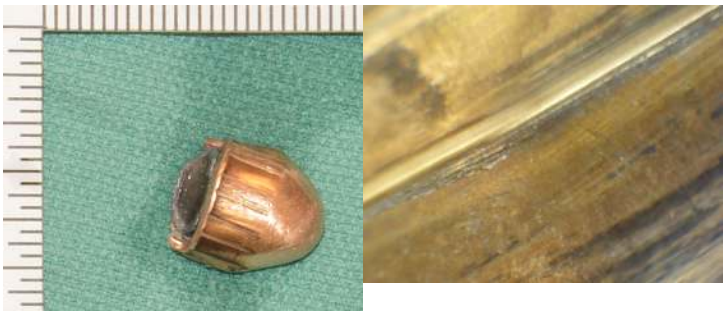


Figure **12.8.1*a/b***: Left: a bullet recovered at autopsy. Right: a comparison of a bullet with an exemplar bullet using a comparison microscope.

STRIATION ACTION MARKS

Chamber Marks

Chamber marks are likely the most common form of striation found on fired cartridge casings. The roughened inner chamber of a firearm can scratch the outer walls of a cartridge case when loaded and removed from the chamber. Although most chamber marks occur when the cartridge is fired, owing to the expansion of the casing within the chamber, some marks can also occur when an auto-loading firearm is placed in and out of battery without firing, or from a cartridge being manually inserted into a cartridge. When the cartridge or fired cartridge casing is pulled out of the chamber, whether manually or mechanically, the sides of the cartridge casing can be scratched by the inner chamber of the firearm.



Figure **12.8.2**: Chamber marks from the manual extraction of a cartridge from an out-of-battery breech. Note the long scratch right of center.

Shear Marks and Firing Pin Drag Marks

The headstamp of the cartridge is the primer end. The space around the primer on a centerfire cartridge provides information regarding manufacturing and caliber. As the cartridge is discharged, the headstamp will be forced against the face of the breech of the weapon. In auto-loading firearms, this will force the softer metal of the primer against the firing pin hole, thus leaving an impression of the firing pin hole on the headstamp. In pre-Generation five Glock auto-loading pistols, the barrel will drop slightly during recoil as the action opens. This action forces the cartridge case to move slightly downward resulting in a scratching movement across the primer face and the lower edge of the imbedded primer to also shear downward and outward from the firing pin hole.

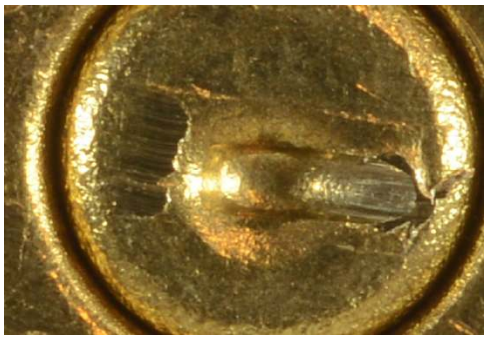


Figure **12.8.3**: Shear marks to the left of the firing pin mark and the tell-tale rectangular firing pin mark on a cartridge fired by a pre-Gen 5 Glock pistol. Note the firing pin drag mark from the retracting firing pin on the right and the rectangular embedded shape of the firing pin hole.

Firing Pin Marks

When the trigger of a firearm is pulled, a sear mechanism will disengage allowing either a hammer equipped with a firing pin or a spring-loaded firing-pin tipped striker to hit a primer either in the center on center-fire cartridges, or the rim of rim-fired cartridges. This creates the action necessary to discharge the cartridge. Each firing pin has unique imperfections from the manufacturing process, damage, or wear, that are transferred to the softer primer material. The position, depth, shape, and marks created by the firing pin on the primers of fired cartridge casings from the scene of a crime can be compared to exemplar casings fired from a firearm suspected of having been used during the crime.



Figure **12.8.4**: Firing pin mark on a fired cartridge casing from the scene of a homicide.

Extraction and Ejection Marks

Most firearms, excluding revolvers that utilize an ejection star that lifts the fired or unfired cartridge casings out of the cylinders, employ a hook-like mechanism that grabs the rim of the casing and, by the action of the weapon, will pull the casing from the breech. As this hook is manufactured for durability, it is a hard metal that may or may not transfer an impression onto the softer metal of the casing, whether by the recoil action of the firearm or by the manual operation of the weapon. Auto-loading firearms also employ an ejector to clear the casing from the loading area. As the extractor pulls the casing clear of the breech, a small spring-loaded arm hits the casing, which causes the casing to be flicked out of the weapon. Once again, this arm may or may not transfer an impression onto the softer metal of the casing.

Summary

In summary, forensic firearm examiners can analyze the microscopic tool marks left by a firearm on bullets and cartridge cases, both fired and unfired providing the unfired cartridge was subject to having been loaded and extracted, to identify a specific gun. The class and individual characteristics of these marks, called ballistic fingerprints or ballistic fingermarks, are created from imperfections in the firearm's manufacturing process, wear, and damage, and transferred to the bullet and casing upon the discharge of the cartridge. Analysts use microscopes, comparison microscopes, and 3-D imaging software to compare bullets and casings from the crime scene with exemplar bullets and casings fired from a firearm to determine if the weapon was or was not used in the crime.

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12.9: Test Questions

1. The distance between successive points of foot-to-foot contact of alternate feet is called the:
    a. Stride
    b. Step
    c. Gait
    d. Gape
2. The linear distance from the heel-strike of the same foot is called the:
    a. Stride
    b. Step
    c. Gait
    d. Gape
3. The bottom surface of a shoe containing the pattern is called the:
    a. Inner sole
    b. Midsole
    c. Outsole
    d. Upper
4. This part of the shoe provides a stable cushion for the foot:
    a. Inner sole
    b. Midsole
    c. Outsole
    d. Upper
5. This form of outsole production uses a die to cut preformed rubber and is commonly associated with the tread pattern of the Nike Cortez tennis shoes:
    a. Open pour method
    b. EVA
    c. Die cutting method
    d. Injection mold process
6. Serial number restoration used this substance to remove uncompressed metals surrounding the metals that were compressed during the serial number stamping process:
    a. Chlorine
    b. Acids
    c. Salts
    d. Water
7. This type of tool mark results when a tool is pressed into a softer material, it will leave an impression that usually contains a clearly identifiable outline of the tool:
    a. Drill and saw marks
    b. Sliding took marks
    c. Striation tool marks
    d. Compression tool marks
8. The analysis of an item associated with a specific source based on the unique way the pieces fit together is called:
    a. Restoration compatibility
    b. Tear reconstruction
    c. Fracture matching or mechanical fit
    d. Part manipulation
9. The ridges and furrows found on a fired bullet are the result of this:
    a. The velocity of the bullet in flight

b. A stability process used in the manufacturing of the bullet
c. Propellants and gases escaping past the bullet as it exits the barrel
d. Barrel rifling

10. This mark is impressed into the primer of the cartridge as a result of the tipping-action of the barrel during recoil in Glock-like weapons.
    a. Shear and firing pin drag marks
    b. Firing pin marks
    c. Extractor marks
    d. Ejector marks

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12.10: Suggested Essay Topics

1. Write an essay about the footwear impressions deposited in the Nicole Simpson-Brown and Ronald Goldman homicide scene, including the footwear analysis conducted by William Bodziak and Henry Lee. Explain the effect of the testimony of the expert witnesses on the jury.
2. Put on a pair of tennis shoes and leave an impression of the shoes in soft dirt or mud. Write an essay explaining how you would document, preserve, and collect the footwear impressions. Compare the impressions to the original tennis shoes using photographs or a casting and explain individual characteristics that you find.
3. Write an essay on gait analysis, including the locomotor movements of the human species and how they can be uniquely identified when captured by video surveillance.
4. Write an essay regarding the analysis of two-dimensional and three-dimensional tire tread impressions. Include information that can be useful to match the impressions to a specific vehicle and the tires on that vehicle.
5. Write an essay on the mechanical functioning of a semi-automatic pistol and how this process can leave impressions on cartridge casings and bullets, and how those items can be compared to exemplar casings and bullets fired from a pistol suspected of having been used in a crime.

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CHAPTER OVERVIEW

13: DNA, Biological Evidence, and Forensic Chemistry

Learning Objectives

- To learn about DNA and its importance to forensic identification
- To understand the role of forensic biology as a scientific discipline
- To learn about the analysis of skin, hair, and fibers
- To understand the role of forensic chemistry as a scientific discipline
- To understand the difference between presumptive testing and confirmatory testing
- To learn about microcrystalline and color testing of drugs and controlled substances
- To learn about confirmatory testing with the GCMS and SEM methods
- To learn about chemicals used for the enhancement or visualization of evidence

Biological evidence has become the cornerstone for modern forensic science and includes physiological fluids, excretions, and tissues, such as blood, saliva, semen, skin tissue, bone, hair, and skin cells. This evidence is not limited to the human species but is shared by every living organism that populates this planet.

13.1: Deoxyribonucleic Acid and Forensic Biology
13.2: Blood Analysis
13.3: Skin, Hair and Fiber Analysis
13.4: Semen and Other Bodily Fluids
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13.1: Deoxyribonucleic Acid and Forensic Biology

When Edmond Locard postulated his principle of evidence exchange, the concept of using deoxyribonucleic nucleic acid, or more commonly referred to as DNA, as a means of identifying individuals specific to a crime was seventy years in the future; yet he could not have been more correct to understand the critical importance of the detection of trace and transfer evidence to DNA analysis today.

DNA is the foundational component for the entire genetic composition of every human and animal. Every person's DNA is individual to that person, except in the case of identical twins. This makes DNA the king of forensic identification. A crime laboratory technician can develop profiles of individuals by analyzing selected DNA sequences called loci. These samples can be extracted from evidence found in a crime scene. Since DNA is found in most cells in the human body, even an infinitesimal sample of bodily fluids or tissue can yield a complete DNA profile. As previously noted, DNA can be extracted from blood, saliva, semen, sweat and other secretions, skin tissue and cells, bone, teeth, finger and toenails, and, in some cases, urine and fecal matter.

Of course, the complete topic of DNA would better merit a complete chapter or entire book in itself and would more appropriately be authored by a microbiologist as opposed to a humble forensic specialist, but for the purpose of this textbook we will keep it as primary as possible.

According to Andy Brunning in his 2015 article, What Makes up the Structure of DNA, the double-helix model of DNA consists of two intertwined strands. These strands are made up of nucleotides, which themselves consist of three component parts: a sugar group, a phosphate group, and a base. The sugar and phosphate groups combined form the repeating 'backbone' of the DNA strands. There are four different bases that can potentially be attached to the sugar group: adenine, thymine, guanine and cytosine, given the designations A, T, G and C. The bases are what allow the two strands of DNA to hold together. Strong intermolecular forces called hydrogen bonds between the bases on adjacent strands are responsible for this; because of the structures of the different bases, adenine (A) always forms hydrogen bonds with thymine (T), whilst guanine (G) always forms hydrogen bonds with cytosine (C).

Cells in the human body are constantly in a cycle of generation, division, intracellular death, and regeneration. DNA replication allows this cycle to occur. During this process, the two strands of DNA split, using two single strands as a guide to construct a new version of the complimentary strand, with A pairing with T, and G pairing with C. Enzymes, called DNA polymerases, replicate the bases of one strand by using the information from the opposite strand.

Forensic laboratories use this polymerase chain reaction process, or PCR, to 'copy' regions of DNA in a test tube. Today, even the smallest sample of DNA can be replicated into the billions in a matter of a few hours.

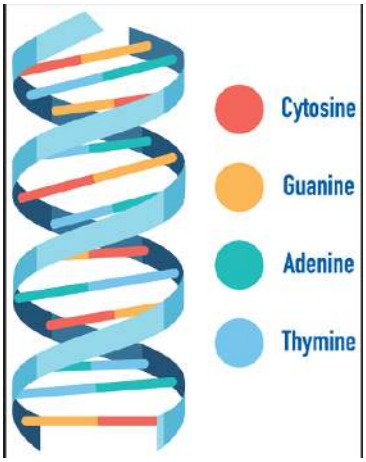


Figure **13.1.1**: Double helix DNA strand

We will discuss the collection of DNA in the next chapter.

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13.2: Blood Analysis

Blood is a vital complex biological fluid, containing red cells, which is present in vertebrates and may be shed during accidental, intentional, and criminal acts. Red cells, called erythrocytes, are the primary method of transporting oxygen through the body through the circulatory system. Red cells are incredibly small, approximately 7 to 8 microns in size, which allows them to pass through the capillaries and tributaries of the circulatory system. In fact, they are bi-concaved in shape, which maximizes the surface area in a small size. Two to three drops of blood may contain one billion red cells. Although the presence of mitochondria has been detected in human blood using electron microscopy, red cells themselves have no mitochondria and therefore they have no method of producing energy. Thus, they have a very short lifespan of approximately four months. Three million red cells expire every second and are passed through the body as waste. Blood is separated into three components: plasma volume, the buffy coat, and red cells. Plasma makes up approximately 55% of the volume of blood and is 90% water and 10% solids. Plasma is the transportations system for the circulation of nutrients, proteins, and hormones through the body. It also collects and removes waste. The buffy coat, so called because if you spin blood in a test tube in a centrifuge, the buffy coat will appear as a thin whitish layer between the plasma and the red cells, contains the white cells, called leukocytes, the primary components of the immune system, and platelets, which are cell fragments that are necessary for clotting. Leukocytes and platelets make up less than 1% of the volume of blood. Red cells make up approximately 45% of the volume of blood. There are approximately 60 milliliters of blood per kilogram of body weight, or two ounces per 2.2 pounds of body weight. The average adult male has about 1 1/2 gallons of blood, whereas the average adult female has 1 1/8th gallons of blood.

Prior to the advent of DNA typing in forensic science, it was common to include or exclude a suspect based on blood typing analysis. Blood typing was accomplished by mixing blood specimens recovered from the crime scene with antibodies to see if the blood cells would clump together. This process is called agglutination, which indicates the presence of specific antigens on the red cells. This tested for the A, B, AB, or O system, and for the positive of negative Rh factor. The technician would then conduct a follow-up “back typing” step to confirm the antigen result by inspecting the liquid part of the blood for antibodies against known exemplars of blood types. This way, if blood from the crime scene was typed as O negative and the suspect was typed as AB, then they could be excluded as having contributed the specimen. However, if the blood type matched the specimen from the scene, then it could be argued, especially when based on the rarity of the blood type, that the suspect was a potential contributor. By example, only 2% of the population are B- and Rhnull (no antibodies) is the rarest blood type. O+ is the most common blood type with approximately 38% of population being of that blood type. It is unfortunate that the criminalistic laboratories have stopped conducting blood typing, because typing could be conducted much faster than DNA typing and there are times when a bloodstain pattern analyst could easily determine which participant contributed blood to certain patterns. Also, blood typing could be used to exclude suspects as noted above, which would be a great time saver to the investigation.

In the infancy of DNA typing, a blood specimen about the size of a quarter dollar coin; however, today all that is needed could fit on the tip of a sewing pin. DNA is found in the nucleated cells in leukocytes, in small fragments also found in plasma called cell-free DNA, as well as in mitochondria that may be found in the blood. Red cells lack a nucleus and therefore do not contact DNA. Again, a discussion on the proper techniques to collect blood specimen will be in the next chapter.

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13.3: Skin, Hair and Fiber Analysis

The skin is the largest organ in the body, consisting of water, protein, fats and minerals. Your skin is the outer layer, or integumentary system, which also includes hair, nails, oil and sweat glands, that regulates body heat and protects your body from germs and infections. There are three layers of skin: hypodermis, dermis, and epidermis. The hypodermis is the lowest layer of skin that protects the muscles and bones from superficial injuries, provides a fat barrier to help regulate heat, provides for a tributary for nerves and blood vessels, and provides the tissue needed to connect to the muscles. The dermis is the middle layer and makes up about 90% of the thickness of skin. It contains the collagen and elastin that makes the skin flexible but strong. The dermis is the layer that hosts the roots of the hair, creates oils and sweat, houses the nerves for feel and touch, and supplies the epidermis with nutrients through blood vessels. The epidermis is outer protective layer of skin. It protects the body from the environment, germs and infections by means of Langerhans cells, which are part of the immune system of the body. The epidermis also provides the pigmentation of the skin. Most important to our story is that the epidermis is constantly making new skin in a process called proliferation. These new cells replace the cells that have died off in a process called desquamation. According to Texas A&M University, the average human sheds about 600,000 skin cells every day. The Imperial London College places the number closer to 200 million. Whatever the number, those jettisoned skin cells are an excellent source of deoxyribonucleic acids; however, as you can imagine, they are very hard to find owing to their size, which is about 0.01mm to 0.03mm in diameter. In spite of this, the forensic technician should consider the possible existence of dead skin cells, especially in sexual assault crime scenes, and to make the effort to collect this evidence using tape-lifting or evidence vacuuming.

Hair is common to humans and mammals. Yes, all mammals, including those that appear to be hairless like the hippopotamus, rhinoceros, whales, dolphins, and your author. Their hair is either very fine, short, or sparse, and may only be perceptible when they are very young. Hair itself is a fibrous protein that contains a vast number of the following cross-bonds or linkages: disulphide bonds, salt linkages, and hydrogen bonds. Each hair is composed of an outer layer called the cuticle, a middle layer called the medulla, and a layer in between called the cortex. The largest mass of a hair strand is the cortex layer. The average human loses between 50 and 150 hair strands per day, which is about the same for an average dog; however, a cat can lose up to 1,000 hair strands per day. Your author's vacuum can prove that fact.

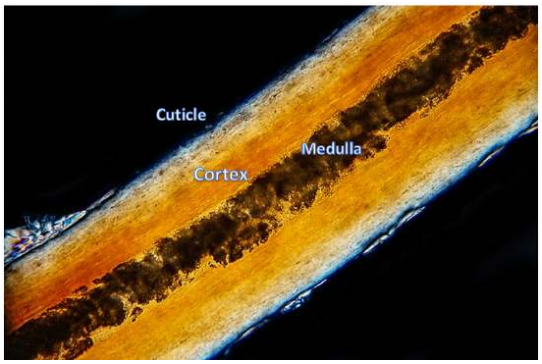


Figure **13.3.1**: Structure of the human hair - Wikimedia

Animal hair is significantly different in appearance under magnification from human hair. Cat hair is different in appearance from dog hair as are different breeds of cats and dogs. Hair is an excellent source of deoxyribonucleic acid. In the past, it was necessary to have the root of the hair in order to type for DNA; however, current techniques for the extraction of DNA have proven successful using just the hair strand. As you can imagine, hairs may be difficult to visualize with just the human eye. It may require the use of an Alternate Light Source or forensic light source in a process called trace evidence examination. If this process is done in the laboratory, it is essential that clothing, bedding, blankets, or carpeting is packaged in clean butcher's paper at the crime scene. Hairs, skin cells, and fibers can be lost when an item is just stuffed into a paper bag. As with skin cells, hairs can be collected using tape lifting or evidence vacuuming techniques, but they can also be collected with sterile tweezers if care is taken not to crush the cortex and medulla. If collected in this manner, your author suggests placing the hairs into a pharmaceutical fold constructed out of clean white butcher's paper, preferably the waxed (freezer) variety, with the waxed side facing inward.

Textile fibers or fibers from natural or man-made products like the hemp or nylon in rope can be exchanged between suspects and victims, or vice-a-versa, between those individuals and objects, or between one object to another object. These fibers can provide

class and individual characteristics that may be associated with or matched to a common source. Textile fibers can be either natural or synthetic in their composition. Natural materials for textile fibers include animal hair, such as wool from sheep or alpaca, or a plant product such as cotton or hemp. Man-made or synthetic fibers such as polyester, nylon, acrylics, rayon, or other chemical derivatives. Over half of all textile fibers used in the production of textile materials are synthetic in nature. Even some natural materials are blended with synthetic materials in order to produce a more robust or resistant fabric. Forensic analysis of fibers considers the rarity or distinct proprietary components of production, the cross-sectional shape, and microscopic characteristics of each fiber strand. Color is one of the greatest variations in textiles and therefore significantly influence fiber analysis and comparison. Synthetic dyes especially can be highly discerning to the forensic analysis of the fibers owing to color variety, batch variations, and the immense array of available colors, which vary from batch and production year. Fabric type can also affect the quantity of fibers available for analysis. Tightly woven wool or knit fabrics tend to transfer fewer fibers than those that are loosely woven or knitted. Fibers that are manufactured using discrete lengths of materials, such as short, medium, or long varieties of cotton, called staple fibers, tend to shed more than fibers of a continuous length, called filament fibers, found in synthetic or blended manufacturing. Fiber transfer occurs in one of two manners: direct transfer or indirect transfer. Direct transfer occurs when the fabric comes into contact with the target by some application of force. Indirect transfer occurs when the target is placed on top of the material. This, of course, is dependent on the type of fabric involved in the contact and the nature and duration of the contact. Fibers should be documented and collected in the same manner as hairs. According to the National Center for Forensic Science, a fiber examiner must employ a stereomicroscope, a comparison microscope, and a compound light microscope equipped with a polarized light capability. Using the comparison microscope, an examiner must view questioned and known fibers side-by-side at the same magnifications in visible light and using alternative lighting such as polarized light or fluorescent lighting. The chemical composition of synthetic fibers can be determined using gas chromatography in conjunction with mass-spectrometry, which will be discussed later in this chapter. One thing to consider is the possibility of the presence of deoxyribonucleic in the form of perspiration. Therefore, it may be wise to carefully swab the fibers for DNA typing in a sterile environment prior to comparison efforts.

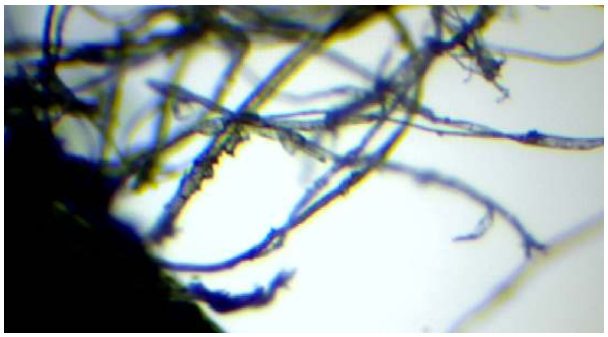


Figure **13.3.2**: Fibers found in the breech of a handgun that were matched to a ski face mask worn by the suspect of an armed robbery indicated the gun had been concealed in the mask at some time. Author's collection

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13.4: Semen and Other Bodily Fluids

Although bodily fluids like semen, vaginal secretion, sweat, and saliva are most common identifiers of suspects and victims in criminal investigations involving violent sexual assaults, the importance of this evidence is not confined to investigations that are sexual in nature. Your author once identified a take-over robbery suspect by a small sweat stain left on a shelf in the bank vault. The sweat had likely trickled down to the inner wrist from a sweaty palm that had spent too much time in a latex glove. Therefore, we will start with sweat.

Sweat, or perspiration, is a saline liquid produced in the glands of humans and other animals. The purpose of sweat is to cool the body through evaporation. Although it is approximately 99% water, it has trace amounts of salt, fat, and other organic compounds such as lactic acids and urea. Although it is important to understand that human sweat glands do not secrete human cells, DNA can transfer to sweat through contact with the microbiota of the skin or as free-floating nucleic acid fragments. Microbial DNA is derived from the bacteria, archaea, and viruses that are found on the skin and are transferred to sweat as it passes through. Sweat is the main contributor of touch-DNA. Although the DNA in sweat is very low in quantity, laboratory technicians can replicate the DNA through Polymerase Chain Replication techniques.

Semen, or ejaculum, is a complex biological mixture of spermatozoa, containing reproductive cells called gametes, and seminal fluid, a liquid substance that is secreted by seminal vesicles, prostate gland, and bulbourethral glands and provides the cells with nutrients and safely transports the semen to successfully fertilize the egg. Seminal fluid itself does not contain DNA. DNA is found in the head of the sperm. It is densely condensed and rich in genetic material.

Vaginal fluids are a mixture of secretions from the cervix. They are composed of transudate, through mucous membranes, and skin cells that have been shed. The shed skin cells contain cellular DNA, as well as bacterial DNA. Vaginal secretions can also be a source of DNA from menstrual blood. Commonly in sexual assault investigations, vaginal fluid will be mixed with seminal fluids and therefore contain DNA from booth or multiple contributors.

Saliva is an even more complex biological fluid produced by salivatory glands in the head and mouth. These glands are the parotid, located just in front of the ears, the sublingual, located under the tongue, and the submandibular, which are below the jaw. Saliva, or spit, is 99% water along with over 1,000 proteins including electrolytes, mucus, white blood cells, epithelial cells, enzymes, peptides, and antibodies. Saliva also contains organic components like urea, glucose, cortisol, sex hormones, and the occasional gnat that managed to get in when you were yawning. Epithelial and white blood cells provide the primary sources of DNA in saliva. Mucus is the slippery fluid that coats the mucus membrane. It is primarily composed of water and mucin glycoproteins, but it also contains human cells, including white blood cells, that are a good source of DNA.

Probably the least said about urine and fecal matter the better, other than to say they are excretion and egestion functions of the human body. The question your author is always asked is feces a good source of DNA. The answer is yes, abundantly so. Urine is also a good source of DNA owing to the presence of white blood cells, epithelial cells, and other small fragments of DNA passed through the bloodstream. However, it must be said that DNA from urine and feces will degrade very quickly and therefore analysis must be done either immediately or it is essential to freeze the sample before typing.

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13.5: Forensic Chemistry

Forensic chemistry is the unsung hero of the world of forensics. Forensic chemistry deals with the identification of substances by their composition; the exploration of their chemical properties and the way they interact, couple, and transform; and the manner in which they form new substances; and to apply all of this to civil and criminal courtroom proceedings. The important role of forensic chemistry is twofold: identification and enhancement. Identification comes in the form of presumptive and confirmatory testing of substances using chemicals and atomic analysis. Enhancement is the process of using chemicals to either improve the visibility of a substance, or to make a substance previously not visible to the human eye visible. We will therefore look at both functions of forensic chemistry separately.

Presumptive and Confirmatory Testing

In forensic chemistry, presumptive testing is the preliminary testing of a substance to establish sufficient cause for either an arrest or to determine the need to proceed with confirmatory testing, which will produce a much higher degree of certainty. Although inexpensive and quick, presumptive testing may not be accurate owing to interpretation by the human eye or cross-contamination of the substance that might prove a false-positive or false-negative result. Confirmatory analysis is often conducted on the microscopic or molecular level and therefore can rule out false conclusions. Presumptive testing is available for patrol officers and forensic technicians alike for the preliminary identification of substances such as controlled substances and narcotics, gunshot residue, blood, semen, urine, and the presence of lead and copper from the impact of bullets. We will start with the presumptive testing of controlled substances and narcotics.

Microcrystalline or color tests are chemical tests resulting in the formation of unique micro-crystals for a given substance when combined with a specific reagent. These are the tests generally used by the patrol officer or investigator in the field to determine if a substance in the possession of a suspect is suspected to be a drug or another product that is legal to possess. They are easy to use and are generally accepted for their ability to detect the characteristics of a family of drugs. Interestingly, most crystalline and color tests are largely empirical in nature. This means that even scientists do not fully understand why there is a chemical reaction between the substance and the chemicals, but the result is predictable and consistent.

Marquis Reagent is composed of 2% formaldehyde in a sulfuric acid base. It is the test that provides results for more than one substance and therefore is often the first test used when the substance being tested is unknown. When combined with a suspected opioid, such as heroin or morphine, the reaction will be a purple coloration with wispy fingers emanating from the substance. When combined with amphetamines, the color reaction is orange to brown. Lysergic acid diethylamide (LSD) will turn a dull olive-black color, whereas mescaline and fentanyl will produce strong orange coloration.



Figure **13.5.1**: Color reaction of black tar heroin with the Marquis Reagent. Author's collection

Mecke Reagent is a mixture of 95% selenious acid and 1 gram of concentrated sulfuric acid. When combined with opiates, the color change will be a bluish green. Lysergic acid will produce a greenish black color change. Your author prefers to use the Mecke

Reagent for opiates that are in the pill form so as not to have a false reaction to the coloring dye used to give the pill its distinct pharmaceutical appearance.

Scott's Reagent is a proprietary color test for the presence of cocaine hydrochloride. It was developed by L. J. Scott, a forensic chemist and former Drug enforcement Administration special agent. The three-part test contains cobalt (II) thiocyanate, acetic acid and glycerin, plus concentrated hydrochloric acid and chloroform. Operator error can produce false-positive results for the presence of powder cocaine owing to the need to observe a blue "speckling" reaction as opposed to just a blue color change.

Simon's Reagent is a two-part color test method for the presence of amphetamines and methamphetamines. Part one is a mixture of 2% sodium nitroprusside and 2% acetaldehyde in water. Part two is a solution of 2% sodium carbonate in water. The reaction with secondary amines will produce a bright blue coloration.

Duquenois-Levine is a three-part color test for the presence of delta-9 tetrahydrocannabinol (Delta-9 THC) in marijuana. The first step of the test is 2% vanillin with 2% acetaldehyde in ethyl alcohol. A small portion of the marijuana leaf is saturated with this chemical mixture. The addition of hydrochloric acid will produce a vibrant purple color change. The addition of chloroform will produce a pink bubble or "eyeball" at the bottom of the test tube. This last part of the test supports the presence of Delta-9 THC). Of interest, the criminalistic laboratory will confirm the substance as marijuana by examining the underside of the leaf for cystolithic hairs, a non-glandular trichome, using a Scanning Electron Microscope, which are unique to the cannabis plant as well a nettles and figs. Of course, since nettles and the fig leaf lack Delta-9 THC they will not react to the Duquenois-Levine test.



Figure **13.5.2**: Cystolithic hairs on the underside of a marijuana leaf. Author's collection

Figure 13.5 - Cystolithic hairs on the underside of a marijuana leaf

Confirmatory testing is conducted by the forensic laboratory technician primarily using the gas chromatograph mass spectrometer (GCMS). The GCMS has two separate functions. Gas chromatography separates mixtures based on their distribution between a stationary liquid phase and a moving gas phase (carrier gas). The results are plotted on a graph reflecting the recorder response (vertical axis) versus time (horizontal axis). The laboratory technician cannot identify the substance based solely on the graph produced by the gas chromatograph. The mass spectrometer allows the material to exit from the gas chromatograph into a high-vacuum chamber where a beam of high-energy electrons is aimed at the sample molecules. The electrons collide and cause them to lose one electron and gain one positive electron (ion). The ions then form unstable smaller fragments that pass through an electronic or magnetic field, where they are separated according to their masses. The fragment patterns are then compared against the known molecular structures of the questioned substance. Under laboratory-controlled conditions, no two substances will produce the same fragmentation pattern.

The chemical composition of gunshot residue, or GSR, is lead, antimony, and barium. Gunshot residue can be found on the hands or sleeves of the person who fired a gun, or is standing in proximity to a gun that is being fired, on garments that are near the muzzle of the gun or are being worn by the person who fired the gun, and on the defect caused by the bullet after it left the barrel of the gun. Magnetic "stubs" are the preferred method of sampling GSR from the hands of the person suspected of firing a gun. The stubs are examined for the presence of lead using the Scanning Electron Microscope.

The Scanning Electron Microscope, or SEM, is a microscope that uses an electron beam to produce a high-resolution image of the surface of a substance in order to identify its chemical composition. The SEM is often paired with energy-dispersive X-ray spectroscopy, or EDS, for precise chemical identification, allowing for the definitive confirmation of particles based on their unique chemical signature. A suitable presumptive test for the presence of GSR sampled from a firearm or clothing is the Sodium

Rhodizonate, or NaRho, color test method. This test is composed of sodium nitrate in aqueous solution followed by the application of a buffer solution of sodium bitartrate and tartaric acid in distilled or deionized water and an application of hydrochloric acid mixed with distilled or deionized water. The reaction with lead will produce a bright purple coloration. If the suspected GSR is on dark clothing, it is recommended to perform the Bashinski Transfer Technique, which involves places laboratory filter paper over the test area and spraying it with a 15% solution of glacial acetic acid in distilled or deionized water. Apply pressure to transfer the suspected GSR onto the filter paper. Place the filter paper on clean butcher's paper and place several layers of dry filter paper on top of the sample filter. Apply heat from a dry iron until the filter is dry. You may then perform the color test. Once dry, the filter paper with the test results can be analyzed using the SEM. Sodium rhodizonate can also be used to detect the presence of lead in and around bullet defects in walls, metal, or clothing. Dithiooxamide, or DTO, is a chemical color test for the presence of copper transferred from jacketed bullets upon impact with a target.

There are several good presumptive color test products for the presence of suspected blood; however, your author will only present two: phenolphthalein, or the Kastle-Meyer test, and leucomalachite green. Phenolphthalein is a three-part color test which reacts with the hemoglobin of blood as a catalyst. A sample of suspected blood is collected on a cotton-tipped swab using distilled water or alcohol. One or two drops of reduced phenolphthalein is then dropped onto the swab, followed by a drop or two of hydrogen peroxide, producing a bright pink reaction. The reaction should be immediate. Any reaction after 15 seconds may be the result of oxidation, which would be considered a false-positive. An interesting sidenote is that phenolphthalein has been an ingredient in laxative medication for many years. Leucomalachite green, or LMG, is a two-step test using the leucomalachite green solution followed by the application of hydrogen peroxide. This test also reacts with the hemoglobin in blood as a catalyst agent that oxidizes the color-less leucomalachite solution and turns it into a blue-green colored result. Although the test is highly sensitive, it is prone to false-positive results. It is important to understand that these tests are presumptive in nature, and the presence of blood should be conducted using confirmatory testing. Contrary to common belief, DNA typing is not a confirmatory test for the presence of blood. It is a confirmatory test for the presence of DNA. Confirmatory tests for blood include the Teichmann and Takayama tests as well as the Rapid Stain Identification-Blood test, which detects a specific red blood cell antigen, glycophorin A.



Figure **13.5.3**: The three-step Kastle-Meyer test. – Shop Evident

The OBTI Bluestar Immunochromatographic Rapid Test, developed by Bluestar Forensics, is a presumptive and confirmatory test for the presence of blood that is human in origin. It is highly sensitive and easy to use. A sample of suspected blood is collected on a sterile cotton swab, which is placed in the solution for 30 seconds. The solution is then poured onto a test cassette that records a positive or negative response.

The Acid Phosphate Test, also known as the Walker Test or Brentamine spot test, is a presumptive test for semen. The male prostrate gland secretes a high quantity of the enzyme acid phosphate, or AP. The test involves the application of a reagent

chemical, such as naphthyl phosphate or sodium alpha-naphthyl phosphate, and a dye, such as Fast Blue B, to a sample of a suspected stain. If semen is present, the enzyme acid phosphatase hydrolyzes the substrate, thus separating the phosphate from the alpha-naphthyl compound. The color change will depend on the dye used in the mixture; however, the reaction with Fast Blue B will be a deep purple color change. Confirmatory testing for semen is conducted using either the Christmas Tree Stain process, which is a dye stain that allows for the microscopic visualization of sperm, or the Rapid Stain Identification-Semen test, which identifies the presence of the seminal vesicle-specific antigen, or semonogelin, which is unique to human semen.

The Phadebas Forensic Press Test is used to detect the enzymatic activity of the alpha-amylase enzyme, which is found in saliva. It is a color test method that uses a laboratory filter paper impregnated with the proprietary Phadebas solution, which is a synthetic biochemical assessment product for the detection of the α-amylase enzyme. A blue “spot” on the filter paper indicates a positive result for suspected saliva. The darker the blue coloration, the higher the presence of saliva. As there is the potential for false-positive results, a second test using the Rapid Stain Identification-Saliva test, which detects the alpha-amylase molecule itself, and specifically, the alpha-amylase from human saliva should be performed. When combined, both tests provide confirmatory results for the presence of human saliva.

Para-dimethylaminocinnamaldehyde, or DMAC, is a simple, fast, and safe test for the detection of urine. However, DMAC reacts with urea rather than creatinine, ammonia or uric acid, and therefore can have inaccurate results. It is essential that confirmatory testing be conducted

Chemical Enhancement

As mentioned in previous chapters, laboratory technicians use various chemicals to enhance, or make visible, evidence that is either latent or degraded to the point where ordinary, non-chemical efforts to visualize the evidence are ineffective. Your author has provided some information regarding the use of chemicals in latent fingerprint development and bloodstain visualization; however, in this chapter we will examine additional chemicals that were not mentioned in that chapter, especially those that fluoresce or have chemiluminescent qualities.

1,2-Indanedione-Zinc chloride, or IND/Zn, is an amino-acid reactive reagent that is an effective process for visualizing latent fingerprints on paper and is considered the best method for developing fingerprints on paper that is old. Fingerprints have been successfully recovered from documents that were 80-years old. Developed fingerprints are visualized using ALS light at 515nm to 570nm green light using a red barrier filter. The application of liquid nitrogen as an end process may increase the quality of the developed prints.

Oil-Red-O is a lysochrome, or lipid-soluble dye that adheres to the fatty components of fingerprint residue, such as those from sebum. It is used on wet or damp paper or cardboard products. The process is simple and inexpensive and involves dipping the item in a bath of the solution for approximately 60 to 90 minutes, followed by a rinse to lower the pH, and then drying the item for a few hours. The developed fingerprints will be dark red in color.

Sudan Black is likely the best development method for latent fingerprints deposited on greasy or waxy non-porous surfaces such as milk cartons, candy wrappers, candles, and the inner surface of latex gloves. It is a lipophilic dye, which means that it will bind with the fatty acids in sebaceous oils. The item is immersed in a bath of the solution until the fingerprint is visualized as a dark blue or black color. It is important to photograph the reaction as quickly as possible because it will degrade in time.

M. B. D., or 7-(p-Methoxybenzylamino)-4-Nitrobenz-2-oxa-1,3-Diazole, is a fluorescent dye stain used on multi-colored non-porous items that have been previously treated with cyanoacrylate ester fuming development medium. M.B.D. will adhere to the polymerized fingerprint ridges developed with cyanoacrylate fuming. The item can be sprayed with M.B.D. or dipped and gently rinsed. The resulting stains will fluoresce brightly in a yellow-green color using an ALS light between 415nm to 535nm with an orange or red barrier filter.

Leuco-Crystal Violet, or LCV, has been mentioned in a previous chapter, but it is well worth mentioning again. LCV is a very effective protein stain used to develop or enhance fingerprints or footwear impressions that were deposited in blood. Leuco-crystal compounds have been used in the dyeing process of fabrics for thousands of years. They are colorless dyes that can be treated to produce oxidation, resulting in a vibrant color change. Heme, the iron-containing compound in hemoglobin, acts as a catalyst that speeds up the oxidation process. The reaction converts the colorless LVC into a bright violet oxidized form called crystal violet. It

is easy to apply by pouring or as a fine misting spray, works best on horizontal surfaces, does not require a destaining rinse, and most manufacturers provide a blood fixative. Your author thinks LCV is, well, brilliant.

Luminol and Bluestar are chemicals commonly used for the detection of blood either in crime scenes or on evidence collected from the crime scene or during the course of an investigation. The reaction between these chemicals and even the smallest traces of blood will produce a chemiluminescent glow that will be bright blue and consistent in color. Luminol, or 3-Aminophthalhydrazide, was originally synthesized in the 1850's in Germany for the detection of copper in mining. It was further developed in the early-1920's, and in 1937, German chemist Walter Specht suggested that it could be used to detect blood in crime scenes when he noticed that luminol produced a reaction when it was catalyzed by the lead in hemoglobin. In 1966, the formula was improved with the addition of sodium hydroxide and hydrogen peroxide. Although it improved the detection quality, luminol needed to be refrigerated until mixed, mixed at the scene, and could only be viewed in total darkness, which presented a problem for photographic documentation. The technician had to pre-focus the camera in manual mode and only had one chance to get the photograph correct. One of the biggest drawbacks of Luminol is that it will significantly degrade DNA, especially with repeated applications. In 2000, Jean-Marc Lefebvre-Despeaux, the president of BLUESTAR™ Forensics, commissioned Loïc Blum, biochemistry professor at Claude Bernard University in Lyon, France, to develop a luminol-based that was more stable, easier to uses, and would not degrade DNA. The result is a highly sensitive blood-visualization reagent that can be used with background lighting that makes photographic documentation easier. It is also easier to detect false positives with Bluestar™ as a reaction with blood is a steady and consistent blue glow, whereas a reaction with copper will be dull and of a short duration, and the reaction with bleach is violent and of a much shorter duration like a super-nova. To highlight the significance of Bluestar™, your author will tell yet another story.

In a city near where your author works as an investigator and Senior Forensic Specialist, in the early morning hours, a patrol officer observed a half-naked, beaten and bruised man staggering down the middle of a street. The story the man gave before being whisked away to the hospital was that he had been kidnapped, beaten repeatedly, and threatened with death by three men at a nearby house, but had managed to escape. The police contacted two of the men at the house and took them into custody, but for some reason no effort was made to locate and process the crime scene. A few days later, a jail deputy was listening to a telephone call placed by one of the men in custody to his mother. During the call, the man instructed his mother to, "Take some bleach out to the garage and do a very good job cleaning everything," and, "Wash the blanket he was wrapped in with bleach." The deputy contacted his supervisor who in turn called the District Attorney's Office. A search warrant was authorized for the house, and the services of your author were requested as mutual-aid. Although no blood was detected in the house, three small blood drops were immediately detected with white light near an expansion joint on the floor of the garage in proximity to the garage door. The lights were turned out and the window covered. An application of Bluestar™ was misted onto the horizontal surfaces revealing the bright, super-nova reaction with bleach. It looked like the mother had done her job well, except for one thing: Mom had forgotten…the doorknob.

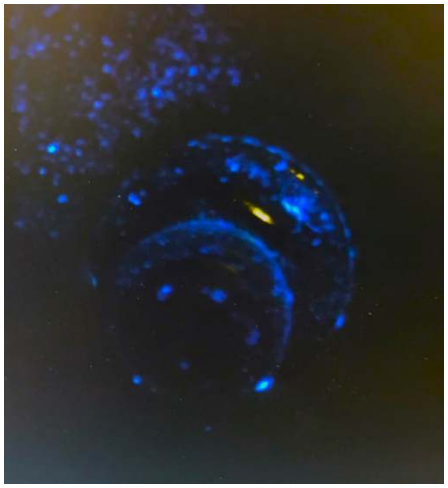


Figure **13.5.4**: Bluestar reaction with blood on a doorknob. Author's collection

The doorknobs on both sides of the door leading from the garage to the house bore evidence of blood transfer. In the laboratory, your author later detected the presence of blood on the blanket, in spite of having been washed with bleach in a washing machine, and on a pair of tennis shoes worn by one of the suspects. The blood was matched to the victim by DNA. The use of Bluestar™

provided a visual representation of the blood-letting event and the efforts of the mother to destroy the evidence of the crime that was significant to telling the story during the subsequent trials, of which there were three; they caught the third suspect a few months after the crime. Oh, and the victim, it was a case of mistaken identity. They thought he was someone else.

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13.6: Test Questions

1. The intertwined pairing of the strands of DNA is called the:
    1. Paired-helix
    2. Double-helix
    3. Combined-helix
    4. Tandem-helix
2. This base structure of DNA always forms hydrogen bonds with thymine:
    1. Atropine
    2. Apocrine
    3. Adrenaline
    4. Adenine
3. This base structure of DNA always forms hydrogen bonds with cytosine:
    1. Glycerin
    2. Glucopyranose
    3. Guanine
    4. Glycophrin
4. What percentage of blood is made up of plasma:
    1. 55%
    2. 10%
    3. 99%
    4. 25%
5. This is the rarest blood type:
    1. AB
    2. B-
    3. O-
    4. Rhnull
6. The average cat may shed these many hairs daily:
    1. 50
    2. 100
    3. 500
    4. 1,000
7. This type of microscope is used as a confirmatory test for GSR:
    1. Compound microscope
    2. Comparison microscope
    3. Scanning Electron Microscope
    4. Atomic Absorption Spectroscope
8. The Scott's Reagent color test is used as a presumptive test for the presence of:
    1. Cocaine hydrochloride
    2. Opioids
    3. Marijuana
    4. Amphetamines
9. Confirmatory testing of marijuana is performed using presumptive color testing followed by a microscopic examination of the underside of the cannabis leaf for:
    1. Carotenoids
    2. Cystolithic hairs
    3. Anthocyanins

4. Phylopic tendrils

10. This test is used as a presumptive test for the presence of semen.
    1. Phenolphthalein
    2. Kastle-Meyer
    3. Acid Phosphatase Test
    4. Leuco-Crystal Violet

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13.7: Suggested Essay Topics

1. Write an essay about the history of DNA replication as it applies to the forensic sciences.
2. Write an essay about the history of blood-typing and its application in medicine and forensic science.
3. Write an essay about the history and development of gas chromatography and mass spectrometry and their application of GCMS in science.
4. Write an essay regarding the history and development of leuco-crystals and their use in industry and the forensic sciences.
5. Write an essay about the history and development of luminol and its application in mining and the forensic sciences. Include information regarding the important scientists who helped in the development process.

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CHAPTER OVERVIEW

14: Evidence Collection and Preservation

Learning Objectives

- To learn about the need for proper collection and preservation of evidence
- To understand the process for the extraction of DNA from items of evidence
- To learn how to properly package clothing items of evidence
- To understand chain of custody and its importance to courtroom proceedings
- To learn how to collect buccal specimen for DNA typing

14.1: Introduction
14.2: Collecting Biological Evidence - DNA
14.3: Bloodstain collection
14.4: Other important information
14.5: Suitable wrapping technique
14.6: Biological Evidence from Victim and Suspects
14.7: Chain of Custody
14.8: Test Questions
14.9: Suggested Essay Topics
14.10: References

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14.1: Introduction

Although the crime scene you inherit may come to you previously contaminated, the biological, physical, transfer and trace evidence need not be contaminated. The target upon which the blood is sitting may have been trampled upon historically by dozens, hundreds, if not thousands, of people, that does not mean the blood, if properly collected and preserved, is without evidentiary merit. The clothing worn by the suspect and the victim will not be compromised if properly collected. The trace and transfer evidence on the weapon found in the crime scene still has integrity. The fecal matter or urine thrown on the custodial officer still supports the elements of the criminal charge and may contain at least minimal amounts of DNA of the jail or prison inmate who, if not threw it, certainly contributed to its construction. The biological evidence left on the rape victim or on the victim or suspect's clothing will still provide the courts with the evidence needed for a conviction. The key is to collect and preserve the evidence in a manner that will be available, free of contamination, for future analysis and court proceedings.

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14.2: Collecting Biological Evidence - DNA

Most crime laboratories can conduct DNA typing on blood and other human biological samples to determine genetic markers. DNA testing does not require a large sample of material; however, the samples must be collected in a manner to prevent contamination or degradation, which can render the DNA testing useless.

Types of biological evidence suitable for DNA testing include:

- Bloodstains/liquid blood
- Semen
- Vaginal fluid
- Hairs
- Saliva
- Mucus
- Bones, nails, teeth
- Fecal samples – large, harder samples will have a greater likelihood of cells on it than softer or loose samples
- Perspiration stains

As previously mentioned, feces and urine are not the best source of DNA owing to the low concentration of nucleated cells present in human waste. DNA also deteriorates quickly in urine if it is present. Mucus can be a good source of DNA, especially if there is bloody discharge with the mucus, but it may degrade if not processed within a month. Vomit is a poor source of DNA, but that does not mean it cannot be attempted. It is best to check with your laboratory before submitting urine or vomit for analysis.

The techniques used for collecting the specimen will depend on the stain itself and the surface upon which it was deposited. The absolute best method for collecting the specimen is to collect the item upon which the stain is found, like a shirt or pair of pants. Unfortunately, the specimen is usually found on a wall, door, bed, sofa, item of furniture, ceiling, or floor. When this happens, you have no alternative but to collect the specimen in situ. It is important to document the specimen's location and relative position to the crime scene and other items of evidence with notes and photography prior to collection. The forensic technician must use universal precautions before handling any biological evidence to prevent contamination or the contribution of their own DNA to the specimen. Wearing proper personal protective equipment, especially an N95 mask and gloves, can also minimize exposure to possible infectious diseases and hazardous materials.

Gloves

Sweat from the collector's bare hands will very likely contaminate evidence. Latex gloves provide a simple barrier against contamination for the evidence collector. The forensic technician should change their gloves each time a new piece of evidence is handled to prevent cross contamination of the evidence. Your author highly recommends to "double glove," which is wearing one pair of latex gloves over another. This keeps the hands of the forensic technician covered at all times, even when changing gloves. Your author also recommends wearing cotton gloves underneath the first layer of latex gloves. This helps to collect perspiration and makes changing gloves much easier. The forensic technician should avoid wiping their forehead or scratching their noses or wiping their eyes while handling items of evidence. Fight the urge to handle a cellular telephone or adjust eyeglasses. Any time gloves have come in contact with such items, it is essential to change them before proceeding to handle items of evidence in the scene. Another thing to consider with latex gloves is the manner in which they are removed from the box. Obviously reaching into the box of gloves with bare hands has the potential to transfer the DNA of the forensic technician onto the very gloves that they hope will prevent contamination. The same applies to that pair of gloves you shoved in your trouser pockets at the beginning of your shift. The proper method of extracting a latex glove from the box is to look for the cuff, lift it with a hooked little finger, remove the glove from the box by the cuff, and carefully don the glove. Then lift the second glove with the gloved hand in the same manner. For gloves that you have prepared and placed in a pouch at the beginning of the shift, your author dons gloves in the manner prescribed, rolls out a clean sheet of butcher's paper, and removes two gloves from the box. I place the gloves on the paper, roll them into a ball, and turn the ball inside out. This will keep the outer surface protected until used.

Masks

Excessive talking, sneezing, or coughing in the vicinity of the evidence may cause small, but detectable amounts of the DNA of the crime scene team members to be inadvertently transferred to the evidence. It is essential for all persons entering the crime scene to don a good mask, such as the N-95, in order to reduce the potential for contamination. Most of the contamination in a crime scene likely comes from the mouth or nose of the technician or detectives.

Collection devices

Disposable tweezers, scalpels and scissors are the best instruments to use while collecting human biological evidence. Your author uses a 10% bleach solution with a distilled water rinse to sterilize the instruments. Your author then places them in a down-draft workstation and subjects them to three minutes of short-wave ultra-violet light before placing them in a clear plastic zip-lock bag.

Touch DNA

Touch DNA is a “touchy subject” for the crime laboratories as many law enforcement agencies now submit hundreds of items of evidence for processing in cases ranging from petty theft to murder. Unfortunately, the laboratories are already overwhelmed with submissions and testing every possible item that a suspect may have touched or may not have touched is adding to an already burdensome backlog. Your author will try not to submit evidence unless he is certain that the item was handled by the suspect. For example, prior to processing an item for latent prints that was likely touched by the suspect, your author first inspects the item for the inherent luminescence or glistening of the undeveloped print. A clean white light used at an oblique angle can assist you in this examination. If it appears to be a partial print or smudge, your author will swab the area for touch DNA typing instead of developing it further for fingerprint impressions. In major cases, your author will use sterile powders and brushes to dust an area for potential latent prints. Smudges and partials that are developed can be collected for touch DNA typing. Cyanoacrylate fuming will develop prints that can later be typed for DNA. Unfortunately, most of our cyanoacrylate fuming chambers are not cleaned and sterilized between development and there may be the potential for cross-contamination. Your author uses shortwave UV light lamps that he places in the chamber prior to every use.

DNA extraction and swabbing

There are two basic methods for collecting DNA from items of evidence and from the crime scene, swatch collection and swabbing. If a biological stain is observed on a garment, like an undershirt or underwear, the stained area can be carefully cut from the garment with a pair of sterilized scissors, packaged in a pharmaceutical fold, and delivered to the laboratory for DNA extraction. The most common method used by forensic technicians to recover the DNA is through swabbing the item with either a sterile cotton swab or sterile foam swabs. The process is quite easy but requires some careful preparation by the technician in order to prevent swab contamination. Your author has a fool-proof method for the proper collection of swabbed DNA evidence. Your author first dons gloves and a face mask. He then selects a sterile cotton-tipped swab in sterile packaging. He writes the pertinent information from the case on the exterior of the packaging with a fine-tipped felt pen taking care not to pierce the packaging. He labels only one swab envelope and collects only one specimen from a specific location at a time as not to introduce confusion or a dodgy memory into the process. He opens the stick-side end of the packaging and cuts about ½” off the ends to facilitate ease in returning the swabs to the packaging later. He places a plastic applicator shield on the stick end of the swabs, generally getting two swabs into one applicator shield. With extreme caution not to touch the cotton-tips of the swab on anything, your author extracts both swabs at the same time with a quick motion. Holding a sterile water ampoule (your author does not recommend using saline) approximately ½” above the cotton tip, he drops one or two drops of water onto the swab. He then gently, with enough pressure to transfer DNA to the swab but not break the sticks, rubs the surface of the item. Once accomplished, your author pushes the applicator shield over the cotton tips and returns it back into the same sterile packaging from which the swabs were removed, because, why not, it is still clean evidence packaging and applicator shields will protect the swabs from contamination. Following this, the swabs are placed in a sterile drying cabinet to dry thoroughly. Once dried, the package containing the swabs is tape-sealed and placed into an evidence envelope with a corresponding evidence inventory label.

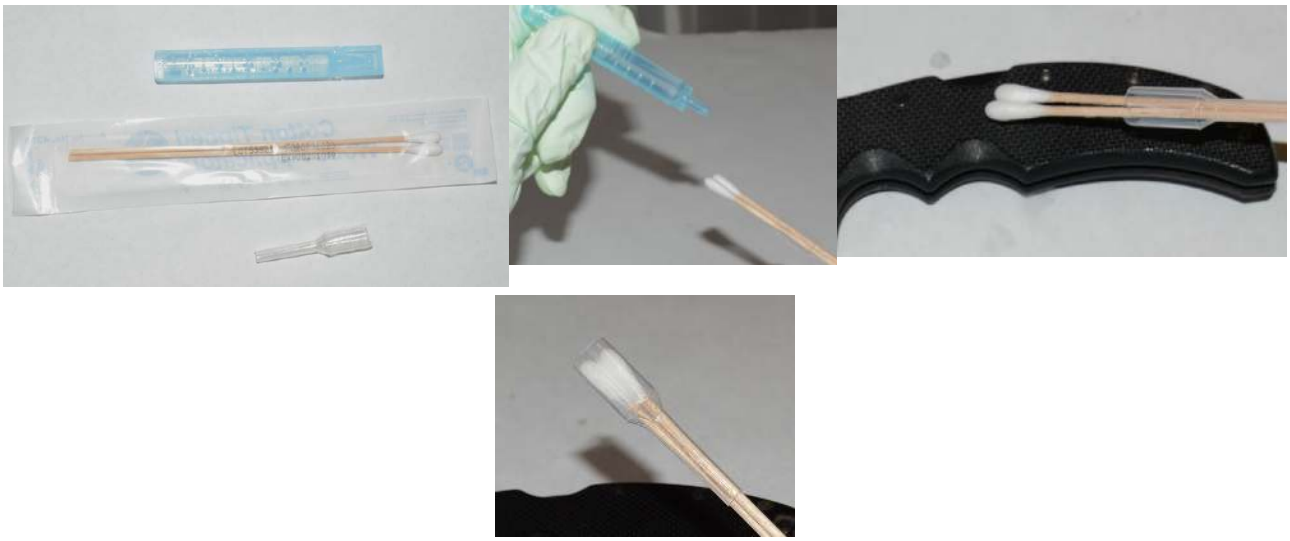


Figure **14.2.1**: Swabbing a knife for DNA. Author's collection

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14.3: Bloodstain collection

Swabbing a suspected bloodstain is the easiest way to collect samples from large or immobile objects. If the stain is still wet, the swab can be dabbed into the stain until the blood is absorbed into the tip of the swab. Your author will avoid swabbing all the way to the target, instead focusing on collecting just the blood and not a potentially contaminated surface. Remember, you only need a small amount of blood for DNA testing. Wet blood should never be frozen; it is always best to place it in refrigerated evidence storage. Never store blood, whether wet or dry, in a plastic evidence container. Always use a paper bag or paper evidence envelope. If the stain is dry, moisten a sterile cotton swab with distilled water from an ampoule; avid using saline. Do not touch the ampoule to the swab, or the stain. Instead drop the water onto the swab or stain from a distance of about ½ of an inch. Touching the ampoule could cause contamination of both the swab and the ampoule. With the moistened swab, dab the stain until the swab contains blood. Remember to collect the blood specimen from the area between the center, which is clotted blood, and the edge, which may be serum. When collecting dried blood, you may have to scrub down to the target. It is unfortunately unavoidable. It is important not to place more than one sample into an evidence envelope and never collect multiple stains on the same swab. If you collected several swabs from the same stain, be sure to label each swab as coming from the same stain. Take a control sample in the same manner as the specimen from the area surrounding the stain without actually collecting blood or DNA evidence should your agency protocols require the collection of control samples. If sufficient sample remains, collect a dry-swab specimen as well. This swab is collected in the same manner as the specimen without using distilled water to moisten the swab. This specimen is generally retained for use by the defense.

Dried flaked blood

Blood that is dried and flaky can still have DNA value. The best method for collecting dried blood is to scrape it into a pharmaceutical fold or coin envelope using a sterile razor blade; or by picking up large flakes with sterilized tweezers. Be absolutely certain to wear safety glasses and a mask whenever manipulating dried blood as the last thing you want to do is flick a flake into your eye or mouth.

Processing wet bloodstained items

Many a seasoned detective or crime scene technician will remember processing wet bloodstained garments in open ‘drying cages’ overnight before carefully folding them up and placing them in paper bags the next day. That was in the days before DNA typing. Today, it is absolutely essential that agency evidence processing areas have contamination-free drying cabinets that use filters to purify circulating air. These cabinets must be lockable and have the means to clean and sterilize between each use and a logbook must be maintained to document the cleaning and sterilization process. These cabinets can be very expensive but are well worth the cost and are one of the most important acquisitions any law enforcement agency can make.

An item of evidence that is thoroughly wet with blood or other human biological evidence can be transported from the crime scene to the evidence processing area in plastic bags. It is best to put only one item of evidence in each bag. The items should only remain in the bag from the time that they have been collected to the time that they arrive at the processing area. The item should then be immediately transferred to the drying cabinet. The plastic bags and any paper placed underneath the item as it was drying also need to be dried and processed as they may contain trace evidence that may have fallen off the original item. Once the item has been dried, it needs to be properly packaged and processed in an evidence locker.

Items that are only slightly wet may not need to be cabinet-dried and may complete the drying process while in an appropriate non-plastic evidence container. Should this be the case, it is best to follow the package instructions listed below.

Bloodied evidence not at the scene

Bloodstained items of evidence often times do not remain at the crime scene. They are instead transported to vehicles or hospitals while the victims or suspects are still wearing them. Although every effort should be made to collect these items before they leave the crime scene, sometimes it is an unavoidable consequence of necessity. It is critical that these items are collected as soon as possible and that proper chain of custody is maintained by those individuals who did the collection. During a recent homicide investigation, your author needed a crucial piece of evidence: the shoes worn by the victim. After three days of searching, he finally found them in a cabinet at the hospital where the victim was taken and pronounced dead. As you can imagine, there was no chain of

custody for the shoes. Regardless, your author collected them and processed them into evidence. They provided valuable information in the subsequent bloodstain pattern analysis and ownership of the shoes was confirmed through DNA typing.

As mentioned, you must never process wet, bloodied items in plastic. This can cause mold to grow that will degrade the DNA. Plastic should only be used to transport items to prevent cross-contamination.

Remember that the best short and long-term storage for liquid blood (such as that collected from a suspect or victim in a vial) is refrigeration. Never freeze liquid blood. Dried human biological evidence is best stored in a temperature-controlled storage area; however, room temperature is acceptable for short-term storage. The same applies to buccal swab samples.

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14.4: Other important information

Collecting and preserving trace evidence can be a challenge. There is little worse than finding that fiber or hair on evidence from the crime scene that definitely associates a suspect with a crime, and then, when it is most needed, not being able to find it for analysis or court proceedings because it was loosely placed in a coin envelope. The best method for collecting and preserving trace evidence such as hairs, fibers, epithelial cells, etc., are best collected, and subsequently preserved, by tape-lifting or forensic vacuuming. Tape lifts should be placed in sterile glass jars. Forensic vacuums collect the evidence in their own sterile collection containers. Questioned documents can be placed in paper evidence envelopes but take care to sandwich the document between thin sheets of stock paper or cardboard and be certain to fill out the information on the outside of the envelope before inserting the evidence. Indentations are fundamental to handwriting comparison. It is therefore best not to contribute additional indentations while filling out the documentation on the exterior of the envelope.

Soil samples should be collected in clean glass jars. Materials from suspicious fires should be placed in metal paint cans leaving approximately 1/3rd of the can empty for gases to collect in that space. Keep in mind that fire material that is wet from firefighting efforts may ultimately rust the bottom of the can. Therefore, the material should be sent off for analysis as quickly as possible. Used condoms can present the investigator with a challenge. If semen is noted within the condom, collect it immediately using either a sterile cotton or foam-tipped swab, or by pouring the semen onto a sterile gauze pad. The condom should then be allowed to dry. Your author will clip a sterilized binder-clip to the top of the condom to allow it to be manipulated without touching the condom itself. Once it is dried, the condom can be wrapped in clean butcher's paper.

Items of clothing evidence should be packaged wrapped separately in butcher's paper and placed loosely in paper bags. This allows for the analysts to open the evidence, make their examination, and then return the item in its original packaging, thus preserving the original chain of custody.

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14.5: Suitable wrapping technique

Hopefully, the practice of initialing items of evidence, especially garments, that may be tested for DNA evidence has been discontinued. Placing initials on the garment may either contaminate the sample or provide a contamination challenge in court. Instead, garments that are of evidentiary importance to a criminal investigation should be processed in the following manner:

- Lay the garment out flat on a clean sheet of butcher paper (shiny side up)
- Be sure to use sufficient sheets of butcher paper to cover the entire garment.
- Place a sheet of butcher paper on top of the garment (shiny side down) under each arm.
- Fold the paper in a manner depicted below:

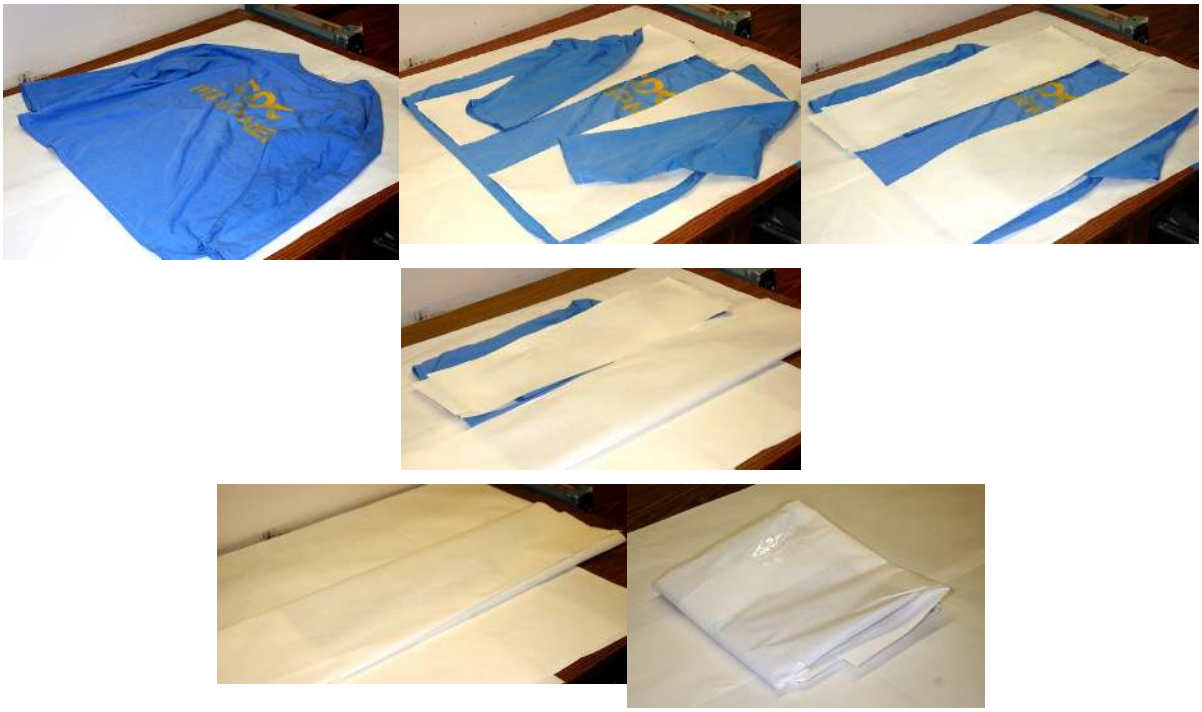


Figure **14.5.1*a, b, c, d, e, f***: The proper packaging of clothing as evidence. Author's collection

https://workforce.libretexts.org/@go/page/53202

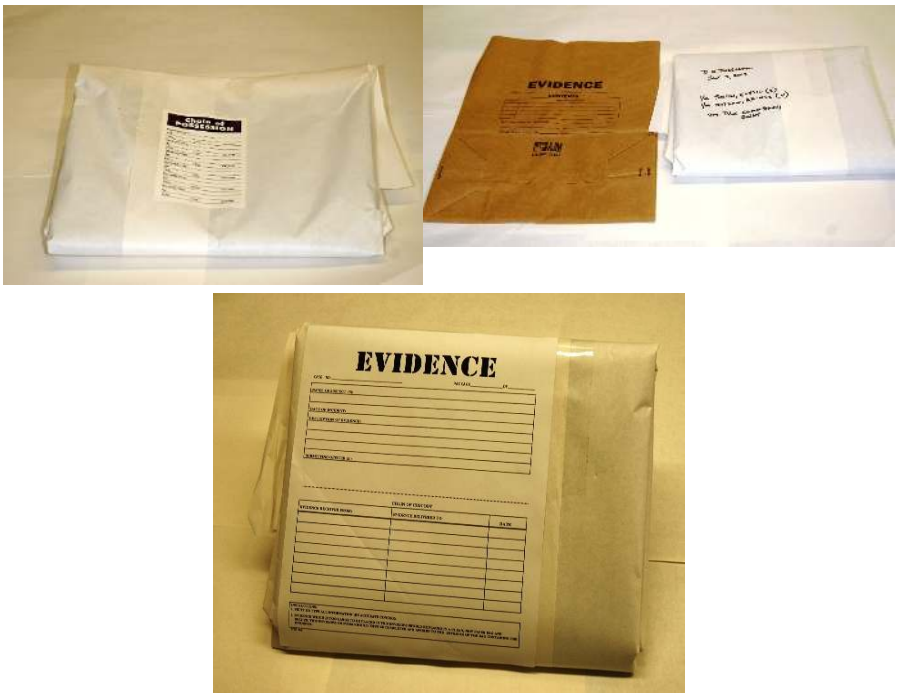


Figure **14.5.1*g, h, i***:*The proper way to package clothing as evidence. Author's collection*

- Fold the butcher paper small enough to fit into an evidence bag.
- Print and sign your name, with the date along with the suspect information and date on one side of the outside of the folded butcher paper (or use a gummed evidence label) and affix a Chain of Custody sticker to the other side.
- If it is necessary to identify an area of the garment that you wish to be sampled for DNA evidence, draw a picture of the garment on the outside of the butcher paper and mark on the picture with a circle and an 'x' where you want the sample taken (Fig. **14.5.2**

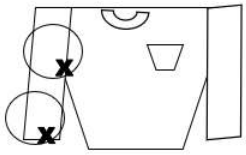


Figure **14.5.2**: Draw the item of evidence on the outside of the packaging and indicate the areas where stains appear. Author's collection

Should an agency require the officer's initials to identify the item of evidence, they can tie an evidence tag to a buttonhole and then the tag is either placed outside of the folded package or tucked between two sheets of paper inside of the package. Try to limit the potential for contamination by not writing directly on the garment.

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14.6: Biological Evidence from Victim and Suspects

Buccal Swabs

Buccal cells are located on the inner cheeks in the mouth and can be collected for DNA typing. Buccal swabs are usually used in place of obtaining blood.

- Only one sterile swab is needed for a mouth.
- Swab the inside of both cheeks by scrubbing the cheek walls on both sides with a sterile cotton swab.
- Place a shield over the applicator and return it to the sterile packaging. Seal the packaging and process it into evidence as normal. If the specimen is wet, it is best to place it in a refrigerated evidence locker. If the specimen is dry, it is acceptable to store it in temperature controlled dry storage.

Fingernail scrapings

Fingernail scrapings may contain trace evidence including blood, tissue, hairs, fibers or other foreign material that may have collected under the nails of the suspect or victim during a struggle or violent interaction. Moisten a sterile cotton swab in the manner described above and vigorously scrub under each nail to the nail bed. Use a separate swab for each finger and process the swabs individually. It is best to use an applicator shield to cover the cotton tip. Place a shield over the applicator and return it to the sterile packaging. Seal the packaging and process it into evidence as normal. If the specimen is wet, it is best to place it in a refrigerated evidence locker. If the specimen is dry, it is acceptable to store it in temperature controlled dry storage.

Bite marks

Bite mark impressions may be found on victims of an assault and can be compared with the teeth of the suspect. Photograph the bite marks with and without a scale and color chart. When using a scale, it is preferable to use a small L-shaped ruler, such as an ABFO #2 ruler, that is designed for bite marks. Also document the bite mark, including measurements. Slightly moisten a sterile cotton swab or sterile gauze pad with sterile water and rub around the bite mark area. Swab a second time around the area using a dry swab. Place the swab bag in its original sterile packaging and process it into evidence after allowing it to air dry in an area free of contamination.

Fired and unfired cartridge casings

Advancements in DNA extraction have made it possible, in certain circumstances, to acquire a genetic profile from a fired cartridge casing. It had long thought that the conductive properties of the metallic cartridge and the super heating that occurs with propellant discharge would evaporate the bodily fluids that contain DNA. However, in recent years various techniques, such as the soak and sonicate methods, have been successful in DNA extractions. Therefore, it is essential that the casings are properly collected at the scene with great care in reducing cross-contamination or sample degradation. To do this, your author has implemented strict guidelines at his agency that everyone must follow when collecting fired and unfired cartridge casings. Gone are the days of picking up fired cartridge casings with bare hands and tossing them in a plastic baggie. Gone are also the days of picking up the casings with gloved fingers. Today, every fired cartridge casing is picked up using a sterile tweezer and placed into an evidence box, the interior of which has been subjected to a three-minute short-wave ultra-violet bath. Each box should contain only one item of evidence. The technician is still required to wear gloves, and it is mandatory that they wear an N-95 mask. Your author is especially careful with bullets that are recovered from the crime scene. The object is to keep the bullets from rolling around within the box. Your author finds it best to use 2”x2” sterile gauze pads, wrapping the evidence item in the gauze pad, replacing it in the sterile envelope from which the pad was removed, folding it in a manner to keep the item from falling out (perhaps even a small piece of tape to secure the open end of the envelope), and placing it within the jewelry box.

Discussions should be had with investigators regarding subsequent cartridge casing analysis. Submission of fired cartridge casings to Integrated Ballistic Identification System, or IBIS, would preclude any additional forensic examination as the cases are thoroughly cleaned before imaging. The history of casings from cold-case investigations must be either known or deduced prior to submission to soak and sonicate laboratories, since the process is expensive and laborious.



Figure **14.6.1**: Jewelry boxes used for evidence collection

Observations

Before handling an item of evidence, consider how a person would hold the item and avoid grasping it in the same place. Inspect these areas for human biological evidence and consider collecting a specimen swab as soon as possible. Consider your options before using any forensic process that will destroy, alter, or contaminate potential DNA evidence. Make every effort possible not to contribute your own DNA to the crime scene or upon items of evidence found within that crime scene. Never discard your used latex gloves into the crime scene and prevent others from doing the same.

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14.7: Chain of Custody

Your author will close this chapter with a few words regarding chain of custody. As you may know, chain of custody is the chronological documentation of the movement and possession of an item of evidence from the time it was discovered and collected to the time it is presented in court. In other words, who had possession of the item of evidence, for how long, and for what purpose. Quite often, the 'for what purpose' gets overlooked, and a 'break' in the chain occurs which might have significant impact to the subsequent investigation or courtroom proceedings. By example, a police officer finds a handgun during a cursory pat search of a suspect. The proper chain of custody for the weapon would be as such: The officer who found the weapon maintains sole possession of the weapon and processes it into evidence and thus begins the chain of custody. The forensic analyst requests the weapon from the evidence custodian in a process that documents the request and release of the weapon. The technician conducts an analysis of the weapon, which might include photographic documentation for disciplinary or courtroom purposes, swabbing the item for DNA-typing, and fingerprint development. The technician then returns the item to documented evidence storage and writes a detailed report. Developed or collected specimen from the weapon is documented and sent off to a laboratory for subsequent analysis, comparison, or typing. The weapon itself is retained by the evidence custodian until it is presented in court proceedings. For this example, let us assume that an additional DNA profile is developed from the collected specimen swab, but the second profile, which did not match the suspect, was not found in the DNA database. This would present a sizeable concern for the prosecution. Let us then imagine another series of events that was never documented in the chain of custody. The police officer discovered the weapon and contacted their supervisor. That supervisor sends another officer to the scene to "borrow" the weapon and bring it to the supervisor's office for inspection. The weapon is retrieved, brought before the supervisor who examines it and instructs the retrieving officer to put it on a desk to take a photograph. The weapon was then returned to the original officer with the instructions to process it into evidence. All of this was done without documentation, and the original officer's report reflected only that he had 'retained possession of the weapon.' Sadly, this story is not fictitious. This second profile likely belonged to the second officer, the supervisor, or may have been transferred from the desk. You can imagine the impact of this second profile on subsequent court proceedings.

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14.8: Test Questions

1. This bodily fluid has the least potential for the recovery of DNA:
    a. Urine
    b. Feces
    c. Vomit
    d. Saliva
2. This is the quality of a latent print that allows the technician to assess the potential for the presence of a fingerprint deposit:
    a. Inherent luminescence
    b. Inherent scintillation
    c. Intrinsic glistening
    d. Effulgent glimmering
3. Wet blood should never be:
    a. Refrigerated
    b. Frozen
    c. Swabbed
    d. Dried
4. Items of clothing should be suitably packaged in:
    a. Cardboard
    b. Aluminum
    c. Butcher's paper
    d. Parchment
5. This should be used when picking up fired cartridge casings:
    a. Your fingers
    b. A gloved hand
    c. A paper scoop
    d. Sterile tweezers
6. Why should the forensic technician consider performing additional analysis of fired cartridge casings prior to being submitted to the IBIS:
    a. Supplemental evidence detection and collection will be lost because the casings are thoroughly cleaned before imaging
    b. Supplemental evidence detection and collection will be lost because the IBIS operator does not wear protective gloves
    c. Supplemental evidence detection and collection will be lost because there is no chain of custody
    d. Supplemental evidence detection and collection may be lost because the evidence is often misplaced or lost in the mail
7. What does the abbreviation IBIS mean?
    a. Investigative Bullet Identification System
    b. Illinois Ballistic Impression Service
    c. Integrated Ballistic Identification System
    d. International Ballistic Identification System
8. Before handling an item of evidence, the technician should:
    a. Wash their hands and gently pick up the item
    b. Consider how a person would hold the item and avoid grasping it in the same place
    c. Take a firm grip on the item so that it is not dropped
    d. Consider how a person would hold the item and grasp it in the same place
9. A written log that tracks an item of evidence from collection to court is called the:
    a. Property inventory
    b. Evidence handling log
    c. Chain of custody

d. Chain of evidence

10. The log that tracks an item of evidence from collection to court provides the judge with the accountability of evidence that includes who had possession of the item of evidence, for how long, and:
    a. At what time of day
    b. In what condition
    c. For what purpose
    d. The recommendation of the person who possessed the item

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14.9: Suggested Essay Topics

1. Write an essay about the evidence discovery, documentation, preservation, handling, analysis, and subsequent courtroom presentation of items of evidence in a major criminal investigation.
2. Write an essay about the development of touch DNA and modern DNA extraction and replication techniques.
3. Write an essay regarding the many ways that evidence can be excluded from courtroom proceedings.
4. Write an essay regarding the various methods of extracting DNA from fired and unfired cartridge casings.
5. Write an essay about the development and purpose of the Integrated Ballistic Identification System (IBIS) and the National Integrated Ballistic Identification System.

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14.10: References

Doglietto, D. (2025). Crime Scene Processing in Correctional Facilities and Prisons. CRC Press, Taylor & Francis Group.

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CHAPTER OVERVIEW

15: Forensic Report Writing

Learning Objectives

- To understand the role of the police or forensic report
- To understand the need for objectivity in forensic narrative or analytical reports
- To understand the role of the forensic narrative or analytical reports in courtroom proceedings
- To understand the basic structure of the forensic narrative or analytical report

15.1: Introduction

15.2: Fairness

15.3: Crime Scene Reports

15.4: Absolutes, Probabilities, and Tolerances

15.5: Test Questions

15.6: Suggested Essay Topics

15.7: References

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15.1: Introduction

> *'It was your average mid-Western strip mall built in the mid-1960s with a laundromat anchored on one end and a dry cleaner on the other. In between was the usual mix of a liquor store, an insurance salesman of some variety, a nail salon with a dubious history and character, and that one store with the darkened windows and vague signage that no one really knew what product they sold or service they provided. Where once a matching convenience store had been built on a corner of the property near the driveway, an Italian pizzeria now stood; a square building, brightly colored, proudly flying Italian flags, and isolated from the grey and silver, glass and concrete, rectangular shape of leased shops that faced the restaurant with scorn and contempt. Instead, the pizzeria rose from the asphalt, like the Pinta or Santa Maria on a vast ocean as they neared the landfall of a new and strange world, as a wonderous yet dreadful vision to the local natives, stalwart in their loathing of new things. The unmistakable smell of garlic, tomato sauce, and freshly baked pizza dough annoyed the senses of the insurance salesman, who, regardless of his perturbance, was a regular customer, a secret kept from the dry cleaner…'*

Perhaps not the beginning of the greatest novel ever written, but your author will bet the creative composition of the story held your attention and intrigued your imagination. The words have been arranged with narrative elements like shapes, colors, senses, tone, and even emotions to draw the imagination of the reader into the story. In doing so, however, your author has done something else: he has also introduced bias, division, and opinion. Whose side of the story are you on? Are you on the side of the stalwart but boring strip mall clan or the daring new pizzeria clan?

Remember the rules concerning the admissibility of evidence in court and how the evidence cannot play on the emotions of the attorneys, judge, or jury. The same is true for written evidence, such as a police or forensic report. Your author likes to refer to this form of writing as being clinical in nature where the emotions have been removed. Let us now look at the same strip mall through the words of the forensic technician who is setting the scene.

> *'The property consisted of a rectangular-shaped strip mall constructed in the mid-1960's using steel, concrete, and glass materials. The building had a south-west exposure, situated approximately 350' north of the 200-block of Main Street, and bore the following addresses above the glass entrance door of each store: 205A, Mom's Do-Your-Own Laundromat, 205B; FiFi's Nail Emporium; 205C, Baker's Insurance Agency; 205D, Fred's Never Leave Them Dry Liquors; 205E, an unknown or vacant store; and 205F, Speedy's Pretty-Quick Dry Cleaners. The strip mall encompassed an area approximately 150' in length and 67' in width. Angled parking stalls were noted directly in front of the walkways of the building and linear parking spaces were noted in the parking lot. 207 Main Street, Anthony's "Just Like Momma Made" Pizzeria, was located in the south-west corner of the property, approximately 18' north-east of Main Street, in proximity to the one driveway giving ingress and egress to the property.'*

A report is a written statement providing a permanent record of your actions, observations, and discoveries. Nearly every official action you take, participate in, or observe will ultimately result in a written report. It is the documentation of what you did, what you saw, what you smelled, what you heard, and what was told to you by eyewitnesses. And yes, like it or not, punctuation, spelling and grammar are important. Notice that your author said that the report is a record of YOUR actions, observations, and discoveries. In this regard, reports generated using artificial intelligence may look great, but they are not a representation of your actions; nor could they ever. Your author can only imagine how an attorney for the defense would use that to their advantage before a jury when

they discover you did not write your own report. Woe betides the forensic specialist who uses artificial intelligence to write a forensic report. Your author strongly believes using artificial intelligence to do your work for you is a clear indication that you have abandoned any hope of striving to be the very best at your profession. Furthermore, most internet-based artificial intelligence report writing “assistance” programs that are not subscription-based may be open-source platforms which would mean that the information being uploaded may no longer be confidential. Even subscription-based services may use the information you uploaded into their systems to improve their services; therefore, information you thought would be confidential may be integrated into the general knowledge of the artificial intelligence model and inadvertently incorporated into responses to other inquiries. This could create a tremendous problem, including litigation, for the law enforcement agency when this highly sensitive information has been revealed.

The forensic technician will generally be tasked with writing two types of reports: a narrative report or a forensic analytical report. A narrative report is generally a chronological accounting of the functions performed by the technician, starting at the point at which the writer becomes involved in the action. The narrative ends at the point where the writer’s action is completed. This form of writing will include the date and time of the action, along with an introduction of the writer, including their assignment and responsibilities, and the purpose for their role in the action. It will then contain a step-by-step accounting of what they did. A forensic analytical report is an official written document that is a record of the scientific examination of a crime scene, or the evidence from that scene, that documents how the evidence was analyzed, the scientific methodologies that were employed, the results of the analysis, and the opinion of the analyst to the conclusions discerned from the analysis. This type of report, and the testimony of the expert witness, serves to assist the “trier or fact” in a legal matter, whether it is the jury or a judge, in order to understand complex technical or scientific matters to help them form an opinion on the guilt or innocence of a defendant. These reports should be highly detailed and objective as to how the conclusions were made.

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15.2: Fairness

The forensic technician is only interested in documenting the facts and discovering the truth. The objective forensic technician looks for evidence that will not only prove guilt but also exonerate the innocent. Therefore, it is imperative to avoid the use of words that may produce connotations that cloud the true meaning of the facts. Do not use descriptive terms that tend to exaggerate what was observed or discovered, like a 'hideous wound' or 'the victim writhed in abject agony displaying a grotesque expression'; however, providing a detailed description is required when it is necessary for accurately. If a laceration must include proper terminology to accurately describe the injury, such as being of 'jagged and uneven appearance with contused abrasions, sub-dermal depressed bone, and bridging, measuring approximately 4" in overall length and exhibiting active bleeding', although conjuring a visual image in the mind of the reader it is an accurate depiction of the wound. In forensic narrative and analytical reports, all essential facts are to be included so as not to require supplemental reports to clarify concepts or correct omitted information. The facts recorded must be relevant to the report. Do not, however, sacrifice completeness for the sake of being concise. If it is necessary to be wordy in order to have an exact description of an event or analysis, then it is better to be wordy. When writing these types of reports, it is best to write in a manner that would convey the most accurately detailed information as if you were trying to paint a picture of the event or analysis to a person you are talking to over the telephone or is visually impaired. In spite of this, your author is a proponent of using photographs within the body of the report to clarify important information. If you are documenting a bullet defect in the fender of a car, provide a written description of the bullet hole and provide a thumbnail photograph to confirm the description so that there is no confusion like this:

> *'Defect AA2 is a perforated bullet hole on the lower left rear taillight lens. Horizontal trajectory was determined by trajectory rod to be 55 degrees traveling right to left with a downward trajectory of approximately 1 degree. The bullet was not recovered.'*



Figure **15.2.1**: Bullet defect in brake lens - Author's collection

Also, do not be a lazy writer. Never abbreviate law enforcement titles (i.e. Sgt., Lt., Capt., etc.). This is the crutch of the lazy writer. Always use the formal title of law enforcement personnel first and then use the more casual title in the remaining text. Therefore, when first introducing a person to the report, use their formal title, such as Correctional Captain J. Smith. Following that introduction, you may refer to this person subsequently as Captain Smith. Never refer to a person by last name only. This is a journalistic technique that has no place in report writing.

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15.3: Crime Scene Reports

Crime scene reports are a form of narrative report but are more detailed than any other incident report because subsequent analysis by other forensic specialists such as bloodstain pattern analysts, shooting scene or crime scene reconstruction specialists, and entomologists may rely upon the condition of the crime scene immediately following the event. As an example, a bloodstain pattern examiner may need to know the environmental condition of the crime scene to understand the drying time of the blood documented in the scene. An arson investigator may need to know the ambient temperature, wind direction, and percentage of humidity to understand the behavior and spread of a fire. I document this information, which is handily found in the weather application on my cellular telephone, immediately upon reaching the crime scene, and I document this information in the introduction of the report like this:

> *'On December 29, 2022, at approximately 1900 hours, I responded to 1503 Redding Avenue to provide mutual aid from the Greenfield Police Department, Forensic Services Unit, following a stabbing incident resulting in an officer-involved shooting. I arrived on scene at 2015 hours. The ambient outside temperature upon my arrival was 48 degrees Fahrenheit, with no detectable winds, with 80% humidity. Outdoor scene lighting was provided by overhead lamps, vehicles headlights, and supplemented with handheld flashlights. Although sufficient for scene inspection and evidence detection, electronic flash was required for photographic documentation purposes. The crime scene perimeter had been established prior to my arrival on scene.'*

Crime scene reports should also contain the following paragraphs:

The introduction

The introduction paragraph informs the reader the date, time, and location of the crime scene. It also includes how you were notified to respond to the crime scene, your title and agency information, and your time of arrival.

Environmental condition

The environmental conditions of the crime scene include the previously discussed weather conditions if the scene is outdoors, or the environmental conditions of an interior location. In indoor settings, this might include the ambient temperature, lighting conditions, whether doors or windows were open or if an air conditioner or heater was running.

Initial observations

Initial observations include all the details of the crime scene upon the first inspection. This may include information regarding the crime scene perimeter, the presence of a decedent, the presence of fired cartridge shell casings, the presence of weapons and their conditions, the need to preserve perishable or transient evidence, evidence of emergency medical attention, and any other observation related to items of evidence first noted in the scene.

The body of the report

The body of the report is a detailed presentation of everything that was done to properly preserve, document, and process the crime scene, and the collection and disposition of the evidence discovered within the crime scene. This may include efforts to enhance latent evidence in the scene or any other procedural effort to identify or visualize trace evidence. This may also include information pertinent to bloodstain pattern analysis or any other impression evidence in the scene.

Evidence inventory

Before closing the report, please include an itemized inventory of the evidence that you collected and its disposition. It is frustrating as a forensic analyst to read through a dozen reports from a shooting incident and seeing that evidence was collected, but is only referenced as, 'Five shell casings were collected from the scene.' It is helpful to include an inventory of the evidence in one convenient place in your report like this:

- While processing the crime scene, I collected the following items of evidence:

Item #1 – One Remington Peters brand 9mm Luger brass fired cartridge casing

Item #2 – One Federal Cartridge brand 9mm Luger aluminum fired cartridge casing

Item #3 – One Winchester brand 9mm Luger brass fired cartridge casing

Item #4 – One Remington Peters brand .40 S&W caliber brass fired cartridgecasing

Item #5 – One CCI brand .40 S&W caliber aluminum brass fired cartridge casing

Include a disposition for the items as well, such as: All items of evidence were processed into long term evidence storage at the Greenfield Police Department.

The following is an excerpt from a homicide investigation. The case has been adjudicated in court, but the names and addresses have been changed and photographs omitted:

> On January 13, 2023, at approximately 1540 hours, while assigned as an investigator and senior forensic specialist with the Greenfield Police Department, and as a member of the Major Crimes Unit, I was notified by telephone of the activation of the Major Crimes Unit following the discovery of a victim of multiple gunshot wounds on the sidewalk in front of 225 Belmont Street, in the city of Greenfield. I arrived on the scene at approximately 1700 hours and was briefed of the known facts by Detective J. Guzman. The deceased victim of the gunshot wounds was preliminarily identified as Robert Cambridge (aged 21); later confirmed by the photograph as it appeared on his California Driver's License. The decedent was covered by a yellow plastic tarp placed by members of the Greenfield Fire Department.
>
> Ambient temperature was approximately 55-degrees Fahrenheit, with winds from the south-east at 7mph. The ambient outside temperature upon my arrival was 48 degrees Fahrenheit, with no detectable winds, with 80% humidity and barometric pressure of 30.06inHg. Outdoor scene lighting was provided by overhead tungsten lamps, vehicles headlights, and supplemented with handheld flashlights. Although sufficient for scene inspection and evidence detection, electronic flash was required for photographic documentation purposes.
>
> 225 Belmont Street is the fourth house northwest of Holly Oak Avenue on the west-south-west side of the street. The house has an east-north-east exposure. It is a single-dwelling residence with a small, attached apartment on the south-south-west corner of the house. Crime scene tape was stretched across the intersection of Belmont Street and Date Avenue to the north-north-west of the crime scene, and across Belmont Street from the telephone pole at the corner of 213 to 212 Belmont Street. The primary crime scene was on the sidewalk and roadway in front of 223 and 225 Belmont Street. A crime scene log had been maintained by Officer T. Grant of the Greenfield Police Department.
>
> The decedent was lying on the sidewalk, in front of the east-south-east corner of the driveway, in the supine position in a north-north-east orientation. The decedent was wearing red athletic shorts, black Nike brand socks, and black Air Jordan brand tennis shoes. A red and black in color nylon jacket and maroon in color long-sleeved shirt had been cut from the decedent and remained in the scene underneath the torso of the decedent. Two AED pads and four electro-monitoring pads were affixed to the chest and stomach of the decedent. Pooled blood was noted underneath the head of the decedent and blood exhibiting flow was noted originating under the right heel of the decedent.
>
> Evidence markers had not been placed by responding officers and therefore the scene was documented in its entirety using scene establishing, evidence establishing, and evidentiary photography prior to the placement of evidence markers, and again after evidence markers were placed to identify items of evidence. It should be noted documentation and processing of the crime scene and the items of evidence it contained occurred overnight and therefore the items of evidence were collected and booked on the morning of January 14, 2021.
>
> Seventeen .45ACP caliber fired Federal brand cartridge casings were noted in the roadway and sidewalk in the primary crime scene. Seven 9mm caliber fired Winchester brand cartridge casings were noted in the roadway directly in front of 223 Belmont Street. It should be noted several of the fired cartridge casings were underneath or in proximity to Greenfield Police Department patrol vehicle #31. After documenting the position of these shell casings, and the position of each tire, I carefully guided the patrol vehicle out of the scene in a manner not to disturb the position of the shell casings. It appeared only one fired cartridge casing (#18) was damaged by the patrol vehicle on arrival at the scene. A 1992 Honda Civic hatchback, white

in color (Vehicle Identification Number and California License Plate have been provided on the face page), was parked in front of 223 Belmont Street. The driver's side and passenger side doors were in the open position. One penetrated bullet defect was noted on the driver's exterior door. One grazed bullet defect was noted on the exterior sunroof. The driver's door window and hatchback window were compromised, and the glass fragmented and displaced. No other defects were noted on the vehicle. The floor mats for the vehicle were removed and on top of the hedges in front of 223 Belmont Street. A 2015 Chevrolet Cruze sedan (provided on the face page), dark grey in color, was parked directly behind the Honda Civic. One perforated bullet defect was noted on the front passenger windshield, and one penetrated bullet defect was noted on the roof line above the driver's side windshield.

The report lists the precise location and description of each item of evidence in the crime scene, as well as bloodstain pattern analysis, shooting investigation details, and other important aspects of the crime scene.

The following is an excerpt from a forensic examination report. The case has been adjudicated in court, but the identifying details have been changed and photographs omitted:

On January 20, 2024, the Gabilan Police Department requested the assistance of the Greenfield Police Department, Forensic Services Unit, for the forensic examination of a firearm and accompanying magazine recovered on January 16, 2022, and processed into evidence by Officer S. Barron as follows:

Item #SB18 – One Taurus brand PT709 Model, silver and black in color, serial number X04228, caliber 9mm Luger (9mmx19mm).

On this date, I conducted a forensic examination and functions test of the above listed item as follows:

Item #SB18 is a Taurus firearms brand PT709 "Slim" model semi-automatic pistol chambered in 9mm Luger (9mm x 19mm), 3" barrel, black polymer frame and matte stainless-steel slide. The unloaded seven-round capacity magazine was inserted in the pistol.

I collected two DNA-specimen swabs from the grips, forestrap, backstrap, slide grooves, and levers as item DJD#1. I collected two additional DNA-specimen swabs from the trigger face of the pistol as item DJD#2. It should be noted all DNA-typing swabs were collected under sterile conditions in the Airstream laminar flow PCR down-draft chamber following standard sterilization procedures. The barrel was tested for gunshot residue using the sodium rhodizonate color test method. This method produced positive results for having been recently fired. I processed the firearm and magazine for latent prints using the cyanoacrylate ester fuming method. This method produced a positive result for a left thumb ridge-print impression on the right side of the slide behind the ejection port. This impression presented sufficient ridge retail for individualization. The impression was photographed with a scale and left in situ for subsequent development using Basic Yellow dye. Portions of the impression that lacked sufficient detail for individualization were swabbed for touch-DNA as item DJD#3.

It should be noted that the pistol functioned properly (extractor, ejector, firing pin, slide, safety, magazine release, sear, and trigger). While conducting the forensic examination of the above listed items of evidence, I collected the following items of evidence:

Item DJD#1 – Two DNA specimen swabs from the grips, forestrap, backstrap, slide grooves, and levers from item #SB18.

Item DJD#2 – Two DNA specimen swabs from the trigger face of item #SB18.

Item DJD#3 – Two touch-DNA specimen swabs from developed ridge-print impression on the right side of the slide of item #SB18.

All items of evidence were surrendered to the Gabilan Police Department with this report.

Conjunctions

Conjunctions have no place in formal report writing unless the writer is directly quoting a person. Conjunctions have invaded not only our common dialogue, but also in our written forms of communication. Even AI programs include conjunctions while "assisting" people with writing essays and emails. This is another example of a lazy writer. Therefore, please, it is (it's) imperative that you do not (don't) use contractions unless you cannot (can't) avoid their use because you are quoting a person. Your author cannot stress this enough.

Your final report

Once you have submitted your final report, no changes to that document should occur. Corrections and additional information should be provided as a supplemental report. Never make a change to your report after the original has become part of discovery in court proceedings.

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15.4: Absolutes, Probabilities, and Tolerances

Absolutes, probabilities and tolerances are concepts that do appear in forensic analytical reports with some careful consideration. Forensic analysis reports avoid the use of absolutes. Several decades ago, it was not uncommon for a fingerprint comparison report to include the language that the comparison was a match to the exclusion of all others. The problem with a statement like this is that although in all our efforts we have yet to find two fingerprint patterns that are in agreement, we have yet to record the fingerprint impressions of several generations of everyone in the world. What we can say is that finding two people with the same fingerprint patterns living in the same area to be highly unlikely. Forensic analytical reports also tend to limit the use of probabilistic deductions unless where necessary. Therefore, rather than writing that the estimated arc of fire for the position of a shooter based on the convergence of trajectory and the cluster pattern of fired cartridge casings in the scene is a zone of probability, it is better to say that it is a zone of possibility. Probability would require a certain amount of mathematical conclusions, and there are too many variables involved in a shooting scene investigation. Probabilities are a mathematical method of quantifying the uncertainty of an event of evidence, used to make a determination of the likelihood of an event. Likelihood Ratios compare the probability of the evidence under at least two different hypotheses (i.e. a specific person versus a random person). This is contrasted by the probability that a random person would match the evidence. This is called the Random Match Probability standard. Probability is important in DNA analysis because the Random Match Probability includes the possibility of a coincidental match, but the Likelihood Ratios compare the strength of the evidence for a person being the source of the match as opposed to a random person being the contributor of the source. Therefore, the Random Match Probability of the match between the contributor of the source DNA and an unrelated person can be extremely, well, unlikely. In fact, it can be as low as one in a billion people. Tolerance can appear in two ways, both of which can present its own problems. In forensic science, tolerance refers to margins of error in analysis. If you recall following the Daubert Decision that the judge is the gatekeeper of the expert witness testimony and one of the considerations for the testimony to be allowed is the known error rates. Error rates may be known in scientific experimentation, but not necessarily in the forensic sciences where observations and opinions may not have known error rates. Therefore, it is important that the forensic expert must be aware that their analysis may contain errors. Consider that a forensic analyst compared the firing pin marks of fired cartridge casings from a shooting scene with fired cartridge casings recovered from a firearm suspected of having been used in the shooting. The casings appear to be in agreement. The analyst would be cognizant that they had not compared every firearm in the country and therefore would be in error if they reported that the firearm was the definitive contributor of the fired cartridge casings found in the shooting scene. The analyst, however, would not be incorrect to report that the fired cartridge casings were in agreement and consistent with having been produced by a common source. If asked during testimony if this is a definitive match, the analyst would respond accordingly as not to give the impression that there may not be another firearm in the world that could have fired the cartridge casings found in the scene. Tolerances may also find themselves introduced into courtroom testimony when a forensic technician is testifying about the confirmatory analysis of a drug. This testimony may include the weight and purity of the drug. It is a defense strategy to introduce the concept of drug use tolerance. Tolerance, in this regard, is the diminished response to a specific drug based on its repeated use and the body's ability to adapt to its continued presence. In other words, it takes more of the drug to achieve a desired result if the person uses the same drug repeatedly.

The analyst should avoid this line of questioning and instead provide an opinion if the quantity of drugs that were analyzed were of a usable amount regardless of their effect on the user. Most states provide statutes for the definition of a usable about as any amount that can be manipulated and consumed.

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15.5: Test Questions

1. A report is a written statement providing a permanent record of _____ actions, observations, and discoveries.
    a. third-party
    b. witness
    c. your
    d. random
2. Forensic specialists such as bloodstain pattern analysts, shooting scene or crime scene reconstruction specialists, and entomologists may rely upon this entry in your report:
    a. Proper grammar and punctuation
    b. The condition of the crime scene immediately following the event
    c. The phase of the moon
    d. The crime scene entry and exit log
3. This portion of your report informs the reader of the date, time, and location of the crime scene. It also includes how you were notified to respond to the crime scene, your title and agency information, and your time of arrival:
    a. The introduction
    b. The weather conditions
    c. The initial observations
    d. The body of the report
4. This portion of your report includes all the details of the crime scene upon the first inspection:
    a. The introduction
    b. The weather conditions
    c. The initial observations
    d. The body of the report
5. This portion of your report is a detailed presentation of everything that was done to properly preserve, document, and process the crime scene, and the collection and disposition of the evidence discovered within the crime scene:
    a. The introduction
    b. The weather conditions
    c. The initial observations
    d. The body of the report
6. These words should be avoided in formal report writing unless used as direct quotations:
    a. Contradictions
    b. Conjunctions
    c. Contractions
    d. Compliments
7. These definitive observations should be avoided in forensic reports:
    a. Approximations
    b. Absolutes
    c. Abstractions
    d. Accuracy
8. These are a mathematical method of quantifying the uncertainty of an event of evidence, used to make a determination of the likelihood of an event:
    1. Possibilities
    2. Potentialities
    3. Probabilities
    4. Predictions

9. These compare the probability of the evidence under at least two different hypotheses (i.e. a specific person versus a random person):
    a. Likelihood Ratios
    b. Likelihood Estimates
    c. Random Match Probability
    d. Random Positive Match
10. This is the probability that a random person would match the evidence:
    a. Likelihood Ratios
    b. Likelihood Estimates
    c. Random Match Probability
    d. Random Positive Match

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15.6: Suggested Essay Topics

1. Imagine a crime scene room with three objects on the floor. The three items are a bloodstained knife, an overturned chair, and a deceased person. Now write a report with precision detail explaining your observations without the use of photographs or diagrams.
2. Write an essay about human bias in forensic analysis and report writing. Include historical examples of forensic reports that exhibited bias and erroneous conclusions.
3. Conduct research on the infamous Jack the Ripper police investigations and provide accurate details and your analysis of the reports that were written, such as the Macnaghten Memoranda, the Warren's Report on the Goulston Street Graffito, and Dr. Thomas Bond's post-mortem report on Mary Jane Kelly. How would these reports differ from those that would be written if the Jack the Ripper investigations occurred in the current year.
4. Write an essay regarding the importance of the forensic narrative or analytical report to the prosecution of a person suspected of a crime and the subsequent proceedings in court. Provide examples of recent high-profile prosecutions.

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15.7: References

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Glossary

American common law system |

A body of unwritten laws based on legal precedents called stare decisis as established by the courts.

Amido Black |

An amino acid staining dye method used in forensic investigations to detect fingerprints deposited with blood. Amido black stains the proteins in blood a blue-black color ($C_{22}H_{14}N_6Na_2O_9S_2$).

Angle-finder |

A useful digital or mechanical tool used for measuring the vertical angle of a bullet defect.

Anoxia |

The complete deprivation of oxygen to the brain.

Ardrox |

A fluorescent spray that is designed for enhancing latent prints that have been developed with cyanoacrylate

Area of convergence (bloodstain) |

The area containing the intersections generated by lines drawn through the long axes of individual stains that indicates in two dimensions the location of the blood source (SWGStain).

Area of convergence (shooting) |

The two-dimension intersection of lines drawn by matching fracture lines in safety glass in a shooting incident.

Artery |

Tubular branching muscular-walled vessels that carry oxygenated blood from the heart through the body to organs and tissues.

Asphyxia |

The partial deprivation of oxygen to the body that may result in hypoxia.

Avulsive laceration |

An injury where the impacting force strikes the skin at an angle causing the skin to slip or rip.

Back-spatter pattern |

A bloodstain pattern resulting from blood drops that traveled in the opposite direction of the external force applied

Ballistics |

The forensic study of bullets or other projectiles in flight (Hueske).

Baseline |

The tape-measure line in diagramming starting at a fixed point and a known compass direction used as a bases for other intersecting measurements.

Basic Yellow 40 |

A fluorescent yellow dye stain used with an Alternate Light Source to visually enhance fingerprints developed by cyanoacrylate ester fuming.

Battery |

The condition of a weapon when it is ready to fire (Hueske).

Bird’s Eye View |

A form of diagram where the two-dimensional depiction of the crime scene is from above and looking down with a zoomed-out perspective.

Bloodstain Pattern Analysis |

Bloodstain Pattern Analysis is the interpretation of bloodstains found at a crime scene in order to understand or reconstruct the actions that caused the bloodshed.

Bluestar™ |

A very sensitive latent bloodstain reagent that produce an intense blue chemiluminescence.

Bolt-action |

A firearm with a breech that is line with the bore and requires manual manipulation to load, cock, fire (typically the release of a firing pin) and extract a cartridge and cartridge case (Hueske).

Bore |

The internal aspect of a barrel beyond the chamber (Hueske).

Breech |

The opening in a firearm where cartridges are loaded into the chamber (Hueske).

Buccal swabs |

A cotton or other applicator-tipped swab used to collect cells from the inside of a person's cheek for DNA confirmatory testing. The word "buccal" means "cheek" or "mouth" and is pronounced as “buckle.”

Bullet |

The projectile component of a cartridge (Hueske).

Bullet defect |

A suitable term for a bullet or pellet hole (Hueske).

Bullet jacket |

The metallic outer skin of a bullet (Hueske).

Bullet wipe |

A combination of grease and soot surrounding the margins of a bullet defect caused by the progression of a bullet (Hueske).

Caliber |

The cross-sectional diameter of the interior of a barrel from land to land. This is also the cross-sectional diameter of a bullet (Hueske).

Cartridge |

The complete components of a round of ammunition including a cartridge casing, primer, propellant, and bullet. A cartridge should never be defined as a “bullet” in your report (Hueske).

Cartridge case |

The metal or paper container that holds the propellant, bullet, and primer (Hueske).

Cast-off pattern |

A bloodstain pattern resulting from blood drops released from an object due to its motion.

Casting |

A process that uses a casting material like dental die stone to create a 3D model of an impression found at a crime scene.

Center-fire cartridge |

A cartridge that has a primer pocket in the center of the headstamp where a primer is seated (Hueske).

Cessation cast-off pattern |

A bloodstain pattern resulting from blood drops released from an object due to its rapid deceleration.

Chamber |

The cavity attached to the barrel that is constructed to fit a particular cartridge, into which is loaded in order for it to be fired. Revolvers will have multiple chambers (Hueske).

Chamber marks |

The transferred striations, impressions, or indentations on a cartridge casing from the imperfections within the chamber walls. These marks are significant of individual characteristics (Hueske).

Clinical photographs |

Non-prejudicial photographs taken of wounds that show only the wound without blood, painful expressions, or any other image that will cause a sympathetic response by the judge, jury, or attorneys.

Clip |

A device used to load ammunition into a magazine (Hueske).

Close contact shot |

A shot fired with the muzzle of the firearm pressed against a target (Hueske).

Close-up photographs |

Photographs taken with the intent to provide detailed images of an item of evidence. The object will appear larger than normal size and centered in the frame. A scale is necessary for comparative purposes.

CODIS |

An acronym for the Combined DNA Index System, which is a computer software program that operates local, state, and national databases of DNA profiles from convicted offenders, unsolved crime scene evidence, and missing persons (Bureau of Justice Statistics).

Compound fracture |

A broken bone that protrudes from the skin.

Contusion |

A contusion, also known as a bruise, is a type of tissue hematoma that occurs when small blood vessels under the skin burst and leak blood into the surrounding tissues.

Coomassie Blue |

An enhancement chemical used to dye blood-contaminated fingerprints on porous or non-porous surfaces, which produce bright blue visible prints ($C_{45}H_{44}N_3NaO_7S_2$).

Cyanoacrylate ester fuming |

A chemical development method that uses esters from cyanoacrylate adhesives to detect latent fingerprints on non-porous surfaces.

Cylinder gas deposit |

The deposition of soot on surfaces of a firearm where a gap exists between the cylinder and the barrel. This is most commonly associated with revolvers (Hueske).

Datum |

The fixed point of the baseline where the tape measure begins at zero.

Diagramming |

The process of creating a two-dimensional depiction of the crime scene using accurate measurements.

Dithiooxamide |

A chemically specific chromophore test for the presence of copper ($C_2H_4N_2S_2$).

DNA |

Deoxyribonucleic acid is a polymer composed of two polynucleotide chains that wrap around each other to form a double helix, which carries genetic information.

Dog dots |

Circular and colorful self-adhesive stickers that are used in crime scene mapping to ensure that photographs are taken parallel to the film plane.

Double action |

A firearm with a trigger mechanism that cocks and releases the hammer without the need for manual cocking (Hueske).

Double-barrel |

Commonly, a shotgun with barrels arranged side-by-side or over-under

Drip trail |

A bloodstain pattern resulting from the movement of a source of drip stains between two points (SWGStain).

Edge characteristic |

A physical feature of the periphery of a bloodstain (SWGStain).

Ejection |

The removal, whether manual or automatic, of the fired cartridge casing from the breech to facilitate a reload (Hueske).

Ejection pattern |

A clustering of ejected fired cartridge cases that may assist in determining the direction a firearm was discharged from a given position (Hueske).

Ejector marks |

Small marks left on the soft metal of a cartridge case or shot shell as it is being ejected from the breech (Hueske).

Evi-Vac System |

A forensic vacuum cleaner that captures trace evidence in a sterile container.

Expectoration pattern |

A bloodstain pattern resulting from blood forced by airflow out of the nose, mouth, or a wound (SWGStain).

Exploded view diagram |

A two-dimensional visual depiction of a crime scene where the ceiling and walls are connected but laid flat.

Exsanguination |

A significant loss of blood from the body to no longer sustain life.

External ballistics |

Also called exterior ballistics, the forensic discipline associated with bullets upon leaving the barrel of a fired firearm (Hueske).

Firing pin |

The mechanism that strikes a primer and causes a discharge of the cartridge (Hueske).

Firing pin impression |

The three-dimensional impression left on the primer by the firing pin (Hueske).

First Responder |

A person with specialized training and authority who is among the first to arrive at an incident or emergency.

Flow pattern |

A bloodstain pattern resulting from the movement of a volume of blood on a surface due to gravity or movement of the target (SWGStain).

Footwear impression |

A detailed impression of a shoeprint either in two-dimension as a transfer or in three-dimension as a molded deposit in a soft material.

Forward spatter pattern |

A bloodstain pattern resulting from blood drops that traveled in the same direction as the impact force (SWGStain).

Fractures |

A complete or partial break in a bone.

Function testing |

The process of testing a firearm to determine operability (Hueske).

Gas operated |

A firearm that utilizes gas from the discharge of a cartridge to cycle additional cartridges into the breech and chamber (Hueske).

Gassing |

A felonious battery by the intentional placing, throwing, or projecting of human bodily fluids, excrement, or other bodily substances on correctional personnel.

Gauge |

In a shotgun, the gauge is the number of pellets or shot by size that equal to one pound (Hueske).

Grid pattern search |

A search technique whereby large areas are reduced to smaller areas that can be easily searched by fewer people. This technique can also be used in smaller areas where it is necessary to locate and document minute trace evidence.

Grooves |

The helical grooves in the interior of the barrel that prove stabilizing spin on a fired bullet (Hueske).

Gunshot Residue (GSR) |

Residue associated with the primer and propellant upon firing (Hueske).

Hammer |

The mechanism that delivers energy to the firing pin (Hueske).

Handgun |

Any weapon that is designed to be held by hand without support (Hueske).

Hexagon (Bluestar) OBTI Immunochromatographic Rapid Test™ |

A two-part presumptive screening test to determine if a blood specimen is consistent with the human species.

Horizontal |

Parallel to the plane of the horizon

Hungarian Red |

An aqueous solution used to enhance fingerprint deposits in blood when used with an Alternate Light Source (between 520nm-560nm).

Impact spatter pattern |

A bloodstain pattern resulting from an object striking liquid blood SWGStain).

Incised wounds |

Also known as a cut or slash, is a clean, straight cut in the skin caused by a sharp object with a sharp edge or tip that leaves a wound that is generally longer than it is wide or deep.

Indeterminate range |

A shot fired from a distance that cannot be determined.

Infrared Imaging |

A photographic technology that captures images of the IR spectrum (750nm +/-) which is invisible to the human eye. It is useful to detect bodily fluids or GSR on dark colored fabrics.

Inmate manufactured improvised handheld weapon |

A common object that has been altered by an inmate to increase its potential as a weapon, or the assembly of objects that can be used as weapon that is small enough to be held in a hand. A “shank” or “shiv” is a specific term used for a stabbing-type weapon.

Intermediate range |

A shot fired when the muzzle of the weapon is held away from the body at the time of discharge yet is sufficiently close to cause powder “tattooing” and stippling (Hueske)

Internal ballistics |

The forensic science that deals with the firearm prior to the bullet exiting the barrel (Hueske).

International Association for Identification (IAI) |

Founded in 1915 by Harry H. Caldwell of the Oakland Pollice Department in California, the IAI is the oldest and

largest association for forensic practitioners, which also maintains certification programs in numerous forensic disciplines including bloodstain pattern analysis, crime scene investigations, and latent print examination, amongst others (theiai.org).

International Association of Arson Investigators (IAAI) |

Formed in 1949 and chartered in 1951, an organization dedicated to support fire, arson, and explosive investigation professionals through leadership in education, training, professional development, certification, networking, advocacy, and the provision of resources (firearson.com).

International Association of Bloodstain Pattern Analysts (IABPA) |

Founded in 1983 be Professor Herbert MacDonell, an organization of forensic experts specializing in the science of bloodstain pattern analysis (iabpa.org).

Jugular vein |

A paired venous structure that collects blood from the brain, superficial regions of the face, and neck, and delivers it to the right atrium of the heart. The jugular veins are not protected by bone or cartilage (NIH).

Keyholing |

A bullet impact that resembles a keyhole the result of a bullet that tumbles or wobbles in flight (Hueske).

Laceration |

A blunt-force injury produced by a shearing or crushing force, such as caused by a fist, a lock-in-a-sock, a broom handle, or an impact-type weapon.

Langer's lines |

Also called cleavage lines, Langer's lines were first described by Karl Langer in 1861 and are skin tension lines.

Latent |

Invisible to the human eye.

Leuco-Crystal Violet (LCV) |

Also known as Aqueous LCV, a reduced form of gentian violet, it is a highly sensitive formula to visually enhance blood prints. The reaction to blood will produce a vibrant violet result.

Leucomalachite Green (LMG) |

A presumptive test for blood that can also be used to visually enhance blood prints. The reaction to blood will produce a greenish-blue result. LMG is a known carcinogen and therefore personal protective equipment must be used.

Lever action |

A firearm that uses a lever to open, close, or cycle cartridges into the breech (Hueske).

Ligature |

In forensic pathology, a device used to externally constrict the throat causing the deprivation of oxygen.

Ligature marks |

Contusions on the neck created by a ligature.

Ligature strangulation |

The act of strangulation with the use of a cord, rope, wire, or other cord-like device.

Lividity |

The settling of the blood in the lower portions of the body dependent to gravity after death resulting in a reddish-purple discoloration of the skin.

Long gun |

A firearm designed to be supported by the shoulder (Hueske).

Magazine |

The internal or detachable box that contains a supply of ammunition that is fed into the chamber of a firearm (Hueske).

Manual strangulation |

The external constriction of the throat using the hands, fingers, arms, or other articulable body part resulting in a deprivation of oxygen.

Mapping |

A process of identifying, measuring, and documenting important items of evidence in a crime scene

Microcrystalline drug test kits |

An empirical presumptive test for drugs in which there is a chemical reaction between a narcotic or controlled substance and a reagent that yields a crystal formation that can be observed as a color change.

Mid-Range photography |

Also known as evidence-establishing photographs, mid-range or medium view photographs record the position of items of evidence in relation to other items of evidence and their position within the crime scene.

Mist pattern |

A bloodstain pattern resulting from blood reduced to a spray of micro-drops as a result of the force applied (SWGStain).

Molded |

Also known as a plastic impression, a molded impression is an impression deposited in wax, mud, dirt, or any soft, rubbery surface.

Mutual Aid |

An agreement between two or more law enforcement or criminal justice entities to provide support regardless of jurisdiction.

Muzzle |

The open end of the barrel (Hueske).

Muzzle blast |

The explosive shockwave at the muzzle as the result of combustion of propellants after discharge (Hueske).

Muzzle imprint |

An abrasion in the skin resembling the muzzle of a firearm following a close or near contact shot (Hueske).

Muzzle velocity |

The speed of a bullet at the moment of exiting the barrel (Hueske).

N-95 mask |

A respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles (FDA).

Near contact shot |

A shot fired from a firearm where the muzzle of the firearm is not firmly pressed against the target but exhibits a small gap between the muzzle and the target (Hueske).

NIBIN |

The National Integrated Ballistic Information Network (NIBIN) is the only national network that allows for the capture and comparison of ballistic evidence to aid in solving and preventing violent crimes involving firearms (ATF).

Ninhydrin |

A chemical reagent used to process ridge print impressions on porous materials. Ninhydrin reacts with amino acids, which produces a deep purple impression called Ruhemann's purple.

Oblique |

Held at a slant or angle.

Overall photographs |

Also known as scene establishing photographs, overall or over-view photographs document the entirety of the crime scene, its location, and boundaries.

Parallel photographs |

Photographs taken with the lens parallel to the evidence in an effort to reduce or eliminate distortion.

Patent |

Impression evidence that can be seen with the human eye without the need of enhancements.

Pellet |

Small round shot used in shotgun shells (Hueske).

Penetration |

A bullet that enters a target but remains within the last substrate it impacted (Hueske).

Perforation |

A bullet that remains within the last substrate it impacts (Hueske).

Perspective photographs |

Crime scene photographs taken with the photographer standing at full height (natural perspective) or at the same height of the person who did the action and with the camera lens set to mimic what the human eye may see.

Phenolphthalein |

A presumptive test for the presence of blood. It reacts to the heme molecule and produces a bright pink positive result.

Pinch-point |

The first impact point of a ricochet (Hueske).

Point of origin (bloodstain) |

Also referred to by area of origin, the three-dimensional location from which spatter originated.

Point of origin (fire) |

A place where a fire first started.

Pooled blood |

A bloodstain pattern resulting from an accumulation of liquid blood on a surface (SWGStain).

Powder stippling |

Powder particles the result of the discharge of a cartridge that impact the skin causing small abrasions that are imbedded into the skin (also known as tattooing) (Hueske).

Prejudicial photographs |

Photographs that may play on the emotions of the judge or jury and therefore, outweigh their probative value.

Primer |

A cup containing a shock-sensitive propellant containing lead, antimony, and barium, that is seated in the base of a cartridge when struck produces the ignition process of the cartridge propellant (Hueske).

Projected bloodstain pattern |

A bloodstain pattern resulting from the ejection of a volume of blood under pressure.

Propellant |

The combustible unit of a cartridge or shotgun shell (Hueske).

Revolver |

A firearm that uses a rotating cylinder to hold and fire cartridges (Hueske).

Rhodamine 6G |

A fluorescing dye used to enhance latent fingerprints developed on non-porous surfaces with cyanoacrylate ester fuming and when used with a laser or Alternate Light Source.

Ricochet |

A bullet that has altered its original trajectory by skipping, bouncing, or deflecting off of a surface but maintains its integrity (Hueske).

Ricochet crease |

An indentation or furrow in a surface caused by a bullet striking a surface but being deflected without penetration of perforation (Hueske).

Rifling |

Spiral grooves cut into the interior of a barrel consisting of lands and grooves that provide spin for the bullet as it travels the length of the barrel.

Rifling twist |

The direction of the rotation of rifling (right or left) in which the grooves are cut (Hueske).

Rigor mortis |

The stiffening of joints and muscles by the depletion of adenosine triphosphate following death.

Rough sketch |

A rough, hand-drawn sketch of a crime scene noting important objects and items of evidence.

Safety glass |

Glass that uses layers of transparent coatings to prevent glass from shattering

into shards with sharp edges and is commonly found on the doors of automobiles.

Same plane photographs |

A photographic technique where a scale is placed on the same plane as the object being photographed in order to produce examination quality photographs minimizing distortions.

Sample Word 1 | Sample Definition 1

Scene perimeter |

The designated demarcation of the scene of a crime separated from its boundaries.

Semi-automatic |

A firearm that automatically fires, ejects and loads cartridges in its chamber after every shot fired and with each pulling of a trigger (Hueske).

Shell casing |

A suitable term for a cartridge casing (Hueske).

Shotgun shell |

A rimmed, cylindrical (straight-walled) cartridge used in shotguns (Hueske).

Skin Print Black™ |

A magnetic carbon-free powder developed by Doje's Forensic Supplies for developing fingerprints on skin.

Slug |

A single projectile loaded into a shotgun shell (Hueske).

Small Particle Reagent |

An aqueous development medium used for latent ridge print impressions deposited on wet, non-porous surfaces including glass, plastic, metals, and adhesive sides of tape.

Sodium Rhodizonate |

A presumptive test used to detect the presence of lead.

Spatter |

A bloodstain resulting from a blood drop dispersed through the air due to an external force applied to a source of liquid blood (SWGStain).

Stab wounds |

A penetrating trauma to the skin that results from a knife or a similar pointed object with an injury that is deeper than it is wide.

Sticky-Side tape formula |

An aqueous solution used for developing ridge print impressions on the adhesive side of tape.

Strangulation |

The obstruction of blood vessels and airflow in the neck by constriction of the throat that may result in asphyxia.

Swipe bloodstain pattern |

A bloodstain pattern resulting from the transfer of blood from a blood-bearing surface onto another surface, with characteristics that indicate relative motion between the two surfaces.

Tempered glass |

A type of safety glass produced by controlled thermal or chemical treatments to increase its strength and is commonly used in vehicles (Hueske).

Trace evidence |

Any type of evidence that is so small that it can be easily transferred or exchanged between two surfaces without being noticed and may need magnification or other enhancement techniques to locate and document.

Trajectory |

The flight path of a bullet or shot after leaving the barrel (Hueske).

Trajectory rod |

A plastic, metal, wood, or fiberglass rod inserted into a bullet defect presenting two points of reference and used to determine the vertical and horizontal angles of impact (Hueske).

Transfer bloodstain impression |

A bloodstain pattern resulting from contact between a blood-bearing surface and another surface leaving behind a distinct shape of the bloodstained object.

Transfer bloodstain pattern |

A bloodstain resulting from contact between a blood-bearing surface and another surface (SWGStain).

Triangulation diagramming |

A measurement method that uses two or more permanent fixed positions forming a triangle in a crime scene to record the location of an item of evidence.

Unintentional discharge |

The discharge of a firearm through human interaction with the trigger when the action was not intended.

Vertical flight path |

At right angles to the horizontal plane, the vertical flight path of a bullet will determine if the bullet was traveling upward or downward upon impact with a surface.

Void bloodstain pattern |

An absence of blood from an otherwise continuous bloodstain pattern.

Wave castoff |

As a drop of blood impacts a target at an angle, the direction of travel is determined by the "tail" or "cast off" caused by inertia.

Wipe bloodstain pattern |

An absence of blood in an otherwise continuous bloodstain or bloodstain pattern.

Zero-edge protractor |

A protractor with a flat edge that crime scene investigators use to determine the horizontal, and vertical, angle of impact (Hueske).

Zone of possibility |

In shooting scene reconstruction, the zone of possibility is determination of the likely position of a shooter or shooters based on bullet defect analysis, trajectory analysis, shell casing ejection pattern analysis, and the understanding a firearm may not be in a fixed position (Hueske).

'V' notch |

In full or partial suspension hanging, the ligature may, upon finding a point of suspension, produce a mark on the neck that resembles an inverted ‘V’ around the neck.

‘V’ pattern |

Also known as a classic ‘V’ burn pattern, a pattern produced by the fire burning up and away from the point of origin.

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